APRIL-JUNE 2026

AEROSPACE AMERICA

The new space race

Why the competition is bigger than landing astronauts on the moon this decade. PAGE 32

AIAA

AEROSPACE AMERICA

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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.

EDITOR'S NOTEBOOK

Expanding our coverage of defense and Congress

Marjorie Censer
Editor-in-Chief
marjoriec@aiaa.org

The Aerospace America staff grew in January, when we welcomed a second staff reporter: Aspen Pflughoeft.

Aspen joined us from McClatchy, where she spent nearly four years. She led the company's international and science coverage for its real-time news team, which means she has a knack for covering and writing about complex news.

For Aerospace America, Aspen will be building out our defense and congressional reporting as it relates to aerospace technology and issues. That means tracking the Air Force and Space Force's emerging technology programs, monitoring progress on the Golden Dome missile defense effort, following NASA and Pentagon research funding proposals on Capitol Hill and watching how defense contractors are directing their technology investments — plus much more.

We're thrilled to have her aboard and hope you enjoy our expanded defense coverage. If you have ideas or tips, you can contact Aspen at aspenp@aiaa.org.

What's next

We're looking forward to a busy few months, from the Space Symposium in Colorado in April, AIAA's ASCEND coming to Washington, D.C., in May, and the AVIATION Forum in June. No matter your specialization or niche, we hope you enjoy and potentially learn from the stories inside these pages and our coverage of these events.

Top of mind for many space officials and executives is the race to the moon between China and the United States. NASA made news in late February when it significantly restructured its own plan to return astronauts to the lunar surface in two years, inserting a new demonstration mission in 2027 to test rendezvous and docking between the Orion crew capsule and one or both of the commercial landers in development. The agency now hopes to conduct not one, but two lunar landings in 2028.

For our cover story (page 32), Leonard David and Associate Editor Cat Hofacker take a closer look at the Chinese and U.S. progress — and the stakes of landing astronauts first this time around. We're of course closely tracking Artemis II (which as of this writing was slated to launch as soon as April 1), but with this story, we wanted to zoom out a bit and examine why this has shaped into what top officials describe as a race and what that means. Indeed, NASA Administrator Jared Isaacman said at a February conference that if China beats the U.S. back to the moon, it would call "almost everything [the U.S. is] pursuing across all these emerging and important technological domains into question."

Also in this issue, staff reporter Paul Brinkmann checks in on NASA's Dragonfly rotorcraft, which was a topic of great interest at AIAA's SciTech Forum in January. Indeed, he spotted multiple technical papers and talks about the mission, and spoke to scientists and engineers about their efforts to overcome key technical challenges so the spacecraft is ready for a 2028 launch to Titan. Paul talked with some of the project leaders to offer a closer look at what those obstacles are, as well as the plans to overcome them (page 8).

Also at SciTech, Cat sat down with Boeing's top safety official for a discussion about implementing sweeping changes at the aerospace giant over the past several years. You'll find excerpts of that conversation in the Q&A section (page 14).

For those interested in innovative aircraft, I'd direct you to our Engineering Notebook (page 18) for a deep dive into DARPA's X-65. Flight tests with this remotely piloted demonstrator could give us the first in-depth examination of active flow control and, if successful, unlock new opportunities for aircraft design.

We've also added a new department this year with the Book Spotlight (page 6), which takes a look at upcoming and recently published books that might be of interest to our readers.

Of course, there's much more in this issue, and, as always, I welcome your ideas for future coverage. We hope you enjoy the issue — and that you visit us online to see our daily coverage of aerospace technology, including our expanded set of topics. ★

The Artemis II SLS and Orion on the launchpad in late January.

United Launch Alliance


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FLIGHT PATH

Building A Global Community

In January this year I spoke to a standing-room-only crowd of over 120 aerospace engineering students at the University of Stuttgart in Germany, organized by AIAA's vibrant student branch there. We ran out of pizza and went over time, but we left energized about the bright future that lies ahead in aerospace.

Earlier that morning, Stuttgart's HyEnD student rocket club showed me their homemade carbon fiber overwrapped tanks and engine components for a two-stage vehicle they designed to reach above the Kármán Line. I also visited their Altitude Test Facility at the Institute of Aircraft Propulsion Systems where students work with industry to test aero-engines and components under simulated flight conditions to power next generation jet aircraft.

Both encounters left me humbled by the students' drive and ingenuity. These impressive young professionals are pushing the boundaries of flight as they prepare to join the global aerospace workforce. I am proud to count them as AIAA members.

Initial Steps Around the World

The trip to Europe was to inaugurate AIAA's local representation in the region. We now have two full-time staff members building ties with universities, companies, governments, and like-minded aerospace societies across the continent. The people I encountered greeted our team warmly, welcoming AIAA and expressing enthusiasm for our partnerships with their local communities.

During my visit, we also welcomed new Corporate Members from the region: Space Industries, GENERGO, and Kurs Orbital. We signed MOUs with Women in Aerospace (WIA)-Europe and AIDAA, the Italian aeronautics and astronautics association. These organizations' participation reflects the growing interest there in connecting with AIAA's global network.

This visit was part of my promise when I stepped into this role 17 months ago – to build bridges across the globe. I am committed to growing our international reach for three core reasons: to generate interest in our world-class publications, to grow participation in our forums and events, and to build AIAA's membership of exceptionally talented engineers and professionals.

Since the merger of the American Rocket Society and Institute of the Aerospace Sciences in 1963, AIAA has been globally respected for technical excellence in aerospace. My visit to Europe this year confirmed that our reputation remains firmly intact.

We know what happens when our technical community connects. We are a knowledge-centered Institute where aerospace professionals convene and learn. Breakthroughs come from innovators who've shared a stage, debated a design, or co-authored a paper – professionals who learn together how to tackle the hard problems in aerospace.

It's vital for AIAA to have representation within countries around the world, allowing us to serve regional priorities and strengthen relationships that support aerospace supply chains and innovation across borders. Local engagement matters. Professionals engage most deeply when someone fluent in their technical community is there to serve them.

Very recently, we added new representation in the Indo-Pacific region in Sydney, Australia. We are actively planning the next steps to enhance our presence in this region, including our participation in the 35th Congress of the International Council of the Aeronautical Sciences (ICAS 2026) in September in Sydney.

Clay Mowry
AIAA CEO

Accelerating with IAC 2029 Houston

In late February, AIAA announced our bid to host the International Astronautical Congress (IAC) in 2029 in Houston, Texas. This effort is a great accelerator to our international strategy and our legacy of welcoming the global aerospace community to the United States.

AIAA has hosted IAC six times before. We are ready to host it again in Space City, Houston's trademarked name adopted by their hometown MLB Astros and NBA Rockets sports franchises.

IAC 2029 Houston would unite the global community's sustainable exploration ambitions. The timing coincides with NASA's push to return to the lunar surface through Artemis and the 60th anniversary of the historic Apollo 11 landing.

We anticipate welcoming an international delegation of 13,000+ delegates from over 80 countries. Our bid has already drawn over 170 support letters from organizations and individuals in 42 countries, including the Honorable Brian Babin (TX-36), Chair of the U.S. House Committee on Science, Space, and Technology.

Our Trusted Future

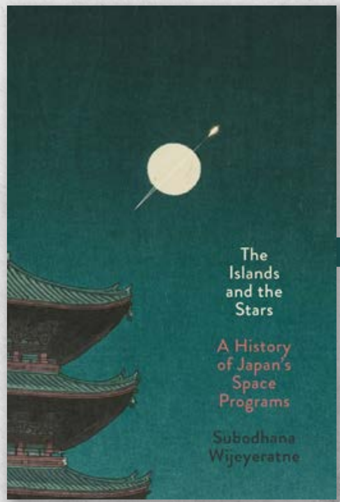
In my first column for *Aerospace America* in October 2024, I shared our three-pronged strategy building on the Institute's proud history: strengthening our international engagement, engaging the next generation, and reimagining our member services.

I am encouraged by the response – membership has grown to nearly 20,000 professional members, 15,000 university and high school members, and 102 corporate members. The community who interacts with our publications and forums now tops 102,000 people. We've seen record engagement in our regional student conferences in the past two years, and we have added or reinvigorated more than a dozen student branches worldwide. Stay tuned as we've only just started growing the next generation of AIAA aerospace professionals.

Member growth is proof that we are headed in the right direction. But our ambition goes beyond numbers. AIAA's vision is to be the most trusted source of aerospace knowledge exchange. That trust is earned. Our commitment is to continue earning that trust with each step we take toward the future. ★

BOOK SPOTLIGHT

A SELECTION OF RECENTLY PUBLISHED AND UPCOMING TITLES



The Islands and the Stars: A History of Japan's Space Programs

RELEASED JAN. 27, 2026
(Stanford University Press)

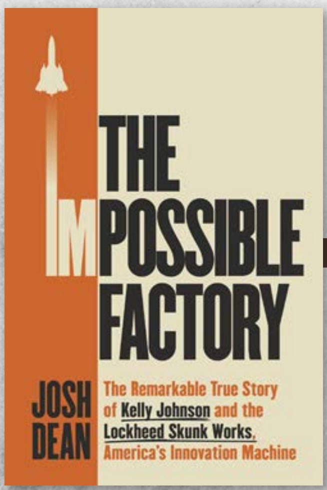
Technology historian Subodhana Wijeyeratne "traces the evolution of Japan's space program from its early origins in the 1920s, through the postwar period of rapid technological innovation, to the consolidation of its various institutional elements into JAXA [the Japan Aerospace Exploration Agency] in 2003," according to the publisher."Wijeyeratne not only illuminates Japan's centrality to the global history of science and technology, but also offers insights into the future of global space exploration, emphasizing the importance of diverse voices and perspectives in the quest to understand our place in the cosmos."

Becoming Martian: How Living in Space Will Change Our Bodies and Minds

RELEASED FEB. 17, 2026
(The MIT Press)

Rice University's Scott Solomon examines how living in space will change humans' bodies and minds. Solomon weighs a range of potential scenarios, from tourists journeying to an orbiting space station to children born on another planet.

"We are on the cusp of a golden age of space travel in which, for the first time, it will be possible for large numbers of people to venture into space," the publisher writes. "But what happens—and will happen—to us in the extreme conditions of space?"



The Impossible Factory: The Remarkable True Story of Kelly Johnson and the Lockheed Skunk Works, America's Innovation Machine

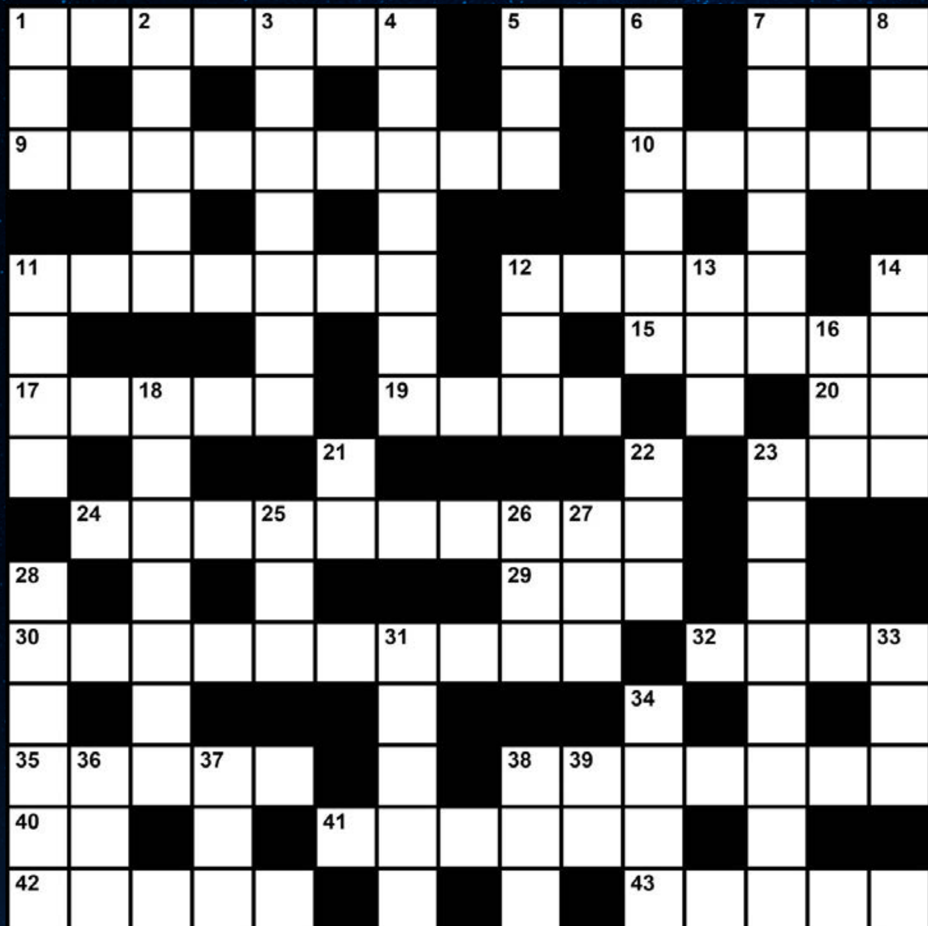
RELEASING MAY 19, 2026
(Dutton)

Journalist Josh Dean chronicles the origins of Lockheed Martin Skunk Works, which go back to a warehouse and a young engineer named Kelly Johnson.

"During Johnson's forty-seven years at Lockheed Martin, the Skunk Works developed at least half a dozen planes that would have been the capstone achievement of anyone else's career," the publisher writes. "But the planes were only part of Kelly Johnson's legacy. There was also his management style, which would come to shape organizations for decades to come."

That style is the model for today's innovative companies. "Half a century before Mark Zuckerberg coined the motto 'move fast and break things,' Kelly Johnson was living that mantra."

Titles are meant to reflect a broad range of topics and are not reviewed or endorsed by Aerospace America or AIAA.



CROSSWORD

Test your knowledge then find the answers online.

Across

1 This autonomous helicopter made its first flight in January

5 Acronym for Starship-Super Heavy flights

7 The subject of our January-March cover story

9 Less formal name for the Extravehicular Mobility Unit

10 The hunter in the sky

11 Take in oxygen

12 This ESA telescope shares a name with a famous philosopher

15 Sudden, bright outbursts in binary star systems

17 _____ terrestrial

19 First name of the astronaut who holds the record for most spacewalks conducted by a woman

20 Wavelength that NASA's Roman Space Telescope will operate in (abbr.)

23 U.S. federal property overseer

24 This suborbital rocket won't be flying for awhile

29 Unit of absorbed radiation, or slang for cool

30 Measurement of the amount of light a star emits from its surface

32 Pioneer pilot and polar explorer, Richard ____

35 The R in TDRS

38 How space telescopes "see"

40 Knot (abbr.)

41 First name of Captain Kirk's loyal yeoman in the original Star Trek

42 Affectionately called the "blue marble" and "pale blue dot"

43 This structure is the basis for microchips and other electronics

Down

1 Some aircraft have this system to alert the crew of potential wind shear (abbr.)

2 You probably never call this Illinois airport by its full name

3 Electric aircraft company seeking to harness blown lift

4 The most stereotypical shape for a UAP

5 Astrophysic___

6 Astronomy term for a small body that shares the orbit of a larger one

7 Last name of the sci-fi author who wrote about solar power, space stations and other futuristic concepts

8 The object at the center of the Space Cola Wars

11 Honey and bumble

12 Camera rotation (verb)

13 Rocket payload capacity is usually expressed in this unit

14 Trillion, prefix

16 Acronym of a SpaceWERX challenge to help transition emerging technologies to the warfighter

18 NASA's Johnson Space Center has multiple facilities for this kind of testing

21 Chemical symbol for Thorium

22 Anomalous

23 You've probably heard of the Black Hawk, but what about the ____ ____?

25 NASA's Parker probe keeps setting records for its proximity to this body

26 The A in STEAM

27 Beam of light

28 Last name of a sci-fi writer who was a great fan of space travel

31 If you've seen the northern lights recently, it's largely due to this kind of flare

33 It was acquired by Leonardo in 2008

34 NASA has yet to announce this component of the first Artemis moon landing

36 If you want to know where someone is, you might ask, "What's your ___?"

37 NDAA, for example

38 This was deorbited 25 years ago in March

39 Shorthand for this community comprised of 18 government orgs

R&D

With Dragonfly mission, NASA faces challenges big and small

BY PAUL BRINKMANN | paulb@aiaa.org

▲ An illustration of the Dragonfly rotorcraft operating on Titan.

NASA/Johns Hopkins APL/Steve Gribben

NASA has sent dozens of spacecraft to distant interplanetary bodies over the decades, but none quite like the Saturnian moon that the car-sized Dragonfly octocopter is slated to land on and explore in the 2030s.

To date, the European Space Agency's Huygens is the only probe to reach Titan's surface, though it was not intended to function long after landing. Instead, the primary mission was to collect information about the moon's dense, almost smog-like atmosphere during its slow, 147-minute descent under parachutes. It also sent back tantalizing surface photos of packed icy sand, pebbles and rocks.

The $3.35 billion Dragonfly mission faces a tougher set of challenges, as NASA is aiming for the craft to traverse Titan for at least three years, surveying the surface via a series of short flights resembling leapfrog hops. The agency's interplanetary rotorcraft experience is limited to the Ingenuity helicopter, which completed 72 flights during its nearly three years on Mars, and Dragonfly will experience vastly different conditions. Titan is about eight times farther away than the red planet, and at their lowest, temperatures drop to about minus 180 Celsius — 100 degrees colder than Mars.

After years of testing rotors, instruments and materials for survival in these harsh conditions, NASA and lead contractor Johns Hopkins University's Applied Physics Laboratory are now building Dragonfly, in preparation for a launch in 2028. Integration tests began in early February, the first time all of the spacecraft's components will be tested as a complete system.

It's impossible to replicate Titan's atmosphere for testing on Earth, but the Dragonfly team has high confidence in its models, says Michael Wright, NASA's Dragonfly entry descent and landing lead. Also, past tests have incorporated real data gained from Huygens.

"You're never getting all the parameters right at the same time," he says. "It tends to be a bit of a jigsaw puzzle to try to match what you can where you can and then put all the pieces together into an integrated simulation of what will happen when we get there."

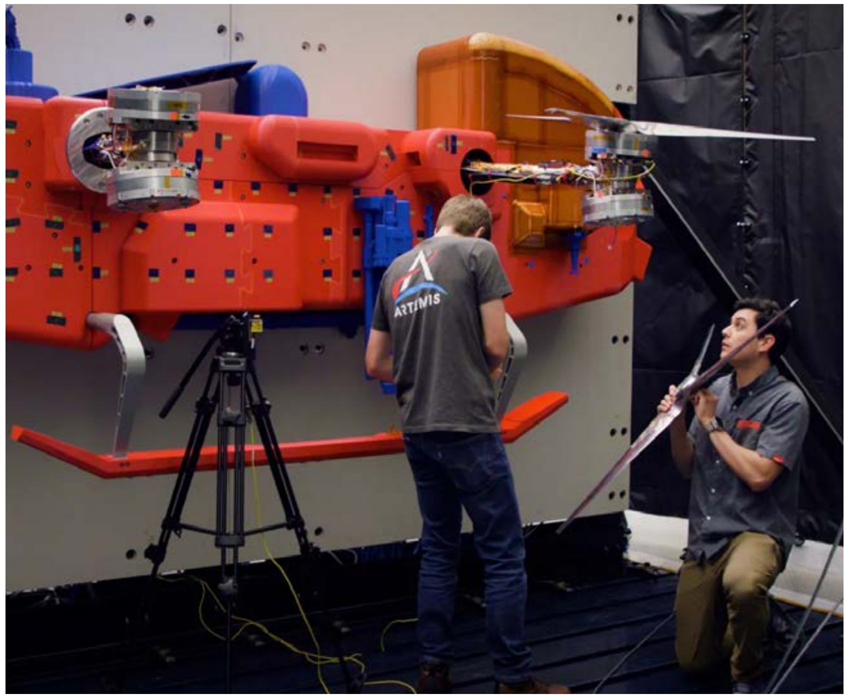
A long, slow trip

From the onset, NASA knew Dragonfly's nearly two-hour descent through Titan's atmosphere to its surface would present different design challenges than those encountered by Mars spacecraft, which must survive the "seven minutes of terror" plunge. These included sizing the drogue parachutes "to provide sufficient stability to overcome" any problematic oscillation during the long duration, Wright says. He compared it to pushing an unoccupied bike to another person: "You can push a bike 3 or 4 feet to your partner, and everything will be fine. If you want to push it 300 feet, you better make sure that bike is very carefully balanced."

For much of the descent, Dragonfly will be encased inside an aeroshell. Then, closer to the surface, it will spring free and spin up its rotors to search for a landing site in what NASA expects will be a relatively flat, smooth region. Plans call for the initial flights to avoid areas with boulders, mountains or what are thought to be oceans of liquid methane, but mission planners would like Dragonfly to eventually explore more diverse terrain.

Delay in reaching a landing zone and becoming fully operative could also pose a problem, because the octocopter is being designed to only fly for about 30 minutes before it must land to recharge its batteries on its internal nuclear power plant. However, Wright is confident designers have eliminated that risk.

"Once the lander is released, it is only a matter of seconds before it is working to achieve stable flight, and the 100-plus minutes of time spent on the parachute prior to that moment are no longer relevant," he says.



▲ APL engineers install a rotor on the Dragonfly test article for 2025 tests in the Transonic Dynamics Tunnel at NASA's Langley Research Center in Virginia.

NASA

Rotor risk

In parallel, researchers at Embry-Riddle Aeronautical University's Daytona Beach campus have spent years simulating and studying the possible impacts of debris being kicked up by downwash or outwash from Dragonfly's rotors, two of which are stacked on each of four short metal booms extending from the body. They identified problems with air pressure interactions between the rotors, which prompted NASA in 2023 to shift the alignment of the dual rotors so they are tilted toward each other on their outer edges farthest from the craft's body.

NASA also made several alterations to flight control software to account for drafts and unsteadiness during landing and to reposition some sensitive instruments to protect them from debris.

"Whenever the lander approaches the ground, you get not just debris but also unsteady loading on the vehicle," says Jackson Asiatico, an Embry-Riddle Ph.D. candidate researching Dragonfly interactions. "Helicopter pilots here on Earth are trained for that, but with an autonomous vehicle, you have to build that into your flight controller."

Staying warm

Given Titan's frigid temps, NASA's initial concern was how to ensure Dragonfly didn't get too cold to operate. However, scientists were surprised to discover in the early design phase that the spacecraft's nuclear thermoelectric generator — the same power source for the Curiosity and Perseverance Mars rovers — ran the risk of getting too toasty.

"There can be a slight breeze on Titan, and we had to design for that potential to stay warm with a breeze," says APL's Elizabeth "Zibi" Turtle, Dragonfly's principal investigator. "But conversely — surprisingly enough — that means the lander could overheat if you have a completely calm day. In testing, we were able to demonstrate that the system and its thermal management software could react to that."

Largely autonomous ops

If there's a problem, mission controllers have no way of quickly connecting with Dragonfly. Radio signals will take up to 90 minutes each way to travel between Earth and Saturn. So the rotorcraft and its computers will be in charge most of the time. To account for that, NASA and APL established a series of software decision trees for several common scenarios Dragonfly could encounter, to help the rotorcraft's flight computer determine when Dragonfly should land immediately, hop to a new location nearby, scout for the next site or return to its last landing site.

For instance, if there's a problem midflight and "we are halfway or more to our designated safe landing site, we're just going to continue going to our safe landing site. If we are not that far along our trajectory, though, we can return to the takeoff site," said Michael Marshall, a Dragonfly guidance and control engineer at APL, during a presentation at AIAA's SciTech Forum in January.

Marshall said the lander will keep a running list of five suitable nearby landing sites, based on previous aerial reconnaissance, in case of emergency.

Scientists will continue to test and verify Dragonfly's responses to "in-flight anomalies" or a bad landing, he added.

"There's a bunch more work going on behind the scenes to actually rigorously test and verify that these [contingencies] are going to behave as we expect across all sorts of known and unknown uncertainties," Marshall said. ★

R&D

NASA'S NEW SUPERALLOY

BY KEITH BUTTON | buttonkeith@gmail.com

The powder form of the superalloy GRX-810.

NASA/Jef Janis

The heat inside the combustion chamber of a rocket or turbine engine can create a hellscape for metal components, with temperatures often exceeding 1,000 degrees Celsius.

To ensure the injectors, nozzles, preburners, shrouds and turbine blades can withstand the heat, engine designers and builders have long relied on two kinds of superalloy metal mixtures — but neither amounts to a perfect solution. Nickel-based mixtures are relatively cheap but weaken at at temperatures over 1,000 C, degrees, whereas superalloys of refractory metals like niobium remain strong above 1,000 C but are up to 100 times more expensive, plus they're corrosion-prone.

NASA might soon be able to offer a better alternative: GRX-810, a nickel-based superalloy in formulation over the last several years that combines the best attributes of today's alloys. Early tests indicate the material retains its strength above 1,000 C while also remaining resistant to corrosion.

The current phase of testing seeks to address the cost portion of the equation. Since October, researchers have been evaluating a new manufacturing method that, if successful, could expand the use of GRX-810 and enable manufacturers to build engines that are significantly cheaper and more reusable, proponents say.

First, the alloy: Based on initial tests, GRX-810 stacks up impressively against today's nickel superalloys, most of which were developed in the 1960s. It can last 2,500 times longer, is twice as resistant to oxidation and retains its strength at up to 1,300 degrees. It was first created in 2021 by NASA materials engineers Christopher Kantzos and Tim Smith as a powder that can be 3D-printed, building parts from thin layers of the powder as it is melted by a laser.

Tests comparing GRX-810 to the old-school materials have been striking. In one example, after heating the new alloy to 1,100 degrees, cooling it, and repeating the cycle 100 times, the GRX-810 was unchanged. For the same test with a common nickel superalloy, "it's completely falling apart into dust," Smith says.

In a strength test under continuous heating at 1,100 C, the traditional nickel superalloy breaks apart after five hours, whereas GRX-810 lasts more than six months. NASA researchers don't precisely know the maximum time yet for GRX-810 on the test. During its first 5,000-hour trial in 2024, the test frame gave out before the alloy sample did.

"That was a good sign: Like, 'Alright, this really is as good as we've been claiming,'" Smith says.

This year's tests are focusing on the cold-spray method, in which researchers blast powder particles of GRX-810 through a nozzle. In this technique, high-pressure gases propel the particles at supersonic velocities to embed them onto a component surface, coating it without melting. If it works, GRX-810 could be applied to turbine blade tips or other worn-out parts to repair them, or as a heat-shielding coating on other metals to make cheaper parts. Cold spraying could also serve as a way of 3D-printing entire parts from GRX-810.

For all the potential benefits, challenges remain, says Michael Schmitt, CEO and senior research scientist for HAMR Industries, a materials development company in Pennsylvania. GRX-810 was originally designed for laser powder bed fusion, in which thin layers of powder are consecutively melted. This 3D-printing process yields dense, finely detailed parts, but it is also time-intensive, expensive and can't be used to repair or add onto existing parts. The laser printing can produce a few hundred grams of material per hour, compared to the tens of kilograms per hour possible via cold spray.

"It's great for certain applications, but it definitely has its limitations," Schmitt says.

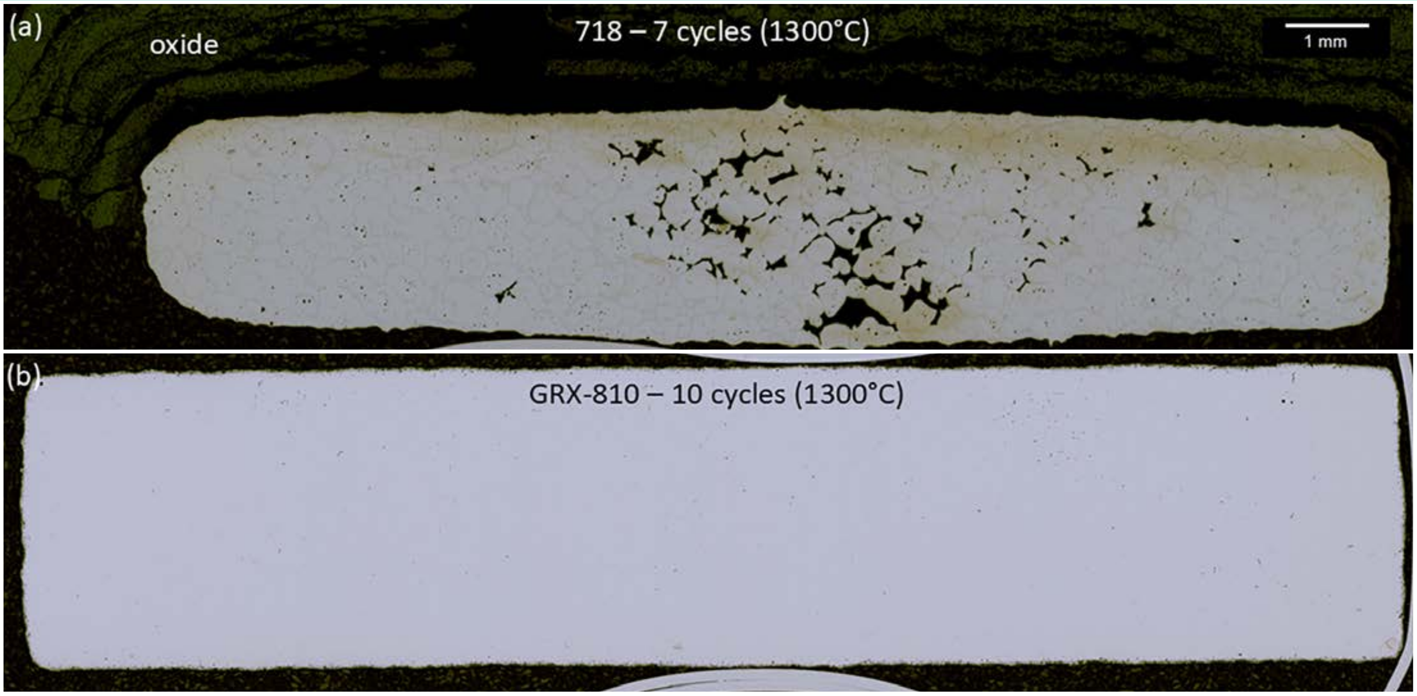
These limitations are partly why NASA is exploring cold spraying, Smith said. The agency last year awarded 12-month contracts of about $150,000 each to HAMR, Elementum 3D of Colorado, and Triton Systems of Massachusetts, with results due by Sept. 30. The overarching goals are to discover the best methods for cold spraying GRX-810 and study whether cold-sprayed parts can be as strong and corrosion-resistant at high temperatures as the ones produced via laser powder bed fusion.

IN A STRENGTH TEST UNDER CONTINUOUS HEATING AT 1,100 C, THE TRADITIONAL NICKEL SUPERALLOY BREAKS APART AFTER FIVE HOURS, WHEREAS GRX-810 LASTS MORE THAN SIX MONTHS.

GRX-810's high-temperature characteristics can be traced in part to the microscopic bits of ceramic embedded in the material's 3D-printed form. In the powder formulation, each particle is coated with a layer of a ceramic called yttrium oxide, much like powdered sugar clinging to a donut. During the laser printing process, the ceramic bits are evenly disbursed throughout its microstructure.

NASA doesn't fully understand what gives the 3D-printed material its superpowers, but early research has revealed some clues. In a January paper in Nature Communications, Smith, Kantzos and 15 co-authors showed that the cubic crystals of yttrium oxide in the powdered form are converted into hexagonal crystals in the laser

Keith Button
has written for C4ISR Journal and Hedge Fund Alert, where he broke news of the 2007 Bear Stearns hedge fund blowup that kicked off the global credit crisis. He is based in New York.



▲ NASA's tests to date indicate GRX-810 outperforms other superalloys in various ways. The photos are of cross-sections of GRX-810 (bottom) and another material, Superalloy 718 (top), after both materials were subjected to multiple cycles at temperatures of 1,300 degrees Celsius.

NASA/Tim Smith, et. al.

3D-printing process, providing added strength at high temperatures. Another contributor is the nanocarbide crystals that grow in the microstructure when the printed alloy is heated and remain there even after it cools.

These crystals prevent the microscopic defects that would typically form in a metal as it is heated toward its melting point, Smith says: "When you heat things up, everything wants to move and relax and start to break apart, and the oxides and the carbides here really are just holding everything together."

A key question for the cold-spray research is whether that method will evenly distribute the yttrium oxide coating throughout the alloy.

To describe the theorized outcomes, the researchers once again reached for baking analogies. Consider the GRX-810 particles like balls of clay coated in flour, says Jeremy Iten, chief technical officer for Elementum. The flour might disperse as the clay balls impact and flatten into pancake shapes on the surface of the component the alloy is being cold sprayed onto. But it's also possible the flour might fly off upon impact, or form rings around the impacts, or form layers that don't allow other balls of clay to adhere.

To examine that question, Elementum has subcontracted with the University of Utah to study how individual particles of GRX-810 impact on a surface at different cold-spray velocities, particle sizes, angles, and temperatures with or without coatings.

The tests involve shooting a pulsed laser at what the researchers call "launchpad" sandwiches — a top layer of thin glass, a middle metal layer about two-thousandths as thick as a sheet of paper, and a thin plastic bottom layer with particles of the GRX-810 stuck to the underside. The laser is aimed from above at a single particle, penetrating the glass and striking the metal layer to create an explosion that sounds like a tiny lightning strike. This propels the particle to the target surface a few millimeters below.

The velocity is controlled by adjusting the power of the laser, and the angle of impact is controlled by tilting the target surface, says Suhas Prameela, the University of Utah materials science professor leading the tests.

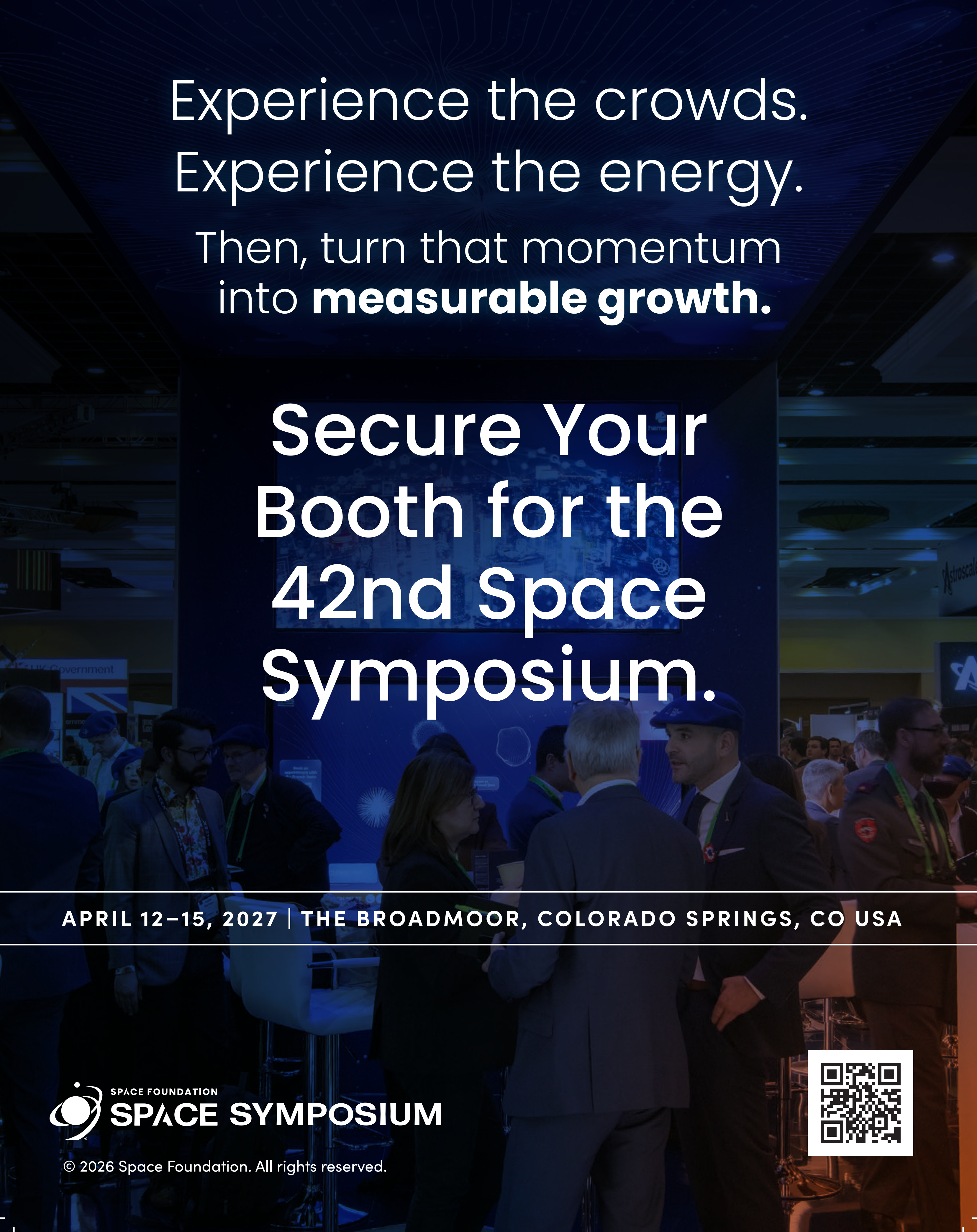
The velocity of the particle is calculated from a 16-frame movie shot with a $600,000 camera capable of taking a billion images per second. If the particle is too slow, it bounces off the surface; if too fast, it can create violent impact craters and erode the surface.

When the particle's velocity is just right and it sticks to the target surface, the researchers check the strength of the particle-surface bond under a scanning electron microscope, examining a cross section of the bond. So far, Prameela's team has conducted thousands of laser shots testing a range of variations for the cold-sprayed particle scenario, he says.

As part of HAMR's contract, the company is studying how the makeup of the GRX-810 powder might be altered to improve the cold-sprayed alloy. For instance, "Can we change a little bit upfront on how we generate these powders to make them more suitable for cold spray to then, down the line, enhance the properties that we get out of it?" Schmitt says.

Under the same contract, he says, HAMR is also looking beyond GRX-810 to explore how NASA might create its "next latest and greatest alloys" through cold spraying — a potentially faster process that could yield additional cost savings.

"They can just buy commercial off-the-shelf materials, which are cheap, easy to get," he says. "We can spray these materials together in the right composition and blend ratio, and then we can let them explore new alloys that way, rather than having to go out and custom cut the materials." ★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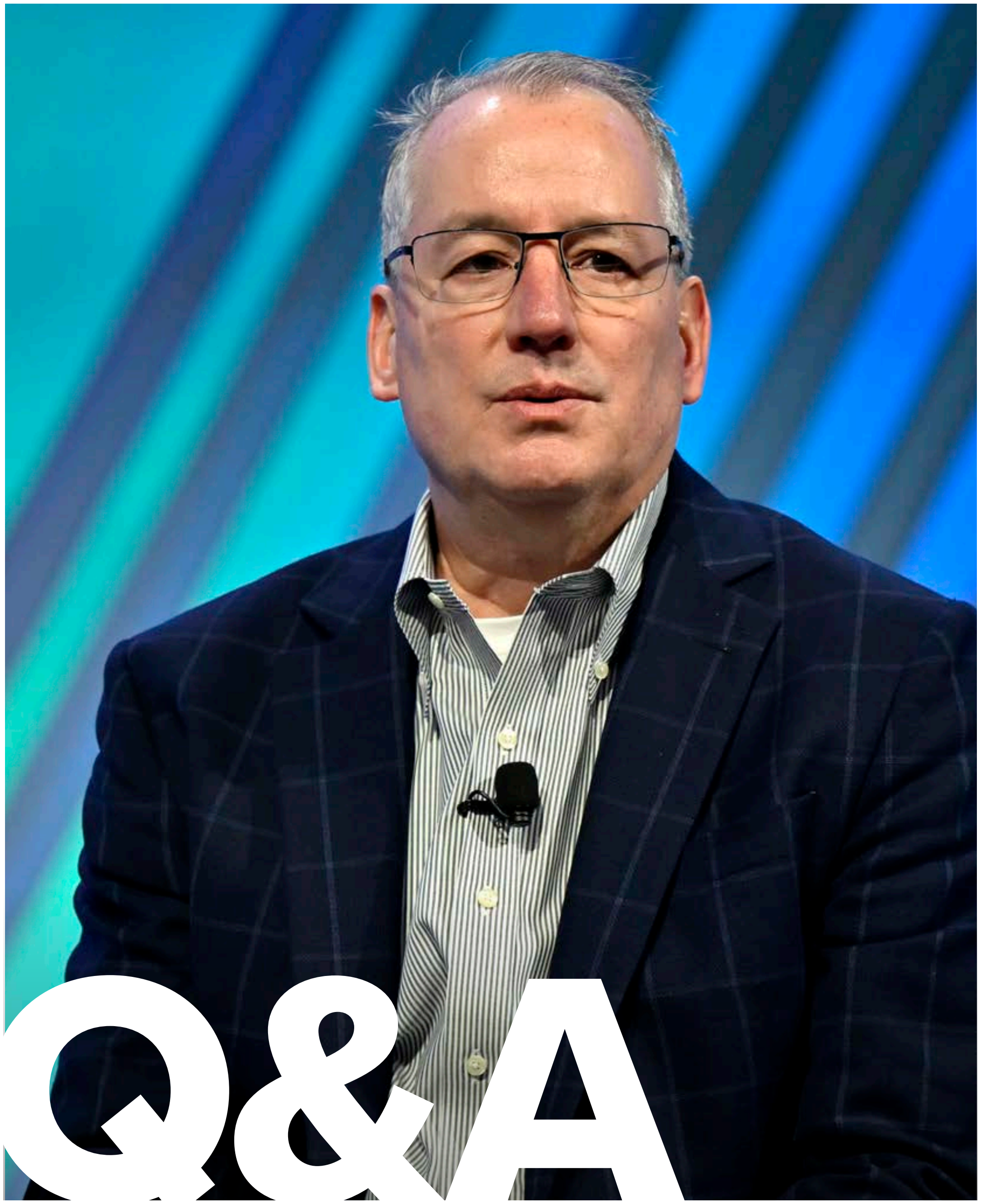


Q&A

Boeing's safety chief

One might assume there are many differences between Don Ruhmann's current job and his past roles in aircraft engineering and program management. But as he sees it, they're "very complementary," he told me on the sidelines of AIAA's SciTech Forum in January.

The chief engineer of an aircraft program is "the singular person responsible for the product integrity of an entire vehicle," he said, and the chief aerospace safety officer is responsible for programs across Boeing's entire enterprise, as well as a host of safety-focused initiatives established in the wake of the fatal 737 MAX crashes and 2024 door plug blowout. Ruhmann oversees a team of a little over 1,200 that conducts product safety assessments and coordinates with regulators, among other tasks.

I sat down with Ruhmann to discuss his first year on the job, 2026 priorities and Boeing's ongoing cultural transformation. The excerpts have been lightly edited for length and clarity. — *Cat Hofacker*

DON RUHMANN, BOEING'S CHIEF AEROSPACE SAFETY OFFICER

KEY POSITIONS:
- Since March 2025, Boeing's chief aerospace safety officer.
- 2024-2025, vice president of development programs for Boeing Commercial Airplanes, overseeing development of new derivative aircraft.
- 2020-2024, vice president and chief project engineer for the 787 program.
- 2013-2020, various engineering leadership roles on the 777 and 777X programs.

NOTABLE:
- Boeing's second chief aerospace safety officer, a position created in 2021 to consolidate the company's safety programs and initiatives under a single office.
- Joined Boeing in 1989 as a liaison engineer.
- Oversaw propulsion systems for the 787 Dreamliner, Boeing's latest clean-sheet aircraft.

AGE: 62

RESIDES: Seattle

EDUCATION: Bachelor's degree in aerospace engineering from Texas A&M University, 1986; master's degree in physics from University of Washington, 1994.

Q: When you took the job in early 2025, what goals were you handed?

A: I was always on the outside looking in, watching the things that they [the chief aerospace safety engineer's team] were doing. At the time, they were initiatives, but they've now become baseline statement of work. So thinking about, for example, getting out and being with the products more directly with our pilots, like we do with field service representatives. We've always done that, but not uniquely with just pilots. There was also changing the way we do training to make it competency-based versus prescriptive, implementing a formal safety management system and including new data analytics and new things focused on safety. All of those things Mike was leading.

He's referring to Mike Delaney, the first chief aerospace safety officer. — CH

So it was really kind of exciting coming in and seeing the position that they've put themselves in to have an incremental positive outcome on safety, which is what it's all about. In the industry as a whole, there have been big changes in 10 years in accident rate improvements and fatal accidents. To keep something like that moving when the numbers are getting so small takes a lot of different thinking and a lot of different approaches, which is what the foundation of Mike's work was. So I didn't have any new mission other than to keep it moving forward.

"We constantly look at new products and new technologies. Even in the darkest days of tough times financially, you have to keep something moving forward as a company — even if it's not 'We're ready to launch a new airplane,' which is what everybody wants to hear."

Q: Using an example like the MAX production increase or 777X certification delays, how does your team interact with the broader company?

A: We're responsible for the safety management system across the enterprise. For commercial airplanes, it's a formal requirement for the FAA, but for Defense & Space and [Global] Services, it's not, but we still do it the same way. So, for example, MAX rate: Safety risk management is a key element of a safety management system, and we built and helped model with our program team a safety risk management build model that evaluated the effect of rate changes on all the different processes that actually would deliver an airplane. The thing that we were trying to prevent is letting a defect get out into the fleet, and going through and evaluating all of the barriers that don't let that happen, that was the key to getting to rate.

You also mentioned 777-9. All the safety analysis that we do to certify an airplane, all the safety engineers are part of my team. And so all the SSAs, or the system safety assessments, all the functional hazard assessments, all particular risk assessments, all of that technical work that we do to actually certify a product is led in-house by my engineers.

Q: What are the areas you're prioritizing in 2026?

A: A big focus is shifting the way we're thinking about safety resilience. You've got all these things that don't break that often. If you only focus on when they're broken or focus on collecting the data to not let them break, you're not focused on 95% of the data that's out there. So you need to figure out a different way to think about it and a different way to do it.

Another focus is continuing on with the initiatives Mike started that have now become baseline statement of work. The 150-ish pilots that we now have around the world, hanging out with our product, talking to our customers, it's creating a new database of information. It's almost exclusively text-based information — observations, learnings — but we're purposely putting it into a database we intended to be able to data mine. So that's the next step.

Reading through text and interpreting things as a human is a lot of work, but if you collect it with a dedicated taxonomy of what you're intending to do with it, data mining it either with AI or machine learning affords you a different opportunity. Then you're looking for that gem of information like, "This airline does this particular thing really, really well." Well, I want 100 airlines to do that really, really well. Can I translate what we learned from them to other airlines?

▲ Boeing's 737 factory in Renton, Washington. The company in October received FAA approval to increase MAX production to 42 a month, up from the cap of 38 imposed in 2024 after the door plug blowout aboard a MAX 9 operated by Alaska Airlines.

Boeing

Q: Transforming the culture has been another big focus. How do you measure progress on that?

A: The reason that's moving and having a positive outcome is because [Boeing CEO] Kelly [Ortberg] is the champion. Part of our safety management system includes a mandatory employee reporting system that can either be anonymous or just confidential. Translating that Speak Up system into the best it can be is also one of my objectives, getting to a point where employees feel really comfortable using it, wanting to tell us everything that's going on.

We teach a positive safety culture class for all new employees, and I took it when I started the job because I wanted to understand how the conversations happened. I got two things out of it: The first is — maybe I got lucky in the class I went to — but everyone talked about how excited they were to come work for Boeing. Considering where we had been for the past five years — we needed to take care of some things as a company. The culture was one of them. In engineering, there's lots of things we had to do. So having somebody be proud of being a new employee was really energetic for me at that time.

The other element was the positive safety culture side of it. At the end of the class, the teacher requested every student share a personal commitment. There were several that talked about, "I know when I drill this hole or I put this fastener in, now I am actually going to tell somebody if it's wrong. I am going to make sure that I hold up my end of the bargain to the rest of you in the room." Now, I need to multiply that by quite a bit to get to 150,000, right? And to your question, it's hard to measure until you get out and actually feel it and see it. We're just going to have to keep doing that.

Q: During an earlier SciTech session, you mentioned rebuilding trust with FAA as another priority. What are the next steps in that process?

A: It's been a journey. After the MAX accidents and then the door plug, there was a number of different independent reviews providing us suggestions on things that we needed to do. There was also a ton of scrutiny on the FAA from Congress that put a huge burden on the FAA — not just management, but the specialists who do the work. It really moved the trust conversation to a different place.

We have to do our work differently, turning in a high-quality engineering document to the FAA that they read and say, "Yep, that's what I expected, check, I approve." You start to earn your trust back by doing these things. It's all incremental, and you have to demonstrate

▲ The inaugural flight of a 777X prototype in 2020.

Boeing

it by your behaviors and by your actions, meaning the products that you produce don't have errors in them, don't have these problems, don't have a finding related to some human factors thing.

So all of that is earned trust, and we've had to do a lot of that recently. We have a very early career workforce, the FAA has a very early career workforce, so getting to a common understanding of the work that we do together is something that's in front of us. We're trying to go on a journey together, so that a specialist at Boeing and a specialist at the FAA who work a particular system are literally on the same page together.

Q: Looking ahead, what role will you play in assessing new airplanes, like the MAX successor or the 777-10 that Emirates is interested in?

A: [Boeing Chief Technology Officer] Todd [Citron] said something in the [earlier] discussion about how you bake in different things from the very beginning of a program. That's the place where we come in.

After the interview, it was reported that Citron is retiring, effective March 31. — CH

When you develop new technologies, you end up with new failure modes. And so [it's] all of that work — getting in on the ground floor when we're getting ready to do technology readiness levels, getting the safety team in early to understand that, to drive the design up front. Because the harder thing to do, the more expensive thing to do, is to deploy a technology, get it in a production system, and come back and realize you didn't account for a safety analysis of some sort, and now you're redesigning something. It's the best practice and way to do it, and that's where our involvement is with Todd and our product development teams. You mentioned the Tim [Clark, president of Emirates] request on what that airplane looks like. We constantly look at new products and new technologies. Even in the darkest days of tough times financially, you have to keep something moving forward as a company — even if it's not "We're ready to launch a new airplane," which is what everybody wants to hear.

Todd's working on all kinds of technologies, but they're going to be deployed across all kinds of different things. But that doesn't mean the next new airplane is around the corner. There's a number of things that still have to come together. We have to be ready, the customer has to be ready. There's things that all have to line up before you go do something like that. ★

ENGINEERING NOTEBOOK

Air jets under pressure

A rendering of DARPA's X-65.

Aurora Flight Sciences

With its X-65 demonstrator, DARPA aims to test whether today's control surfaces can be replaced. Paul Marks spoke to the program leads about the design and forthcoming flight tests.

BY PAUL MARKS | paulmarksnews@protonmail.com

For over a century, aircraft pitch, yaw and roll control has been provided by a familiar trio of control surfaces: ailerons, rudders and elevators. But have these heavy, draggy, difficult-to-actuate mechanisms had their day? Could the aerodynamic maneuvering forces these legacy control surfaces generate be supplied by other means?

The answer to those questions could begin to emerge in late 2027. That's when the X-65, a 3-metric-ton demonstrator commissioned by DARPA and built by Aurora Flight Sciences, is to take to the skies to test a new method of steering: active flow control, or AFC.

This remotely piloted aircraft is to maneuver by firing small jets of pressurized air, tapped from its single jet engine, through banks of nozzles that are strategically distributed around the surfaces of the wings and tail structure, to give full control of the airplane in three dimensions.

If it works, AFC could bring a swath of advantages. Getting rid of the need for heavy, hinge-jointed control surfaces and their complex hydraulic or electromechanical actuators could make airplanes lighter, less complex and more maneuverable, says Christopher Kent, who manages X-65 within DARPA's Control of Revolutionary Aircraft with Novel Effectors (CRANE) program.

"There's lots of good reasons to do this, some military, and some very interesting ones that are more to do with imagining a world where aircraft no longer need control surfaces, which allows you to really simplify parts of the aircraft," Kent told me in a mid-February interview.

"You could potentially even 3D print the whole aircraft wing with no hydraulics in it and just have all the air distribution surfaces designed in."

The idea of blowing pressurized air from aircraft surfaces isn't a new one, he notes. "Blowing-based lift augmentation has been around for decades — the British Buccaneer fighter had it, and the Japanese US-2 amphibian plane still has it," says Kent.

Both of those designs had pressurized air bled off the engine or auxiliary power unit and blown over the wing surfaces, plus a horizontal stabilizer to enhance lift and stall suppression in short takeoff-or-landing applications. Called boundary layer control, this technique helped the Royal Navy's Blackburn Buccaneer in carrier landings in the 1950s, and the ShinMaywa US-2 today in search-and-rescue scenarios on water. By forcing air through a vent to blow over a flight surface, the separation of airflow from that surface can be prevented — seriously enhancing lift at low speeds.

Blown air has also been used to successfully steer aircraft, says Kent, but only on small tailless, flying-wing-style drones. That research was led by another Pentagon lab, the Office of Naval Research, alongside the Illinois Institute of Technology and NASA.

"At DARPA, we're particularly interested in proving that you can do this at a much larger scale than previously demonstrated with those drones, which weigh just hundreds of pounds," he says. "We're going to do it at a very large size, with our 7,000-pound [3-ton] aircraft, because we need to fully understand if, and how, active flow control scales."

Building X-65

As of late February, Aurora Flight Sciences was preparing to mate the aircraft's diamond-shaped swept wings to the fuselage, working toward "a complete aircraft rollout sometime later this year," says Kent. With a 9-meter wingspan, X-65 will have close to the wingspan and mass of a six-seater Beechcraft Baron 58 twinprop.

An aircraft that size cannot take to the skies maneuvered solely by experimental vectoring technology. So as part of Aurora's FAA experimental certification requirements, X-65 will also have regular control surfaces as a safety backup.

"We'll have both systems, with the hydraulics and the AFC air jets, so we have the ability to fall back to the conventional control surfaces," says Kent. "It's a crawl, walk, run approach."

Central to the design is a bleed air distribution system, which taps pressurized air off an auxiliary power unit above the turbofan engine that runs the length of the airplane. That bleed air will be routed through the aircraft via pipes, regulated by flight computer-controlled valves, that direct air volume flow to 14 differently sized banks of nozzle-like air effectors embedded in the wing and tail surfaces.

Kent describes each effector as "basically a long tube with a number of small holes in it that lead out to nozzles on the wing surface."

One advantage of distributing relatively low-pressure

Paul Marks
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 innovation in electric aviation and commercial spaceflight.

> “In theory, this type of AFC control could potentially be much quicker for responding to gusts, or changes in the air environment.”
>
> **— Christopher Kent, DARPA**

air this way is eliminating the need for the highly pressurized hydraulics that today’s aircraft require to move their control surfaces. Leaks in such systems can do maintenance engineers serious harm through burns, severe cuts or fluid injection.

A big unknown with AFC acting as a control surface replacement is whether the sweep of the wings affects the operation of the air jet banks. Wings are swept one way or the other to reduce drag, but how will that air-pressure-based effect be modified when jets of air are providing the control? To find out, Aurora has designed a reconfigurable diamond-shaped wing with removable sections so that multiple wing sweep shapes — forward, backward and somewhere in between — can be tested.

“The two forward-most wings have a backward sweep angle, and the aft ones have a forward sweep angle. The outboard ones are different again. All these different sweep angles let us check what each one does best under different blowing configurations,” says Kent.

These removable wings largely account for X-65’s stumpy appearance, because they require Aurora to place the fuel tanks in the fuselage.

“The volume of the fuselage is driven by the amount of stuff we have to fit in there,” says Kent. “We have to power both the conventional hydraulic system and the air distribution system. And because the wings are modular and removable, we’re not storing fuel in the wings.”

Based on the results of model-based wind tunnel tests, DARPA anticipates some novel maneuverability possibilities from the aircraft’s air-driven vectoring system.

“In a conventional aircraft, it’s very hard to turn it in the air relative to its flight angle, what’s known as ‘crabbing’ the aircraft through the air,” says Kent, referring to a phenomenon mainly seen on high crosswind landings, when a plane approaches the runway threshold at quite an angle to the runway center line, only to be straightened up dramatically on landing with a sharp rudder input.

“We think AFC may allow us to actually potentially point the nose of the X-65 a little bit off of that and crab sideways” in any wind, he says — a maneuver that could be tactically useful for some missions.

And because AFC vectoring is based on fast, reactive firings of that pressurized bleed air, rather than slower aileron, rudder and elevator movements, designers suspect it will also be easier to keep the airplane straight and level in turbulence.

“In theory, this type of AFC control could potentially be much quicker for responding to gusts, or changes in the air environment,” says Kent. If so, that would be a boon for aircraft carrier landings: “You can turn these air jets on and off so quickly, and so fractionally over the surface, they might be able to do that even better.”

Those fast, fractional bursts of vectoring air emitted on wings and tail are going to need a hyper-accurate control system to regulate the air volume flow out of the effectors. Kent says the flight computer and autopilot Aurora is developing to do this is a “key piece of core technology that will convert your intent into how the AFC jets perform the maneuver that you so desire.”

Preparing for first flight

X-65's flight computer is slated to go into ground-based bench tests later this year, incorporating learnings from "a billion computer hours" of computational fluid dynamics simulations, Kent says. If all goes as planned, taxi tests will commence in early 2027, and first flight — with an Aurora remote pilot in control — will take place in late 2027.

Aurora is encouraged by the results of the testing done to date, says Larry Wirsing, the company's vice president of aircraft development: "The most surprising finding we've made while developing the X-65 has been the versatility and scalability of Active Flow Control as an aerodynamic tool," he told me via email. "While AFC was initially considered a 'localized' solution to manage the boundary layer, through multiple wind tunnel tests, subsystem validations, and full-scale bench testing we've now demonstrated that integrating AFC into the control loop not only works – but also enables entirely new design trades that can improve airplane performance."

And despite AFC's novel way of vectoring an airplane in three dimensions, Aurora is following a familiar process to train its remote pilots to fly the X-65, says Wirsing. "We'll start with training on concepts of operations to learn how the aircraft works, and the behaviors that are expected, and then we'll move into system reviews to get more detail on the individual systems and how they will all work together."

He adds: "Once that 'book' learning is done, each crew member will participate in sessions on our hardware-in-the-loop simulator to run through normal flights using the same ground station hardware that will be used in flight. And when the team is comfortable with normal operations, we'll inject abnormal and failure situations into flight scenarios to ensure that the entire crew knows how to diagnose and resolve any problems that may come up during flight."

But AFC won't be working from the moment the airplane first leaves the ground. Instead, "We'll first fly under the conventional control surfaces, and then convert over to active flow control as we work through the test program," Kent says.

"Our first flight under AFC is where DARPA's responsibility ends — and after that, the program will live on through Aurora's efforts." ★

▲ The X-65 fuselage under construction. Aurora Flight Sciences and DARPA are targeting this year for a rollout and late 2027 for the inaugural flight test.

Aurora Flight Sciences

ENGINEERING NOTEBOOK

PREDICTING HEAT SHIELD PERFORMANCE

Researchers at Sandia National Laboratories have spent the last three years creating a computer model meant to reduce the number of physical flight tests that hypersonic missile designers must conduct. Keith Button has the story.

BY KEITH BUTTON | buttonkeith@gmail.com

Varda Space Industries' latest capsule could help verify a streamlined approach to designing hypersonic missiles.

Researchers at Sandia National Laboratories in September culminated a three-year project, developing a computer model to predict how different heat shield materials will hold up during hypersonic flight based on their ingredients and shape. If the calculations prove accurate, the model could save designers time and money that would be spent on flight- and ground-testing every thermal protection iteration under consideration. That benefit would extend to Sandia's customers, including the U.S. Defense Department.

"Understanding the performance of heat shields can be an expensive and long process," says Justin Wagner, Sandia's lead researcher on the project. "By having this project, we developed the tools to be able to understand how that heat shield is going to perform in a quicker fashion."

As of this writing in mid-March, Varda's W-6 beach ball-size capsule was scheduled to carry the heat shield experiment to orbit by early April. As the capsule reaches hypersonic velocity during reentry, onboard sensors will record the temperature of the heat shield samples embedded in the vehicle's nose, chosen to represent similar formulations but different manufacturing methods.

This would be the team's first opportunity to compare the model's prediction against real flight hardware, because previous flight tests were conducted with expendable rockets that broke up and fell into the ocean. "In getting the materials back, you can put your eyes on them, make measurements, see how they responded in that flight environment," Wagner says.

They plan to examine the chemical structure of the postflight material under microscopes and with X-ray tomography, then compare it to the model's predictions and adjust the software, if necessary. "We're modeling how much material loss we might have in flight, and this allows us to directly compare to that flight and see how that material did," Wagner says.

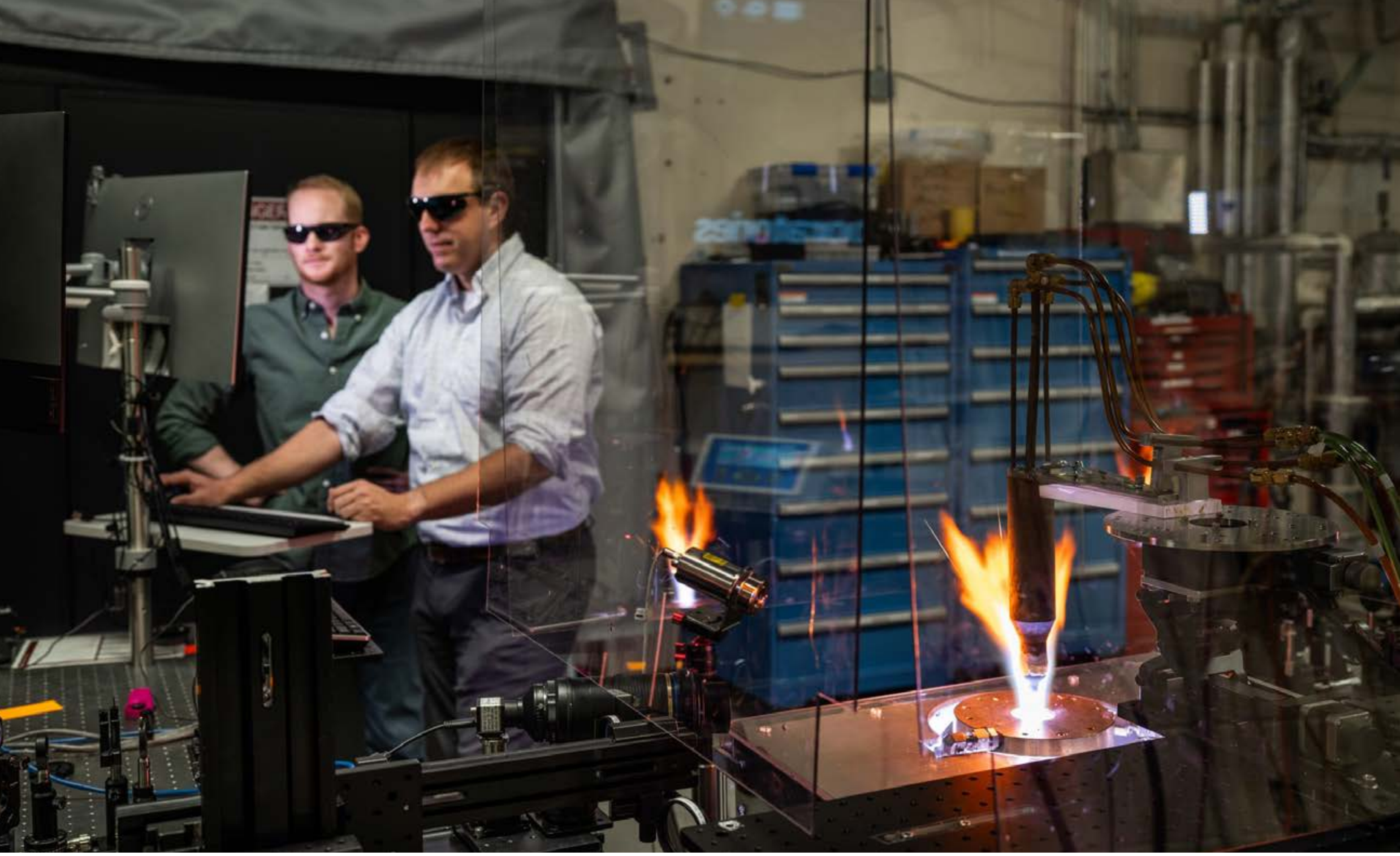
Choosing the right stuff

Heat shield materials are typically silicon- or carbon-based, designed to protect the leading edges of a hypersonic missile's fins or nose from extreme heat while gradually ablating during flight. Designers need to know how quickly the material will erode and how well it will continue to protect the missile as this erosion progresses. Those answers help to determine how much and what types of material are best for a particular vehicle and to calculate how the receding surfaces will alter the aerodynamics of the missile.

Keith Button
has written for C4ISR Journal and Hedge Fund Alert, where he broke news of the 2007 Bear Stearns hedge fund blowup that kicked off the global credit crisis. He is based in New York.

A Varda capsule streaks across the sky in February 2025 during its reentry.

Varda Space Industries



▲ Sandia engineers conduct a plasma torch test on a sample of heat shield material, one of dozens of tests conducted between 2022 and 2025 to develop the predictive computer model.

Sandia National Laboratories/Craig Fritz

To develop a computer model that could provide this information, the researchers knew an early step would be building a "full-physics model" that runs on a supercomputer to factor in the complex aerodynamics of hypersonic air flows and shock waves over the heat shield surface, plus the chemical interactions of the material with super-heated air molecules, Wagner says.

The plan was to then take the model and produce a streamlined "reduced-order" model that could be run on a desktop computer. Users would be able to input the shape and silicon and carbon makeup of a prospective heat shield material, along with the missile's velocity, and the model would calculate the temperatures the material would reach and the ablation rate.

They kicked off the project in 2022 by evaluating previously developed advanced chemistry models that predict how silicon and carbon materials react with superheated air. They compared the models' predictions to real-life material tests and selected the most accurate models for incorporation into the full-physics model.

"We could ingest many of those different models into the project workflow and compare them all to the experiment and see which one might be the best," Wagner says.

Sandia enlisted about 40 researchers in the project, along with teams at the University of Colorado Boulder, General Atomics, the University of Illinois Urbana–Champaign, Kratos Defense & Security Solutions, the University of Minnesota Twin Cities, Oak Ridge National Laboratory, PSE Technology, Purdue University, the Stevens Institute of Technology and the University of Texas at Austin, to help with the materials testing and computer models.

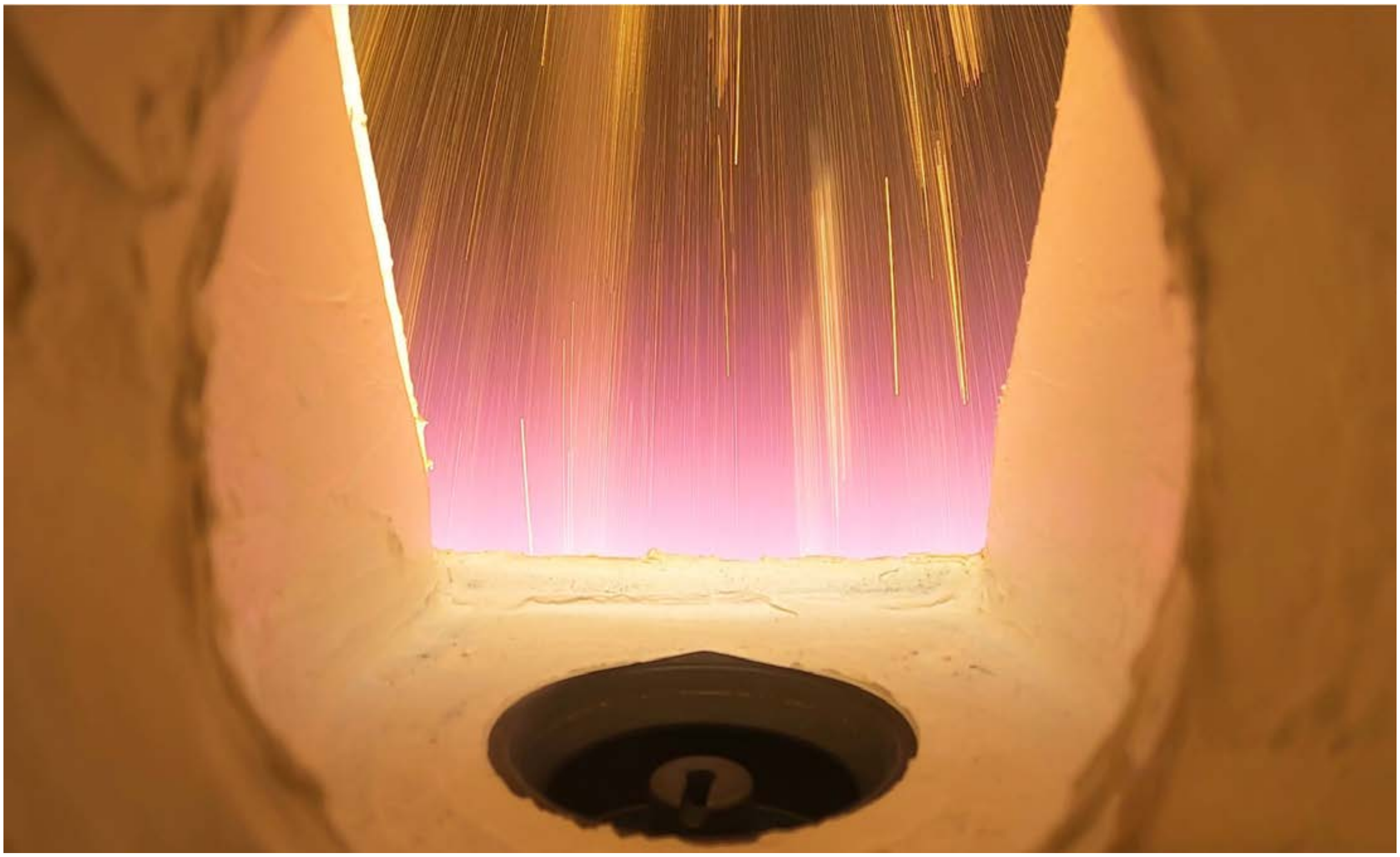
Over the first 18 months, they made hundreds of samples of carbon heat shield materials for tests of thermal conductivity, tensile strength and other thermal and mechanical properties as compared to model predictions. Starting in the second year of the project, hundreds of silicon-carbide samples were made, with testing for both sets of materials conducted in hypersonic shock tunnels and plasma torches.

"A model is only as good as the experiment or the validation that goes with it. So a big hurdle here was developing methods to understand how well our models are doing," Wagner says.

Putting the material to the test

Starting in 2023, plasma torch tests were conducted on 30-50 thermal material samples at the University of Texas at Austin, simulating the heat that builds up on the blunt leading edges of a missile at hypersonic velocities.

In those conditions, a shock wave is created in front of the nose, and the air between the wave and the missile decelerates from hypersonic to subsonic velocity, heating that air up to 5,700 degrees Celsius — roughly the same as the surface of the sun. That tears some of the nitrogen and oxygen molecules in the air into single atoms, and



the changing air chemistry interacting with the surface of the heat shield material can make the material erode more quickly.

"What we are simulating is the gas composition: What is superhot air actually composed of?" says Noel Clemens, an aerospace engineering professor at UT Austin. "That's what you see behind the shock."

For these tests, researchers wore goggles to protect their eyes from the blindingly white light of the vertical plasma torch plume and heated 30 millimeter-diameter samples of the thermal material, shaped like oversized pencil erasers. They pointed pulsing lasers into the plume, each tuned to induce photons of light from a specific type of atom. They then measured the increase in the brightness of light produced by those specific atoms.

The lasers helped to identify both the gases created by the extreme heating and the gases coming off the surface of the material as it interacted with the superheated air. They deployed another set of lasers to measure temperatures within the plume via a spectroscopy method.

Cameras pointed at the surface of the samples measured the rate of ablation. They also measured the weight, surface elevation and shape of each sample before and after the plume. "It might ablate more on the corners than it does on the central line, for example, just the way the flow accelerates around it," Clemens says.

To compare their model to actual hypersonic flight conditions, the researchers tested heat shield materials in 2024 and 2025 aboard two rockets launched under the Pentagon's Multi-Service Advanced Capability Hypersonics Test Bed program. Those samples weren't recovered, but data on temperatures, surface pressure, internal vibration and shear stress were collected.

During the first flight, an onboard spectrometer also measured gases flowing over the material. For the second flight, they attempted to measure gases produced by the ablating material with a laser-shining instrument. That device failed to communicate its data to the ground, but researchers plan to try again after the Varda flight, Wagner says.

Once the full-physics model was developed, the team trained the reduced-order model to use only the most mathematically relevant parts of the more detailed model to predict the temperature and amount of ablation for a given material with 90% accuracy.

"The reduced-order model team has to learn: What information do I need from the full-physics team to actually get our model to work? And how little can I actually get away with and still retain accuracy?" Wagner says.

Today, Sandia uses the model for customer work, but Wagner says he would like to make it accessible to other researchers. "Potential future work is to make some of the capabilities that we've developed here more universally available," he says. "There's still some work to be done to make things more deployable." ★

▲ An onboard camera recorded the 2024 reentry of Varda's W-1 capsule, the company's first.

Varda Space Industries

THE BIG QUESTION

What should be Jared Isaacman's top priority for NASA?

His time as NASA administrator promises to be an eventful one, from the race to land U.S. astronauts on the moon before China; preparing for the transition from the International Space Station to privately owned and operated stations; and the ongoing shift from traditional contracting to a shared-cost model with the increasingly capable commercial sector. He must also navigate this against the backdrop of a polarized political environment and volatile geopolitical landscape.

In the early days of Isaacman's tenure, I reached out to lawmakers, a former NASA center director and representatives of industry groups for their views about his priorities. — *Jon Kelvey*

Sen. Maria Cantwell (D-Wash.)

Ranking member of the Senate Committee on Commerce, Science, & Transportation.

Administrator Isaacman needs to prioritize three big technology transformations because NASA is the ultimate science agency that will enable America to inhabit and benefit from the space frontier.

First, NASA must return to the moon by 2028 ahead of China. A sustainable lunar presence is not about landing astronauts once; it is about building the infrastructure, systems and partnerships that will allow humanity to thrive beyond Earth. The moon is where we perfect the technology and establish the operating cadence that makes deep-space exploration possible. This includes life support, surface power, communications, navigation systems and lander vehicles that are robust and resilient enough to withstand the moon's two-week-long night, craters and other low-lying areas that experience almost permanent darkness. These areas are the proving ground that prepares us for the next big frontiers, including Mars.

Second, we must promote the space economy while protecting services critical for public safety and national security. More than half of all satellites launched into space were launched in the last five years. This provides new opportunities for communications, including high-speed broadband from space, as well as new challenges, including potential interference to essential systems for national security, weather forecasting, and aviation.

NASA must continue to shape the design standards and operating procedures needed to maintain safety and security in orbit, including protecting against collisions and orbital debris, avoiding radiofrequency spectrum interference with defense and weather forecasting satellites and ensuring astronomy can continue to unlock the wonders of our universe. This means continued investment in NASA's science portfolio that drives innovations integral to future economic growth in the United States.

Third, Mr. Isaacman must ensure America continues to lead on aerospace manufacturing. Building lunar and deep-space systems at scale means also supporting America's advanced manufacturing base and, specifically, perfecting advanced materials technology such as thermoplastic composites, and enabling the manufacturing of large-scale components for both commercial and military aircraft, space vehicles and structures. Thermoplastic composites are vital to reducing the structural weight of air vehicles by 20% to 50%, significantly improving fuel efficiency and performance, and can speed production volume.

For commercial aircraft, America will be able to capture more of the market for 40,000-plus aircraft over the next two decades. For space systems, thermoplastics mean building large structures with fewer joints and connections, potentially simplifying processes and certification requirements. These ambitious goals depend on advances in production capacity, resilient supply chains and continued training and education for the workers that make mission success possible.

The state of Washington shows how to do this. Washington has been supplying critical systems to NASA since the dawn of the space age, and 42 of our companies are Artemis suppliers. NASA selected Blue Origin in Kent to provide a human lunar lander for the Artemis program, and Washington now produces more than half of the satellites in low-Earth orbit. And my state is home of the Spokane Aerospace Tech Hub, aiming to meet the demand for advanced composite aerostructures to benefit NASA and commercial and defense aerospace markets.

Administrator Isaacman must drive these transformations. He can, and must, position NASA to lead not only in exploration, but in the scientific discovery and technology development that feeds the space economy and keeps the United States at the forefront of aerospace leadership for decades to come.

"He can, and must, position NASA to lead not only in exploration, but in the scientific discovery and technology development that feeds the space economy and keeps the United States at the forefront of aerospace leadership for decades to come."

Dave Cavossa

President of the Commercial Space Federation, a trade association representing 80-plus commercial space companies, air and spaceports, and universities.

NASA's biggest challenges over the next three years are within the human spaceflight programs. At the Commercial Space Federation, we believe that with his outside perspective, Administrator Isaacman is the right person, at the right time, to guide NASA through this period of change. We are urging the agency to face these challenges by seizing on new opportunities created by the increasing capabilities of commercial space operators.

First, with the ISS slated for retirement in 2030, how will NASA ensure the U.S. maintains a presence in LEO as the Chinese continue to build out their space station? Commercial companies are ready to compete for NASA's Commercial Low Earth Orbit Destinations [CLD] program; the industry needs to know what the plan is for when the agency will move forward with procurement activities for CLD.

And then there is Artemis. It's important, of course, to ensure the success of Artemis II and Artemis III, especially in the context of competing with China. But do we have the pieces in place to compete long term, to keep returning to the moon, to build moon bases and related infrastructure like lunar communications and surface power? China is not going to stop shooting for the moon just because we beat them there in 2028.

A sustainable presence on the moon requires multiple missions each year, not just touching the ground and coming back to Earth after a week. We'd like to see NASA begin including commercial capabilities in Artemis to build a truly robust program. Administrator Isaacman hinted at such during his confirmation hearing, and we hope he'll release an acquisition strategy that shows how NASA can leverage public-private partnerships to achieve the goals of Artemis. NASA will benefit from commercial capabilities and competition; however, the industry needs to understand what NASA's requirements will be for transporting humans to the moon.

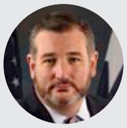
Putting these human spaceflight programs on a solid footing for the future will not be easy. Many of these programs stalled in 2025 as NASA waited for a permanent administrator, and three years goes by quickly when you're talking about government procurements. Add to that the fact that the agency lost 4,000 staff over the past year. But while it may not be possible to get every piece in place, Administrator Isaacman can put the agency on the right path by continuing to fully utilize ISS, starting the competition for CLD, and initiating agreements to broaden capabilities and programs needed for a sustainable lunar program.

Isaacman is uniquely suited for this task. We've seen how he used media and Netflix to publicize his own private space missions, effectively communicating to the American public why these missions are important. *[Netflix released a documentary about Inspiration4, the free-flying mission to LEO that Isaacman and three others conducted in 2021. —JK]* That can help ensure NASA continues receiving the resources it needs to succeed. And with his outsider perspective, we hope he can lead the agency to new, creative solutions, and help NASA show the world what a 21st-century civil space agency looks like.

"A sustainable presence on the moon requires multiple missions each year, not just touching the ground and coming back to Earth after a week. We'd like to see NASA begin including commercial capabilities in Artemis to build a truly robust program."

Sen. Ted Cruz, (R-Tex.)

Chairman of the Senate Committee on Commerce, Science, & Transportation.



NASA is at the forefront of American leadership in science and technology. It is critical to our national security amid what I have called the second "space race" that we prioritize beating China back to the moon.

Mr. Isaacman is taking the helm just as NASA is set to launch Artemis II — the agency's first crewed use of the Space Launch System rocket and the first crewed mission on the Orion spacecraft, which will bring American astronauts closer to the lunar surface than at any point since 1972.

I know Mr. Isaacman will be a strong leader who sees that Artemis II launches safely, successfully and without delay. He must then turn to Artemis IV, landing Americans on the moon before China, which is aiming to send its own taikonauts there by 2030. NASA cannot take its eye off the ball.

Fortunately, Congress has given clear direction and substantial funding to achieve this goal. In the Working Families Tax Cut Act *[The formal name of the sprawling tax and spending package that President Donald Trump signed into law last year. — JK]*, President Trump and a Republican Congress committed nearly $10 billion to specific parts of the space program, including the Space Launch System and future lunar missions Artemis IV and V; the Gateway space station at the moon; and the International Space Station. The vision for NASA enshrined in the Working Families Tax Cut Act is unambiguous, and it must be executed faithfully to beat China back to the moon and bolster U.S. leadership in space.

But investments in hardware alone won't guarantee mission success. Equally indispensable is NASA's workforce. Houston's Johnson Space Center is home to one of the most capable, experienced and mission-driven workforces in the world. JSC is home to our astronaut corps — America's spacefaring heroes — who represent the best of our nation. Preserving that talent is essential, and I trust that JSC will continue to thrive under Mr. Isaacman's leadership.

Mr. Isaacman will need to prioritize stability, accountability and respect for the men and women who make the agency's missions possible. As the commander of Inspiration4, the first all-civilian spaceflight, and the first private citizen to walk in space, he knows that every successful mission depends on the skills and dedication of its crew, as well as the countless professionals supporting them from the ground. He brings a unique perspective to NASA at a critical moment.

Mr. Isaacman is as committed as I am to American supremacy in the final frontier. He is laser focused on astronauts returning to the lunar surface and developing the capacity to reach Mars. The United States must remain the unquestioned leader in space exploration.

"Investments in hardware alone won't guarantee mission success. Equally indispensable is NASA's workforce. ... Mr. Isaacman will need to prioritize stability, accountability and respect for the men and women who make the agency's missions possible."

Casey Dreier

Chief of space policy at the Planetary Society, a nonprofit with a global community of some 2 million members advocating for funding NASA, planetary science and astronomy.

"His challenge, ultimately, is to act as a consensus builder within a political system that abhors consensus the way space does a vacuum. … Projects begun under highly partisan framing, or that consumed the budgets and activities of other popular programs, could face significant headwinds under future Congresses or presidents."

In his stewardship of NASA over the next three years, the most important priority for Administrator Jared Isaacman is ensuring the agency remains a bastion of nonpartisanship, to protect NASA as a unifying symbol, with its successes perceived as the successes of all Americans. That is not to say that Isaacman should ignore politics by any means, but to act as a bulwark against the ever increasing intrusions of partisanship into the nation's space program, whether from the left or right side of the political spectrum. His challenge, ultimately, is to act as a consensus builder within a political system that abhors consensus the way space does a vacuum.

But it's only by maintaining NASA as a unifying symbol that the agency can pursue grand missions of exploration that take years or decades to complete. Every initiative begun under his tenure will, by necessity, be implemented by a subsequent administration and NASA administrator. Projects begun under highly partisan framing, or that consumed the budgets and activities of other popular programs, could face significant headwinds under future Congresses or presidents. Managing NASA is like taking part in a relay race, but your team member will choose whether or not to accept the baton.

Artemis presents an excellent example. Started under the first Trump administration, Artemis was adopted wholesale by the subsequent Biden administration — the only lunar return effort in history to survive a presidential transition. This was not an accident. Artemis was intentionally designed to engage a broad coalition of partners. Then-NASA Administrator Jim Bridenstine and members of the National Space Council, among others, put in the legwork to secure buy-in from members of Congress in both parties. By ensuring that Artemis was perceived as a benefit for the nation, and not any one particular presidential administration, it could more easily survive the transition to the Biden administration. You could count the number of other major policies that made that political leap on one hand.

Science missions must endure similar political time scales. The Europa Clipper mission began under the Obama administration, was built and funded largely by the first Trump administration, and launched under the Biden administration. It will spend the entirety of the second Trump administration en route to Europa. Its mission begins in 2030 under the next president. There is no way to shortcut such missions given their complexity and extreme distance from Earth. They must be broadly popular and nonpartisan in nature.

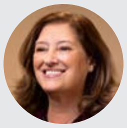
Space science is a major area of opportunity for long-lasting new initiatives. Multiple high-quality polls going back to 2018 repeatedly find that NASA's scientific activities commanded far broader public support than any other agency priority, with near-equal enthusiasm from Republicans and Democrats. This was made clear last year when large congressional majorities outright rejected the extinction-level cuts proposed for NASA science (cuts announced before Isaacman was administrator). Programs with such broad, bipartisan support are what carry NASA across administrations and Congresses.

Every NASA administrator is a steward of the most respected and legendary brand that the United States has, a reputation that extends around the world. This reputation took decades to build. It is easy to take it for granted. I do not think for a minute that Isaacman is someone who takes this for granted. Everything we have seen so far shows that he understands how important NASA is as an idea. But none of us gets to choose the moment in which we live, and his is one that demands a steady hand. Such will be Isaacman's challenge in the years ahead.

"This moment calls for a deliberate reinvention of NASA's operating model — one that systematically enables what commercial, academic and nonprofit partners can contribute to accelerate discovery and exploration at lower cost to the taxpayer."

Laurie Leshin

Professor of space futures at Arizona State University and former director of NASA's Jet Propulsion Laboratory.



To use a term the administrator favors, Jared Isaacman's top priority should be to make NASA a true "force multiplier" for science, exploration and humanity's future as an interplanetary species. His task is to position NASA to fully unleash the broader space ecosystem — enabling partners to move faster, bring capital and creativity, take appropriate risks and deliver innovations that unlock human potential, transformative discovery and enduring American leadership.

Based on many years of NASA leadership experience, I know how easy it is to become consumed by the urgent. Operational challenges demand immediate attention, and addressing them can be both necessary and exhilarating. Beginning a tenure with an ISS medical emergency *[The early return of Crew-11 in January — JK]* and preparing for Artemis II makes this pull unavoidable. Yet, I would urge Jared to trust the teams who have spent years preparing for these moments and instead devote the majority of his time to decisions with decades-long consequences — those that shape what NASA becomes, not just what it manages.

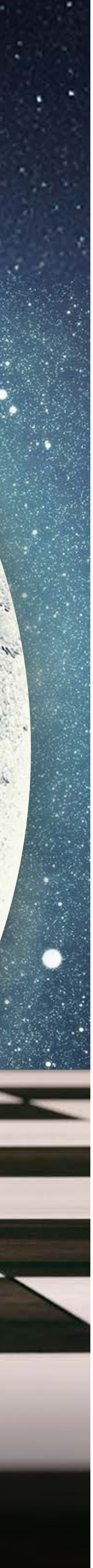
The nation's space enterprise stands at an inflection point. Capabilities now exist that were unimaginable just a few decades ago, along with both successful and less successful efforts to integrate them. This moment calls for a deliberate reinvention of NASA's operating model — one that systematically enables what commercial, academic and nonprofit partners can contribute to accelerate discovery and exploration at lower cost to the taxpayer.

There are proven examples to build upon. The Human Landing System model — where NASA funds partners to deliver essential services while also resourcing NASA expertise to help navigate inevitable challenges — offers a template worth expanding. Had similar structures existed for CLPS, early mission outcomes might have been stronger. *[Of the four commercial lunar landers funded and launched to date under NASA's Commercial Lunar Payload Services program, only one landed upright and operated for the duration of its planned mission. — JK]* Just as importantly, such models engage the full agency, not only headquarters, in supporting new partnership approaches.

NASA's science programs should undergo a similar evolution. NASA should fly many more small, focused missions — like SPARCS [Star-Planet Activity Research CubeSat] and Pandora — leveraging experienced universities, innovative companies, and low-cost launch, while allowing these efforts to succeed without excessive oversight. *[These small satellites were launched in January to study low-mass stars and exoplanet atmospheres. — JK]* Expanding this model would accelerate discovery, train the next-generation workforce, and broaden participation. Increased commitment to data buys would further stimulate private investment while advancing NASA's scientific objectives.

The difficult year NASA has just endured could lead the agency to retreat into caution and bureaucracy. Instead, Jared should seize this moment to remake NASA into a bold, disciplined force multiplier for exploration and discovery. Only by doing so will the agency fully enable humanity's reach beyond Earth — and truly help us reach for the stars. ★

The new space race



The U.S. is once again trying to beat another nation to landing astronauts on the moon, and NASA officials and U.S. lawmakers say the stakes are even higher than they were in the 1960s. Leonard David and Cat Hofacker explore the implications of this 21st century space race.

BY LEONARD DAVID AND CAT HOFACKER | newsspace@aol.com and catherineh@aiaa.org

When NASA Administrator Jared Isaacman took the stage at a Northern Virginia conference in mid-February, the agency was preparing for a second fueling test of the Space Launch System (SLS) moon rocket, in hopes of launching as soon as March.

But that day, much of Isaacman's remarks revolved around the progress of "our great rival," China, which was preparing for a crucial flight test of its own Long March 10 moon rocket and crew capsule.

"We are in a new space race" to the lunar surface, "and if we fall behind, we may never catch up," Isaacman said. "If we wake up and we see our rival's taikonauts on the moon before we're able to return, the blow to American exceptionalism will be so damaging, the shock wave will be felt around the world."

There have been many twists and turns since the first Trump administration announced NASA would return U.S. astronauts to the lunar surface in 2024 as a precursor to establishing a surface base. The latest shake-up came in late February, when NASA inserted a new mission into the sequence: a 2027 Earth-orbit demonstration of how the Orion crew capsule would dock with one or both of the commercial lunar landers in development — a crucial maneuver if the agency is to achieve up to two lunar surface landings in 2028 and establish a base by 2030.

The schedule for those landings — now Artemis IV and V, respectively — partly hinges on the outcome of the Artemis II lunar flyby, which as of mid-March was targeted for liftoff on April 1. The 10-day mission is to send four astronauts around the moon, demonstrating many of the technologies and techniques required for the early surface missions.

"We do not have a lot of schedule margin here," Isaacman told reporters at a press conference about the new sequence. He was referring to China's plan to conduct a crewed landing of its own by 2030. Since announcing that objective in 2023, the China Manned Space Agency (CMSA) and its state-owned contractors have made steady progress on hardware development and testing, which has drawn the attention of the White House and U.S. lawmakers.

Chief among them is Sen. Ted Cruz (R-Tex.), chairman of the Senate Committee on Commerce, Science, & Transportation, which held a September hearing on the matter.

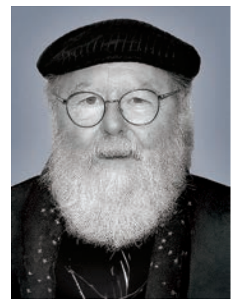
"This is a pivotal moment for our nation's space programs," Cruz said in his opening remarks. "America must maintain leadership in low-Earth orbit, while also embarking on a new era of exploration with Artemis. Make no mistake: we are in a new space race with China."

The chief concern is that whichever nation is the first to land astronauts on the moon this century will be viewed as the global leader in space — and possibly on Earth.

"This is not just about exploration. The choices we make now will determine whether the United States leads in space or cedes it to an authoritarian regime," Cruz said.

China's ambitions

In the February test Isaacman referenced, a prototype Long March 10 rocket carried an unoccupied test article of the Mengzhou crewed spacecraft topped by an escape tower system. Shortly after liftoff, the tower's engines ignited as planned and carried the spacecraft away from the rocket, simulating a scenario where the rocket failed after launch and the crew needed to be whisked to safety. The rocket's first stage and the spacecraft's return capsule splashed down in a designated sea area, according to a government statement.



Leonard David has reported on the space industry for more than five decades. He is the author of several books, including "Mission to Mars — My Vision for Space Exploration," co-authored with Apollo 11's Buzz Aldrin.

Cat Hofacker became associate editor in 2021 after two years as our staff reporter, covering the Boeing 737 MAX crashes and inception of NASA's Artemis moon program.

▲ China in February conducted a "low-altitude demonstration flight" with a Long March 10 prototype, the first flight test of the moon rocket.

China Manned Space Agency

The test built on previous ones conducted throughout 2025, a particularly active year for China's moon effort, known as the Chinese Lunar Exploration Program, or CLEP. This multipronged program encompasses lunar orbiters, stationary landers, rovers and sample return spacecraft, as well as the nation's projected human lunar lander initiative, all using the Long March series of rockets.

Requests for comment to CMSA went unanswered, so this story draws on public documents and reports by state media.

In an October press conference broadcast on China Central Television and reported by state-run news services, CMSA officials said development of the crewed lunar mission was proceeding smoothly.

"The scientific research and application systems have finished payload design for all planned flights, while the development and the construction of ground facilities, including launch sites, telemetry, tracking and command networks and landing-recovery systems, are being accelerated," said Zhang Jingbo, a CMSA spokesman.

CMSA completed Long March 10 static fire testing in September, igniting the test article's cluster of engines at the Wenchang Spacecraft Launch Site in the southern island province of Hainan.

Testing is also underway of the Lanyue lander, Wangyu spacesuit and a two-person Tansuo moon buggy — and CMSA has "completed the major tasks of the prototype phase," Zhang said.

At a high level, China's architecture is very similar to the one NASA created for Artemis, in which the crew and their lander are launched aboard two separate rockets. Two successive Long March 10s would lift off, one carrying the astronauts in their Mengzhou spacecraft, the other hoisting the lander.

The two vehicles would rendezvous in lunar orbit, so the crew can transfer to the lander for the descent to the surface. After the moonwalkers complete their duties, they would take Lanyue back into lunar orbit, joining up with and moving into Mengzhou for the journey back to Earth.

Beyond the initial 2030 landing, China is also laying the groundwork for a sustained lunar surface presence. At the center of those efforts is the International Lunar Research Station (ILRS), a two-phase moon base the China National Space Administration is developing with Russia's space agency, Roscosmos.

Wu Weiren, CLEP chief designer, said in a 2025 interview with the state-run China Central Television that the ILRS encampment will benefit from two upcoming robotic lunar landings: Chang'e-7 in late 2026, tasked with completing environment and resource surveys in the lunar south pole region, and Chang'e-8 in 2028, which is to tackle on-the-spot utilization of lunar resources.

The first phase of the ILRS project calls for a "basic station" to be constructed by 2035 in the lunar south pole region, Wu said, with an expanded facility scheduled to be completed by 2045. This phase also entails establishing a moon-orbiting space station to carry out lunar studies and perform experiments and projects that will help prepare for a future human landing on Mars, Wu said.

Dean Cheng, a nonresident scholar with the George Washington University's Space Policy Institute, said China seeks to establish what it calls an "Earth-moon space economic zone."

References to this aspiration date back almost a decade, to 2018 remarks by Bao Weimin of the China Aerospace Science and Technology Corp., the main contractor for China's national space program. Bao said early studies estimated that by 2046, the total annual output value of this economic zone would be at least $10 trillion.

In Cheng's view, China's steady progress and the start of ILRS development show the country is serious about its long-term moon plans. "Space is not just about science, not just about exploration, but space is also about politics," Cheng says. If China is the driving force behind a lunar economy, it will be able to influence standards, including those for positioning, navigation and timing data, "to make sure that Chinese is a language, if not the language, of space."

Although the technology approaches are similar, one big difference between the U.S. and Chinese programs is the level of government support. Consider the Apollo years, when Congress increased Saturn V funding from $8 million (in 2020 dollars) in fiscal 1961 to $11.6 billion (in 2020 dollars) in fiscal 1966. By contrast, the annual budget for SLS increased from $1.8 billion in fiscal 2011 to $2 billion in fiscal 2016.

China's commercial space program is much younger,

Taking stock of the architectures

China and the U.S. have embraced nearly identical plans for landing astronauts on the lunar surface later this decade.

PHOTO SOURCES:

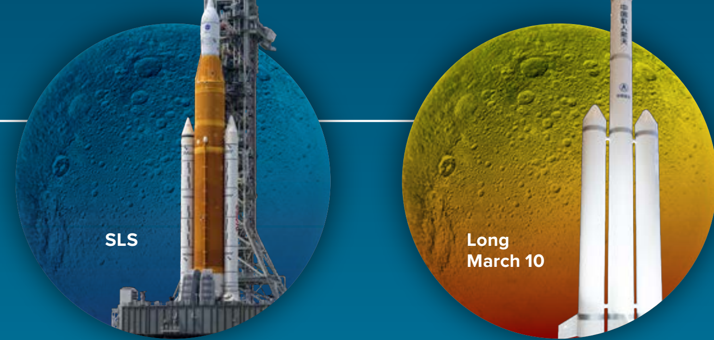
Axiom Space, Blue Origin, CCTV, CMSA, NASA, SpaceX

ARTEMIS | **CLEP**

Rocket

Multiple launches are required, one for the crew and at least one for the lander.

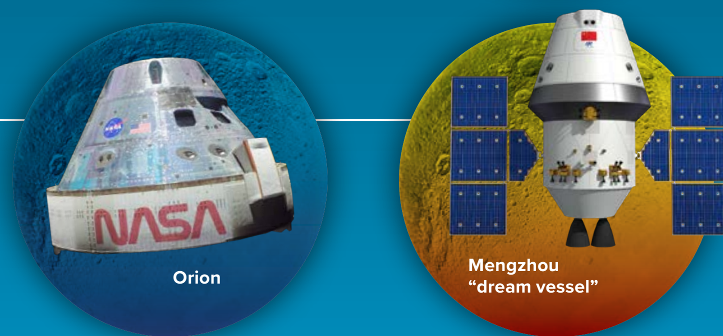
For Artemis, the lander will be launched aboard a commercial rocket.



Crew Capsule

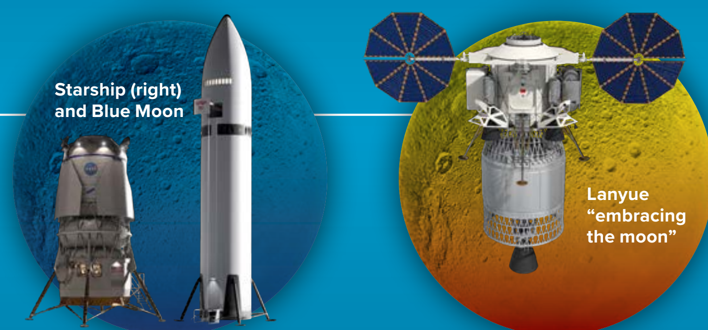
Once in lunar orbit, these spacecraft would rendezvous and dock with the lander.

NASA aims to demonstrate this maneuver next year in low-Earth orbit.



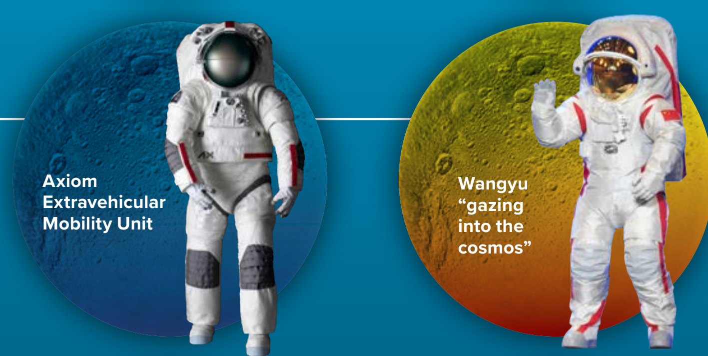
Lunar Lander

For Artemis, NASA has contracted SpaceX for the Artemis IV lander and Blue Origin for Artemis V.



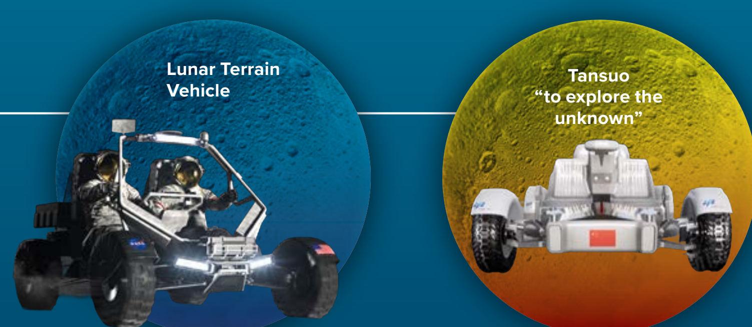
Spacesuits

The crew will don these for surface excursions.



Lunar Buggy

These vehicles would enable astronauts to traverse longer distances on subsequent missions.



Inside the Artemis II delays

NASA originally hoped to commence its crewed lunar flyby as soon as Feb. 8, but a series of technical issues with the SLS rocket have pushed that launch to no earlier than April 1.

The first arose during a Feb. 2 trial run of launch day preparations. While fueling up the rocket, NASA detected hydrogen leaks in the tail service mast umbilical that runs from the base of the mobile launch platform to the main tank in the SLS core stage. Similar leaks arose during prelaunch rehearsals and actual launch attempts of the 2022 Artemis I uncrewed demonstration, delaying liftoff for months.

For Artemis II, NASA replaced the hydrogen seals and conducted a second wet dress rehearsal Feb. 19, during which there was "really no leakage to speak of," Charlie Blackwell-Thompson, Artemis launch director, told reporters. Officials were confident in the odds of an early March launch, but those hopes were scuttled hours later when teams reported issues with flowing helium to the engine of the SLS upper stage — something that could not be addressed on the launchpad.

SLS was rolled back to the Vehicle Assembly Building at NASA Kennedy, and engineers replaced a seal that appeared to rectify the problem. *— Cat Hofacker*

The rocket and crew capsule for Artemis II, pictured in late January at Launch Pad 39B in Florida.

ULA

but government investment has skyrocketed over the last decade, according to a report, titled "Redshift," released in September by the Commercial Space Federation. Since 2014, the country has invested a cumulative $85 to $95 billion in military and civil space technologies, "with [a] year-on-year trend upward from $4.9 billion in 2016 to nearly $20 billion in 2024," the report reads.

"Given this impressive, sustained commitment, NASA should certainly count on Chinese astronauts getting to the lunar surface by 2030, and perhaps as early as 2028," says Thomas Jones, a former NASA astronaut who completed a trio of spacewalks across four space shuttle missions.

NASA's next steps

Since becoming administrator, Isaacman has emphasized his intent for the Artemis architecture to eventually "evolve" after the initial landings to incorporate more commercial rockets. But at least for Artemis IV and V, the plan hinges on an SLS lofting the astronauts in an Orion crew capsule to orbit, a process that was first tested to a degree in the 2022 uncrewed Artemis I demonstration. Artemis II is to build on that by testing Orion's life-support systems, among other technologies.

In the original mission sequence, Artemis III was to be the inaugural landing, and also the first time an Orion capsule would rendezvous and dock with the chosen lander, a SpaceX Starship. NASA awarded the company $4.5 billion in contracts to supply landers for the first two landings, which at the time were Artemis III and IV.

But last year, U.S. lawmakers and NASA's interim leadership began expressing concerns that Starship would not be ready in time and relies on techniques that remain unproven.

Chief among them is on-orbit refueling. SpaceX's architecture calls for stationing a propellant depot in Earth orbit, which requires at least 10 tanker launches to fill up the depot with liquid methane and liquid oxygen. Each Starship lander must lift off atop a Super Heavy booster, then dock with this depot to fuel up before heading to lunar orbit. Multiple refueling launches were also required for Blue Origin's architecture, which has a $3.4 billion contract to supply the Artemis V lander.

NASA late last year asked both companies to submit revised architectures for simplified landers that could be ready by 2028. In January, Isaacman told reporters he'd met with both providers about these plans.

"They both reduce technical risk from where we were before, so that's good," he said. "But in the end, it's going to come down to launching vehicles very frequently to learn."

He added: "If we are on track, we should be watching an awful lot of New Glenns and Starships launch in the years ahead."

SpaceX is targeting later this year to demonstrate "ship-to-ship propellant transfer," the company said in an October website post. And in January, Blue Origin announced it would pause flights of its New Shepard suborbital rockets "and shift resources to further accelerate development of the company's human lunar capabilities." The companies did not respond to requests for additional comment.

There's reason to believe China could move up its own lunar landing, says Clayton Swope of the Center for Strategic and International Studies, based on how the country has accelerated other programs. He pointed to the launch date of the Tianwen-3 Mars sample return mission, which China moved from 2030 to 2028.

"We should watch for clues that China might be doing the same for its crewed moon landing," Swope says. "But there is a lot that can happen in four years."

▲ Artemis II payload specialist Christina Koch (left) and pilot Victor Glover during an August dress rehearsal. The 10-day mission around the moon will send Koch, Glover and their two crewmates farther from Earth than humans have ever traveled.

NASA/Kim Shiflett

The long view

In NASA's view, the updated Artemis sequence is a more certain path to a landing by 2028 and establishing a surface base by 2030: "Updating our architecture now demonstrates NASA's and President Trump's commitment to achieving the national space policy objectives," an agency spokeswoman told Aerospace America. "With an increased cadence of lunar missions, NASA will maintain U.S. superiority in space exploration, including ensuring America's timely return to the surface of the Moon ahead of China — this time, to stay."

The experts interviewed for this piece were divided about the implications of a Chinese landing before a U.S. one. To Marcia Smith, a space policy analyst and founder of SpacePolicyOnline.com, the increasingly loud drumbeat in political circles of "beat China" is dismaying.

"Whining about China is just a distraction," she says. "If China canceled their program, would we stop Artemis? The U.S. will always be the first country to land on the moon. We don't need to do it again."

In a similar vein, NASA's schedule and objectives have limited bearing on China's plans, notes Swope.

"No matter what the United States was doing with Artemis, China would still be going to the moon," he says. "No doubt that China would be happy to have that trophy and do it before Artemis returns U.S. astronauts to the lunar surface."

Others cast this "space race 2.0" in starker terms: not just a race to the moon, but as a demonstration of technical prowess.

If China lands astronauts first, "they'll use this lunar triumph to tout their communist system's effectiveness, but also that of their military and aviation technology exports," says Jones, the former astronaut. "The U.S. will have to work hard and fast to dig out of that geopolitical hole."

U.S. Rep. Brian Babin (R-Tex.) put forth a similar argument in late February, during a keynote address at AIAA's ASCENDxTexas conference.

"Leadership in space is not symbolic," said Babin, who chairs the House Committee on Science, Space, and Technology. "It shapes standards, partnerships and long-term strategic influence."

He added: "This moment is not just about returning to the moon, folks. It's about defining the next era of human exploration."

In that sense, the stakes are higher than those of the 1960s race between the U.S. and Soviet Union, says Jonathan Roll of Arizona State University's NewSpace Initiative. He is the lead researcher and co-author of the Commercial Space Federation's "Redshift" report, which concluded the U.S. could lose its dominant strategic position in space to China.

"This is not really a race" between two nations, Roll says. "This is a perpetual competition of technological advancement. And that means it's going to be multi-generational to have continuity with different groups being interested in advancing technologies faster."

Metaphorically, he describes the U.S. as the driver of a car who sees a small speck in the rearview mirror, barely visible on the horizon, but coming up fast.

"China is accelerating. They have shifted gears," he says. "America still has the toolkit to also shift into another gear. Otherwise, they are going to blow by us." ★

ROCKET LAB'S NEXT STEP

Neutron illustration. Rocket Lab

The company is positioning its reusable Neutron medium-lift rocket as an alternative to SpaceX's Falcon 9, particularly for the coming wave of satellite constellations. Jonathan O'Callaghan examines how Neutron stacks up and the road to launch.

BY JONATHAN O'CALLAGHAN
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Rocket Lab's Neutron does not look like other rockets — short and squat with a wide base, plus a nose cone that unhinges like a Hungry Hungry Hippo and looks like it could have been plucked from a James Bond movie.

Yet the California-based launch provider chose all of these features with a clear purpose in mind: deploying the many satellites required for the vast constellations taking shape around Earth to provide internet, imaging and other services.

"We didn't really have to stew too much about the configuration," says Adam Spice, Rocket Lab's chief financial officer, of when executives began envisioning Neutron a decade ago. "We were going toward where the market was going to be."

Most of the satellites launched since 2019 have been aboard SpaceX Falcon 9s for the company's Starlink broadband constellation — which currently numbers more than 10,000 — but governments and companies around the world are proceeding with plans to establish their own networks in the coming years.

Rocket Lab tailored Neutron, now scheduled to debut at the end of 2026, for such launches. Its "Hungry Hippo" fairing is wide enough to accommodate the large, flat buses popular among megaconstellation builders in particular, with rails to deploy many at a time, like a stack of pancakes.

The rocket's shape is also meant to lend itself to another key goal: reusability. A booster with a wider base creates more drag during its plunge back through the atmosphere in preparation for a vertical landing, as Rocket Lab plans to do for nearly every launch. To date, only SpaceX and Blue Origin have achieved that feat.

"Our goal is to get to orbit on the first attempt," says Shaun D'Mello, Rocket Lab's vice president for Neutron. For that debut flight, he says, teams "won't have a landing platform in position, but we intend to exercise a glide of the rocket and then attempt to reignite the engines for a soft water landing."

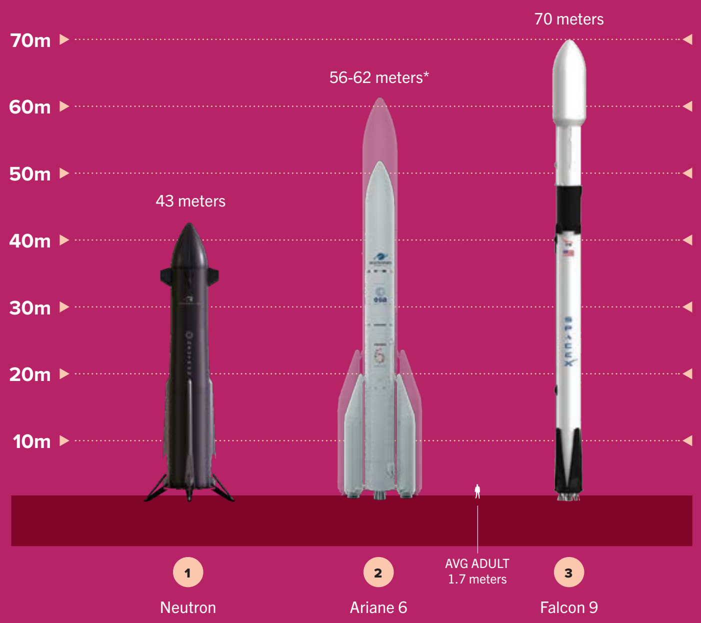
Rocket Lab is positioning Neutron as an alternative to the Falcon 9, which launched a whopping 165 times in 2025 — six times more than all the other U.S. providers combined. But can Neutron challenge such a dominant force?

"Neutron is competing with arguably the most successful launch vehicle ever," says Carissa Christensen, founder and CEO of BryceTech, the Virginia space analysis firm. "It's going to have to find some definitive niches to settle into."

Rocket Lab has already announced half a dozen contracts. These include a multi-launch contract for an

▲ Each Neutron first stage will be powered by nine Archimedes engines, one of which is shown here during a 2025 hot fire test.

Rocket Lab



Assessing the market

Rocket Lab has been vocal about considering SpaceX its top competitor, but, based on the numbers, its Neutron rocket is comparable to at least one other launcher.

* Depending on fairing size

	PROPELLANT	FAIRING DIAMETER	PAYLOAD CAPACITY (LEO)	REUSABILITY	FIRST FLIGHT
1 **Neutron**	Liquid methane and liquid oxygen	5 meters	13,000 kg	Booster and payload fairing	2026 (planned)
2 **Ariane 6**	Liquid hydrogen and liquid oxygen	5.4 meters	10,300 kg (Ariane 62 variant) or 21,650 kg (Ariane 64)	None	2024
3 **Falcon 9**	Rocket-grade kerosene and liquid oxygen	5.2 meters	17,500 kg (reusable mode) or 22,800 kg (expendable)	Booster and payload fairing	2010

unnamed commercial satellite constellation and an agreement with U.S. Transportation Command to use Neutron to ferry cargo around the world. Rocket Lab hasn't shared dollar amounts for most of the contracts, but the most lucrative customer could be the U.S. Space Force, which last year added Neutron to the pool of vehicles eligible to compete for a subset of national security launches — valued at a combined $5.6 billion.

An open market

Founded by New Zealand entrepreneur Peter Beck in 2006, Rocket Lab is now the leading player in the small-launch market. Its Electron rockets have flown 83 times as of mid-March, mostly from the Mahia Peninsula in New Zealand, but also twice from Wallops Island off the coast of Virginia in the U.S.

At 18 meters tall, Electron is about one-fourth the height of Falcon 9. It's also expendable, the first stage dropping into the ocean once it's propelled its payload to orbit. In the past few years, however, Rocket Lab has begun to toy with reusability, recovering some Electron boosters from the ocean and even catching one midair via helicopter in 2022.

Neutron marks a step forward for the company. At twice the height of Electron, Neutron was designed to lift 13,000 kilograms to orbit — far more than Electron's 300 kg and close to Falcon 9's maximum of 23,000 kg. That puts it in the medium-lift category, comparable to the variant of Europe's Ariane 6 that flies with two solid rocket boosters.

"There is a gap in the U.S. market for a medium-class vehicle right now," says Caleb Henry, director of research at analysis firm Quilty Space, after United Launch Alliance retired its Delta II in 2018.

Based on the numbers, Ariane 6 is the launcher "Neutron will most closely compete with," says Henry. The design has flown six times since its 2024 debut.

However, Ariane was not designed for reusability as Neutron was. "We set a very ambitious goal to make sure there's nothing on the rocket that takes more than 24 hours to recycle," says D'Mello.

SpaceX's record for reusing a Falcon booster is nine days, though the company is averaging well under 30 days, Spice notes. "Ultimately, there's no reason why Neutron can't get there as well."

He's also confident Rocket Lab's design strategy will allow it to achieve a booster landing much earlier than SpaceX, which recovered its first Falcon booster five years after the design's inaugural flight.

SpaceX did not respond to a request for comment on competition with Neutron.

Designing for reusability

The desire to land and refly influenced various aspects of Neutron's design. First, the fuel. The first stage will be powered by nine of the company's new Archimedes engines, fed by a mixture of liquid oxygen and methane.

That combination burns cleaner than fuels like kerosene, leaving less soot on the vehicle to clean after each flight and potentially reducing the time it takes to refurbish each rocket, says Chad Anderson, founder and managing partner of the venture capital firm Space Capital, an investor in Rocket Lab.

"It's becoming standard industry knowledge that that is a better way to build a reusable rocket," says Anderson. Blue Origin, for instance, selected liquified natural gas for the first stage of its New Glenn with a similar goal in mind. That design is firmly in the heavy-lift class, with a 7-meter-diameter payload fairing and lifting capability of 45,000 kg to low-Earth orbit.

Then there's the overall configuration. Like most rockets, Neutron has two stages, but they aren't stacked on top of each other. Instead, the first stage comprises the entire outer body. The second stage is completely enveloped within the first stage and would be released in orbit once the payload fairing opens.

Neutron is to fly at a steeper trajectory than other rockets so it can release that second stage at a higher altitude, where it will encounter less drag. Once deployment is complete, the rocket will descend back through the atmosphere. Neutron's 7 meter-diameter-base — twice as wide as Falcon 9's — should create more aerodynamic drag and slow the rocket's rate of descent.

That means Neutron only needs to fire its engines once to make it back to Earth, just before landing. "We don't need to burn through reentry," says D'Mello. "Having a big diameter allows us to skip that part of the mission and glide all the way back."

For the landing, Neutron has wing-like aerodynamic surfaces on top, rather than the grate-like grid fins that Falcon deploys, to guide it down to a floating barge in the ocean.

For those landings, "the only burn that takes place is just before touchdown," says D'Mello, using three of the rocket's engines. For the ground landings Rocket Lab hopes to achieve in the future, an additional boost-back burn will be required.

Then there's the Hungry Hippo fairing from which the second stage and any payloads will exit. In a first for a rocket, this fairing won't detach. Instead, it will open like the jaws of a Hungry Hungry Hippo — a reference to the popular children's game that inspired its name. The move is also reminiscent of the rocket in the 1967 James Bond film, "You Only Live Twice."

Rocket Lab believes fairing recovery is an important cost-saving measure. Falcon 9 fairings, for instance, reportedly cost $6 million each. SpaceX took years to perfect its technique of gliding fairings via parachute onto floating barges.

▲ After deploying its payload on orbit (shown in the top illustration), Neutron is to return to Earth for a vertical landing on the ground or a barge.

Rocket Lab

"One of the things we looked at is: Can we have the fairing stay attached to the first stage?" says D'Mello. "We did the math and it was in theory possible."

No one has done this before because "it frankly didn't matter until reuse," says Henry. "If the whole rocket is expendable, who cares if the fairing comes off? We're in the early learning curve stages of an industry that is just barely starting to normalize reuse."

That desire also prompted Rocket Lab to construct the fairing and Neutron's primary structure out of carbon fiber, a much lighter material than the aluminium or stainless steel used on Falcon and the majority of other rockets.

"If we used another material, it would make virtually no sense to carry a fairing to space and bring it back," says D'Mello. "The idea behind Hungry Hippo is to reduce the number of operations to get hardware back. Your plane lands with the doors on it. It's the same sort of architecture here."

The company is betting on this reusability yielding cost savings, so has set Neutron launches at $55 million. In comparison, SpaceX in February raised the price of the

Inside the launch delays

When a first-stage propellant tank ruptured on the test stand in late January, it also ruptured hopes of Neutron making its inaugural flight early this year.

The tank was undergoing a hydrostatic pressure test, in which it was filled with water and pressurized to levels much greater than it would experience during flight.

"It came down to a manufacturing defect," says Shaun D'Mello, Rocket Lab's vice president for Neutron. "We were pushing it beyond its maximum flight mode to see how much margin it had, but it failed before we expected it to fail. That's something we want to go and rectify."

Future tanks were already planned to incorporate a different manufacturing technique, which Rocket Lab is confident will eliminate the defect, executives said during a February earnings call. Neutron's debut is now slated for sometime between October and December.

"Once completed, the new tank will undergo an extensive test and qualification campaign to verify flight readiness, and we're going to take our time with that process," CEO Peter Beck said on the call. "The priority will always be to bring a reliable rocket to market, even if it means taking a few extra months."

more capable Falcon 9 from $70 million to $74 million.

"SpaceX has set the bar for affordable launch," says Henry. "If you are not at least in the vicinity of that launch price, it's very hard to compete with them."

Several of the analysts I spoke to believe that prices could decrease in the future if Neutron can be a true competitor to Falcon 9 or Ariane, requiring the other launch providers to lower costs to attract customers.

"I'm incredibly happy that there's competition coming online," says Anderson. "There has been a lack of competition for a long time. If you want cost savings to be passed along to customers, you need competition."

Mind on megaconstellations

The other driving force for Neutron's design was ensuring it could deploy dozens of satellites at once, as many of the constellation operators desire so they can quickly build out their networks.

Neutron's wide width is intended to accommodate stacks of flat satellites, similar to the flat panels of SpaceX's Starlink. And to ease deployment, there's a guided rail mechanism, with four pneumatic cylinders to push out the satellites.

"The whole second stage is suspended inside this Hungry Hippo fairing," says D'Mello. "When the fairing is open, like cargo doors on a plane, the second stage is deployed."

Henry sees the constellation market as particularly lucrative. "We're seeing more constellations come online or demand launch," he says.

These include multiple private and government efforts in the U.S. and U.K., including Europe's planned constellation of 300 IRIS^2 satellites. The U.S. Space Development Agency also plans a 500-satellite constellation.

"Everywhere you look, you see more demand for constellations," says Henry.

Rocket Lab even has plans for its own constellation, but executives are tight-lipped about what purpose that might serve. "We're holding our cards close to our chest on that one," says Spice, although he indicated the plan is not to compete with Starlink in deploying such a large broadband network.

"It's very likely what Rocket Lab goes after is something that's much more achievable when you don't have the world's richest man's capital behind you," he adds, referring to SpaceX founder Elon Musk.

Outside of megaconstellations, Anderson expects Neutron to have plenty of customers.

"There's clearly a ton of demand" with Falcon 9 "booked out years in advance," he says. "The market desperately needs additional capacity."

There are potentially broader ambitions for the design, as well. Beck has spoken about it one day launching humans to low-Earth orbit — possibly to one of the several commercial space stations in development. Neutron is also capable of launching 1,500 kg worth of satellites to the moon or Mars, according to the company.

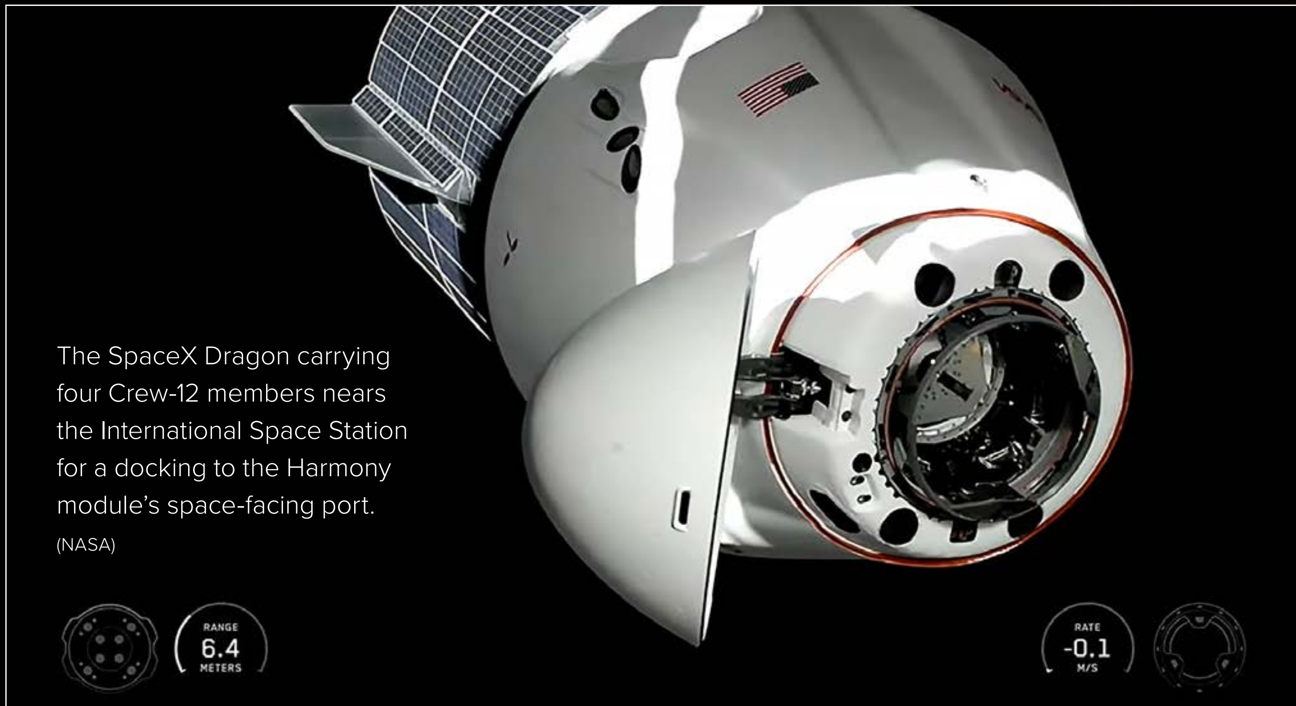
If all goes to plan, Rocket Lab could win a sizeable slice of the launch market, Spice says. However, he acknowledges this will take at least a few years and that SpaceX has an ample head start.

Neutron "won't be initially as proven, because Falcon 9 is a phenomenal vehicle," he says. "But ultimately, we don't enter a market to be No. 2." ★

Jonathan O'Callaghan is a space and science journalist from the U.K. A regular contributor to Scientific American and New Scientist, his work has also appeared in Forbes, The New York Times and Wired.

ABOVE + BEYOND

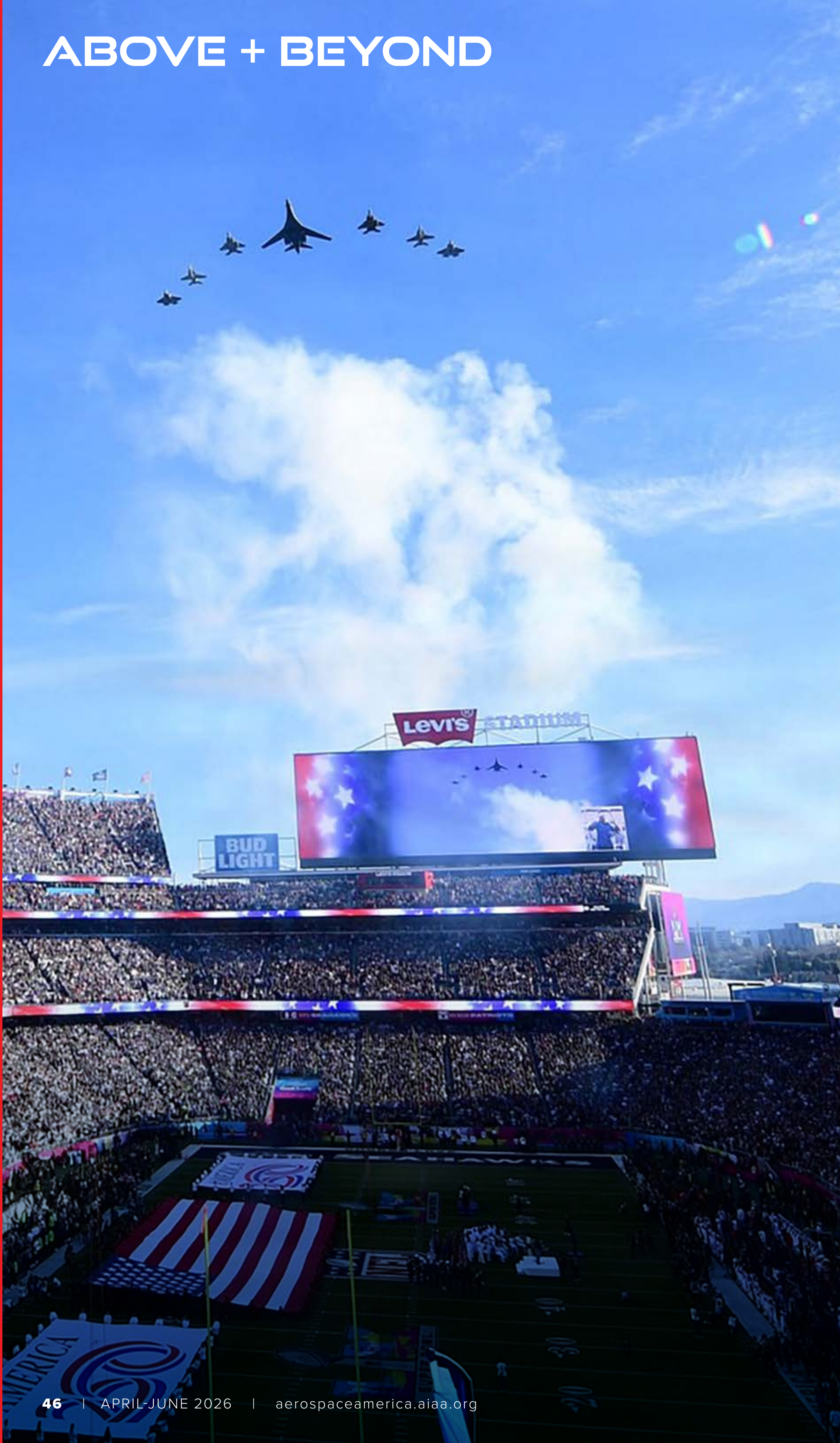
AIAA'S PHOTO SECTION HIGHLIGHTING THE BEST IMAGES OF THE QUARTER



The SpaceX Dragon carrying four Crew-12 members nears the International Space Station for a docking to the Harmony module's space-facing port. (NASA)

A SpaceX Falcon 9 rocket and Dragon spacecraft launched at 5:15 a.m. EST, 13 February 2026, from Space Launch Complex 40, Cape Canaveral Space Force Station in Florida. NASA's SpaceX Crew-12 was aboard, headed to the International Space Station, including NASA astronauts Jessica Meir and Jack Hathaway, plus ESA astronaut Sophie Adenot, and Roscosmos cosmonaut Andrey Fedyaev. (NASA/Aubrey Gemignani)

Crew 12 arrives


Levi's
STADIUM
BUD LIGHT

U.S. Navy and U.S. Air Force pilots conduct a flyover at Super Bowl LX at Levi Stadium, Santa Clara, California, 8 Feb. 2026. The flyover included two U.S. Air Force B-1 Lancers, two U.S. Air National Guard F-15 Eagles, and two U.S. Navy F/A-18 Super Hornets and two F-35C Lightning II. This historic Navy/Air Force flyover involving the U.S. Navy, U.S. Air Force, and California Air National Guard commemorates America's 250th anniversary by honoring the Nation's 250 years of service, teamwork, and precision.
(U.S. Navy official photo by Mass Communication Specialist 1st Class Aron Montano)

From the Institute

APRIL-JUNE | AIAA NEWS AND EVENTS

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2026			
7–9 Apr*	5th IAA Conference on Space Situational Awareness	Madrid, Spain (https://iaaspace.org/event/)	15 Dec 25
7 Apr–12 May	Fault Management and Autonomy for Space Systems Course	ONLINE (learning.aiaa.org)	
8 Apr–20 May	Introduction to Satellite Communications Course	ONLINE (learning.aiaa.org)	
9 Apr–14 May	Space Weather and Space Systems Course	ONLINE (learning.aiaa.org)	
10–11 Apr	AIAA Region III Student Conference	Ann Arbor, MI	6 Feb 26
12–13 Apr	AIAA Region I Student Conference	College Park, MD	2 Feb 26
14–16 Apr	Integrated Communication, Navigation, and Surveillance (ICNS) Conference	Herndon, VA	
14–30 Apr	Launch Vehicle Avionics Systems Design and Applications Course	ONLINE (learning.aiaa.org)	
16–19 Apr	30th Annual Design/Build/Fly Competition	Wichita, KS (USA)	
18 Apr	Pacific Northwest Technical Symposium	Seattle, WA	
21–30 Apr	Business Development for Aerospace Professionals Course	ONLINE (learning.aiaa.org)	
21 Apr–14 May	The Anatomy of Autonomy Course	ONLINE (learning.aiaa.org)	
25 Apr	Southern California Aerospace Systems and Technology Conference	Irvine, CA	
27 Apr–11 May	Cislunar Exploration: Challenges and Opportunities Course	ONLINE (learning.aiaa.org)	
28–29 Apr	Essential Model-Based Systems Engineering Course	ONLINE (learning.aiaa.org)	
28 Apr–7 May	Generative AI for Code Generation and Evaluation Course	ONLINE (learning.aiaa.org)	
28 Apr–2 Jun	Spacecraft Rendezvous and Proximity Operations Course	ONLINE (learning.aiaa.org)	
4–7 May	Applied Space Systems Engineering Course	ONLINE (learning.aiaa.org)	
4 May–1 Jun	Flight Test Techniques for UAS Course	ONLINE (learning.aiaa.org)	
13–15 May*	1th International Conference on Recent Advances in Air and Space Technologies (RAST2026)	Istanbul, Turkey (https://rast.org.tr/)	
16 May	2026 American Rocketry Challenge National Finals		
18 May	2026 AIAA Fellows Induction Ceremony and Dinner	Washington, DC	
19–21 May	ASCEND 2026 Powered by AIAA	Washington, DC	18 Sep 25
21–24 May*	ICNPAA 2026: Mathematical Problems in Engineering, Aerospace and Sciences	Sanlirufa, Turkey (https://event.fourwaves.com/icnpaa2026/pages)	

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2026			
26–29 May*	32nd AIAA/CEAS Aeroacoustics Conference	Brussels, Belgium	19 Nov 25
1–5 Jun*	28th Aerodynamic Decelerator Systems Conference and Seminar	London, United Kingdom	18 Dec 25
6–7 Jun	Hypersonic Aerothermodynamics In-Person Course	San Diego, CA (aviation.aiaa.org/registration)	
6–7 Jun	Propeller Aerodynamics for Advanced Air Mobility In-Person Course	San Diego, CA (aviation.aiaa.org/registration)	
7 Jun	Computational Aeroelasticity In-Person Course	San Diego, CA (aviation.aiaa.org/registration)	
8–9 Jun	Design of Electrified Propulsion Aircraft In-Person Course	San Diego, CA (aviation.aiaa.org/registration)	
8–12 Jun	AIAA AVIATION Forum	San Diego, CA	13 Nov 25
15–20 Jun*	2026 International Rocket Engineering Competition (IREC)	Midland, TX	
21–25 Jun*	US Congress on Theoretical and Applied Mechanics	Pasadena, CA (www.nationalacademies.org/our-work/us-national-committee-for-theoretical-and-applied-mechanics-usnc-tam)	
7–10 Jul*	27th AIAA International Space Planes and Hypersonic Systems and Technologies Conference	Naples, Italy	
26–30 Jul*	2026 AAS/AIAA Astrodynamics Specialist Conference	Whistler, British Columbia, Canada (space-flight.org/docs/2026_summer/2026_summer.html)	
1–9 Aug*	46th Scientific Assembly of the Committee on Space Research (COSPAR 2026) & Associated Events	Florence, Italy (cospar2026.org)	
13–18 Sep*	35th Congress of the International Council of the Aeronautical Sciences	Sydney, Australia (icas2026.com)	
5–9 Oct*	76th International Astronautical Congress	Antalya, Turkey (iac2026.org)	
3–4 Dec	AIAA Region VII Student Conference	Adelaide, Australia & Online	
2027			
11–15 Jan	AIAA SciTech Forum	Orlando, FL	
16–18 Mar	AIAA DEFENSE Forum	Laurel, MD	
18–20 May	ASCEND 2027	Washington, DC	
7–11 Jun	AIAA AVIATION Forum	San Diego, CA	

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

AIAA Continuing Education offerings

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.).

AIAA Announces 2026 Election Results

AIAA has announced the results of its recent 2026 elections. The newly elected AIAA officials will take office in May.

Integration and Outreach Activities Division

Director – International Activities Group
Luisella Giulicchi, European Space Agency

Director-Elect – Young Professionals Group
Stephen Clark, The Boeing Company

Regional Engagement Activities Division

Director – Region I
Kyle Zittle, Johns Hopkins University Applied Physics Laboratory

Director – Region II
Chris Crumbly, Auburn University

Director – Region VII
Björn Nagel, German Aerospace Center (DLR)

Technical Activities Division

Director – Aircraft Technology, Integration and Operations Group
Gabriele Enea, MIT Lincoln Laboratory

Director – Space and Missiles Group
Stephen Blanchette Jr., The Aerospace Corporation

New Board of Trustees and Council of Directors Positions Filled

In January the Council of Directors elected three new **Members–At-Large** who will begin their three-year term in May.

- **Danielle Curcio,** RTX
- **Dimitri Mavris,** Georgia Institute of Technology
- **Sabrina Steele,** The Aerospace Corporation

In February, the Board of Trustees elected **Johnathon Caldwell,** Lockheed Martin Space, as **Treasurer-Elect**.

In December the Regional Engagement Activities Division (READ) elected **Jim Guglielmo,** The Boeing Company, as READ Chief. In January, the Technical Activities Division (TAD) elected **Richard Mange, Ph.D.**, Lockheed Martin, as TAD Chief. They will begin their three-year term in May.

Get to Know Our New Board and Council Members

Board of Trustees Members–At-Large

Danielle Curcio, RTX

Curcio is corporate senior vice president of Global Engineering and Program Management for RTX. In this role, she is responsible for overseeing RTX's world-class engineers and program managers. She guides the company in innovating and enhancing its engineering and program execution to deliver to our customers across RTX. Curcio brings more than 25 years of engineering, technology development and program experience to this position. Previously, she was the vice president of Engineering for Raytheon. She led an Engineering team of over 25,000 engineers and managed all engineering activities pertaining to the design and integration of air and missile defense systems, precision weapons, radars, command and control systems, space systems and advanced defense technologies. Throughout her career, Curcio has held leadership roles of increasing responsibility for Engineering and Program Management at both the business unit and corporate levels. Curcio holds a master's degree and bachelor's degree, both in mathematics, from the University at Buffalo.

Dimitri Mavris, Georgia Institute of Technology

Mavris is a Distinguished Regents Professor, the Boeing Chaired Professor of Advanced Aerospace Systems Analysis in Georgia Tech's School of Aerospace Engineering, and Executive Director of the Professional Master's in Applied Systems Engineering program. In addition, he is the Director of the Aerospace Systems Design Laboratory (ASDL), leading a large research program that supports 40 full-time research engineers and 300 graduate students. He has raised over $350M in research since ASDL's inception in 1992. Mavris has served as principal investigator on 425+ studies funded by organizations including AFRL, FAA, NASA, ONR, Airbus, Boeing, GE, Lockheed Martin. He serves as the Georgia Tech site director for two FAA Centers of Excellence (COE): Alternative Jet Fuels & Environment (ASCENT) and Partnership to Enhance General Aviation Safety, Accessibility, and Sustainability (PEGASAS). He is the Georgia Tech Principal Investigator for the Siemens COE for Simulation and Digital Twin and the Airbus COE for Model Based System Engineering-Enabled Digital Overall Aircraft Design (2016–2022). Mavris is a Fellow of AIAA and the Royal Aeronautical Society. He has held various leadership roles with AIAA. He served as President of the International Council of the Aeronautical Sciences from 2023 to 2024. He formerly served as a member of the U.S. Air Force Scientific Advisory Board, co-chair of the review board of independent experts for ICAO's Committee on Aviation Environmental Protection (CAEP), and co-chair of the Technology Sub-group for the Long-Term Aspirational Goals initiative of CAEP. Mavris earned his B.S., M.S., and Ph.D. in Aerospace Engineering from Georgia Tech.

Sabrina Steele, The Aerospace Corporation

Steele is executive director of Corporate Affairs and Communications at The Aerospace Corporation, a nonprofit leader in advancing national space capabilities. Steele leads a highly recognized team who develop compelling space stories that engage and inspire employees, customers, and the larger space community. She has been a driving force developing partnerships that deepen connections between innovative commercial startups and the nation's national security, civil and international space programs. Before joining Aerospace, Steele held progressive leadership roles at what is now known as RTX. Prior to that, she was an award-winning reporter/editor for the Press-Telegram, a Knight-Ridder paper based in Long Beach, California..

Johnathon Caldwell, Lockheed Martin Space

Caldwell is the vice president and general manager of the Strategic & Missile Defense (SMD) Systems line of business at Lockheed Martin Space. He leads a team of more than 8,500 employees dedicated to missions that include strategic deterrence, missile defense and hypersonic strike for the U.S. Department of Defense and U.K. Ministry of Defence. Previously, Caldwell served as the vice president and deputy general manager of the National Security Space line of business, and as the vice president and general manager of the Military Space line of business, delivering integrated end-to-end solutions, high-performance systems, critical space architectures and innovative concepts to help U.S. and allied customers successfully execute defense and intelligence missions. With over 30 years in the industry, Caldwell has held progressive leadership and technical roles within Lockheed Martin, including leading the digital modernization and sustainment of Lockheed Martin Space, leading the company's positioning, navigation and timing business portfolio, and serving as chief engineer for the GPS III Program. He has held diverse roles in program management, engineering, and supply chain, across missions ranging from space and ground systems for missile warning, commercial and military communications and data transport and to commercial imaging systems. Caldwell, an AIAA Associate Fellow, serves on the President's National Security Telecommunications Advisory Committee and the Board of Directors of Astris AI, a Lockheed Martin company which delivers secure and scalable AI solutions across the defense industrial base and high-assurance commercial industries.

Regional Engagement Activities Division (READ) Chief

Jim Guglielmo, The Boeing Company

Guglielmo has had a 30-year career at The Boeing Company, specializing in aerodynamics, wind tunnel testing, and multidisciplinary design analysis & optimization (MDAO). He previously led the MDAO Technology Domain within Boeing Research & Technology, before transitioning to an Aerodynamics Senior Manager role within the Boeing Air Dominance organization. An AIAA Associate Fellow, Guglielmo is active in the AIAA St. Louis Section, including roles as chair, newsletter editor, and webmaster. He held multiple leadership roles within the Applied Aerodynamics Technical Committee (2007-2015) and has also held positions at the national level including as 2017 AIAA AVIATION Forum Chair and 2016 Deputy Forum Chair. He is currently the Technical Activities Division Liaison to the Honors & Awards Committee. Guglielmo was recognized with the St. Louis Young Professional Award (2003), and the AIAA Outstanding Section Award (2020). He earned his B.S. and M.S. degrees in Aerospace Engineering from the University of Illinois at Urbana-Champaign (UIUC).

Technical Activities Division (TAD) Chief

Richard Mange, Ph.D., Lockheed Martin

Mange is currently Vice President of Lockheed Martin (LM) F-35 Engineering. He previously was the Chief Engineer of LM F-35 program and multiple Skunk Works programs. An AIAA Fellow, Mange has held positions as Aviation, Technology, Integration and Operations (ATIO) Director (2020–2023); ATIO Deputy Director (2015–2020); 2017 AIAA AVIATION Forum Co-Technical Chair; 2016 AIAA AVIATION Forum Deputy Technical Chair and ATIO Conference Technical Chair. He was also a member of the V/STOL Aircraft Systems Technical Committee and currently serves as its chair. He was the Lockheed Martin organizer and editor for the 2018 AIAA AVIATION Forum sessions and subsequent book, *F-35 Lightning II: From Concept to Cockpit.* Mange earned his B.S., M.S., Ph.D. in Aerospace Engineering from the University of Illinois at Urbana-Champaign.

AIAA Announces Class of 2026 Honorary Fellows and Fellows

AIAA has announced its Class of 2026 Honorary Fellows and Fellows. The class will be inducted during a ceremony on 18 May 2026, in Washington, DC.

Honorary Fellow is AIAA's highest distinction, recognizing preeminent individuals who have made significant contributions to the aerospace industry and who embody the highest possible standards in aeronautics and astronautics. In 1933, Orville Wright became the first AIAA Honorary Fellow. Today, 248 people have been named AIAA Honorary Fellow.

AIAA confers Fellow upon individuals in recognition of their notable and valuable contributions to the arts, sciences or technology of aeronautics and astronautics. Nominees are AIAA Associate Fellows. Since the inception of this honor 2,120 persons have been elected as an AIAA Fellow.

2026 AIAA Honorary Fellows

Laura J. McGill,
Sandia National Laboratories

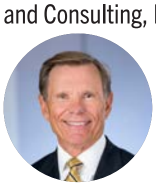
Daniel J. Scheeres,
University of Colorado Boulder

Steven H. Walker,
Lockheed Martin Corporation (retired)

2026 AIAA Fellows

William H. Ailor, III,
The Aerospace Corporation (retired)

The Honorable Robert Behler,
RFBehler Engineering and Consulting, LLC



Gillian Bussey,
US Space Force

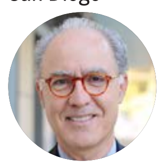
Simone D'Amico,
Stanford University

Paul Danehy,
NASA Langley Research Center

Juan M. de Bedout,
RTX

Daniel Dumbacher,
Purdue University

Miroslav Krstic,
University of California San Diego



Sanjiva Lele,
Stanford University

Arthur A. Mabbett,
North Wind

Dan E. Marren,
Marren Associates LLC

David M. McGowan,
NASA Langley Research Center

Karl Wieland Naumann,
kwnaumann Dynamic Technologies Expertise and Consulting

David Oh,
NASA Jet Propulsion Laboratory, California Institute of Technology

Information about the 2026 Fellows Dinner can be found at https://aiaa.org/events/2026-aiaa-fellows-induction-ceremony-and-dinner/

Paul H. Park,
Lockheed Martin Corporation, Bell Helicopter, Northrop Grumman (retired)

Khanh D. Pham,
Air Force Research Laboratory/Space Vehicles Directorate

Dawn R. Phillips,
NASA Marshall Space Flight Center

Ugo Piomelli,
Queen's University

Kurt Polzin,
NASA Marshall Space Flight Center

Rusty Powell,
Astrion

Sukesh Roy,
Spectral Energies, LLC

Hoyt Lee Sampson Jr.,
Lockheed Martin Aeronautics

Puneet Singla,
Pennsylvania State University

Sonya T. Smith,
Howard University

Kon-Well Wang,
University of Michigan, Ann Arbo

Christopher Watkins,
Gulfstream Aerospace Corporation

James W. Weber,
Office of the Under Secretary of War for Research & Engineering

David Williams,
Illinois Institute of Technology

AIAA Announces 2026 Premier Award Winners

AIAA has announced the 2026 recipients of the AIAA Premier Awards, recognizing the most influential and inspiring individuals in aerospace whose outstanding contributions merit the highest accolades. The winners will be recognized at AIAA events throughout the year.

The winners are:

AIAA Goddard Astronautics Award

Indian Space Research Organisation, honored "For the groundbreaking landing of the ISRO's Chandrayaan-3 near the lunar south pole region, to deepen our understanding of the moon and beyond."

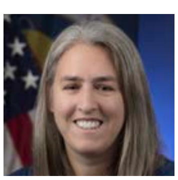
AIAA Reed Aeronautics Award

Boom Supersonic XB-1 Team, honored "In recognition of the historic design and development of Boom Supersonic's demonstrator, XB-1, the first independently developed supersonic jet, which demonstrated Boomless Cruise on two supersonic flights in 2025."

AIAA Distinguished Service Award

Mark J. Lewis, President & CEO, Purdue Applied Research Institute, honored "For outstanding and notable contributions to AIAA at the section, regional, and national level over the past four decades."

AIAA Engineer of the Year Award



Jenna L. Eppink, Research Aerospace Engineer, NASA Langley Research Center, honored "For exceptional engineering and technical innovation developing Lensless Particle Image Velocimetry (PIV) and a simple static-pressure-tap boundary-layer transition detection technique, expanding near-body flow-physics measurement capabilities."

AIAA Lawrence Sperry Award

Thomas C. Underwood, Assistant Professor, University of Texas at Austin, honored "For pioneering contributions to air-breathing electric propulsion and plasma-enabled pathways for sustainable and in situ fuel production."

AIAA Public Service Award

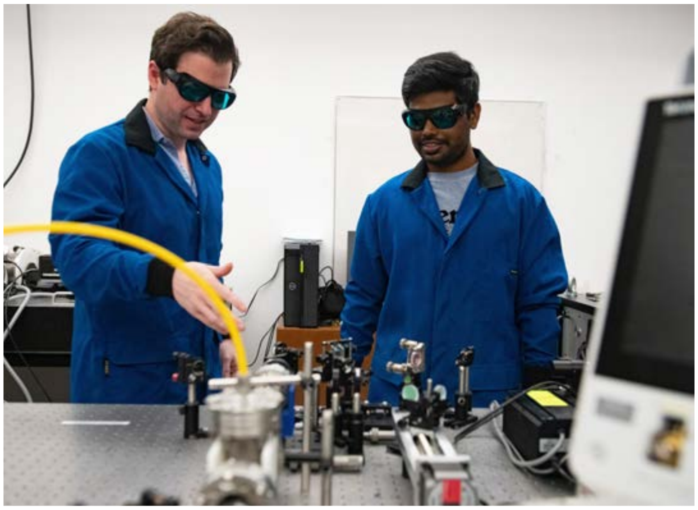
Thomas Zurbuchen, Professor of Space Science and Technology, ETH Zurich, honored "For bold and impactful leadership through energetic public service in space science, entrepreneurship, education, and NASA space program management."

Daniel Guggenheim Medal

Charbel Farhat, Vivian Church Hoff Professor of Aircraft Structures School of Engineering, Stanford University, honored "For pioneering advances in the computational mechanics of fluid–structure interaction, transforming simulation methodologies and enabling major breakthroughs in aircraft design and optimization."

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

Redefining Propulsion: Thomas C. Underwood Receives the 2026 Lawrence Sperry Award



Lawrence Sperry Award

Each year, AIAA recognizes a notable contribution by a young professional, age 35 or under, to the advancement of aeronautics or astronautics with the Lawrence Sperry Award. This year Thomas C. Underwood is honored "for pioneering contributions to air-breathing electric propulsion and plasma-enabled pathways for sustainable and in situ fuel production."

Underwood, Assistant Professor in the Department of Aerospace Engineering and Engineering Mechanics at the University of Texas at Austin, received his Ph.D. in Mechanical Engineering from Stanford University and was a postdoctoral fellow at Harvard University. His research lies at the intersection of plasma physics, fluid mechanics, and chemistry, and seeks understanding of how plasmas can be leveraged to address challenges in space, propulsion, and the synthesis of clean sustainable fuels. Underwood is a recipient of numerous distinctions including the AFOSR Young Investigator Award and the NASA Early Career Faculty Award.

A Childhood Shaped by Curiosity and Hands-On Learning

Underwood grew up in rural Florida, "where life moved a little slower and there was space to think. That quiet environment gave me the freedom to pursue my interests," he noted. "For me, that was always building something, taking things apart, trying to understand how they worked, and putting them back together in new ways. A lot of engineers say that, but for me it was less about the gadgets and more about the thinking. When you grow up without so much noise, you learn to sit with problems and find the fun in solving them. That spirit continues to drive me to find solutions, even as I find my ideas don't work. The fun and joy of discovery just cannot be matched."

He became passionate about science in high school thanks to guidance from great teachers and his parents. Although he was inspired by many educators throughout his life, who instilled curiosity and a love of learning, one teacher, Chip Davis, made a large impact on the direction of his life in science. "Mr. Davis was really passionate about alternative ways to teach kids to think. He believed that real understanding came from building things, by getting your hands involved, seeing how systems operated, and learning through experimentation."

That mindset continues to shape Underwood's teaching philosophy today. "I believe students grow most when they encounter concepts embedded in real systems – when students are forced to practice and think through how ideas interact with the real world. This kind of learning is fundamentally different from the traditional approach of isolating concepts and layering complexity gradually. Both have value, but there is something powerful about seeing ideas come alive in action. It builds intuition, confidence, and the kind of problem-solving ability that lasts well beyond the classroom."

He also described one teenage experience that stood out to him. "A few years after the Space Shuttle *Columbia* exploded, I traveled to Cape Canaveral to see the launch of Space Shuttle *Discovery*. Seeing that launch was powerful. It showed me what engineers can build and what ingenuity can do. For someone who didn't come from a family of engineers or professors, this was an important moment for me, a moment that gave me confidence that engineering is what I wanted to pursue. It also inspired me to pursue big problems that matter to our society."

"What excites me most about propulsion today is that traditional design limits are being reconsidered. New architectures that integrate new energy sources, acceleration mechanisms, and ideas that rethink how propellant is stored, harvested, and utilized in missions are emerging because existing technologies are approaching practical limits. There is still a long way to go, and that uncertainty makes the field dynamic and rewarding."

The Pursuit of Fundamental Truths Through Research

His path to aerospace engineering was somewhat atypical. Underwood explained that he "started in nuclear engineering with the goal of working at a reactor. After my freshman year the Fukushima nuclear accident happened and that dream changed quickly." Transitioning to physics attracted by its rigor, "I gravitated toward classes that pursued very fundamental answers to why things happened. As I have grown in my own career I always come back to searching for fundamental truths to ground any idea I have."

Research had the biggest impact on his trajectory during his undergraduate years. "[As] someone that came into college not knowing what research was, how research was conducted, or how problems were chosen, I was very fortunate to begin working with Professor Subrata Roy (AIAA Associate Fellow) at the University of Florida as a very early undergraduate student. He taught me how to funnel my passion for science into technologies." Underwood began working in his lab in 2009 on plasma flow control. "I was exposed to the world of low-temperature plasmas that became the field that I continue to work in. The use of low-temperature plasmas was a topic that was growing in popularity at the time for active flow control and turbulent drag reduction. I worked with Subrata on this topic and was able to deploy it in a low-speed wind tunnel at NASA Langley a few years later. That experience taught me that, while drag reduction could be measured, the physics driving it in the plasma were rich in complexity."

During his sophomore year he interned at Army Research Laboratory and began working on rotorcraft flow control using plasma actuation with Dr. Bryan Glaz. "That experience allowed me to see an end technology goal to motivate what I was studying. It really helped frame research and is something that I still think about today."

Underwood also completed internships at Princeton Plasma Physics Laboratory and through NASA Langley's Aerospace Research Student Scholars (LARSS) program providing access to world-class experimental facilities and exposure to the scale and rigor of aerospace research at NASA. "More importantly, it reinforced my desire to pursue experimental work, to build, test, and learn directly from physical systems."

While pursuing his Ph.D. at Stanford University, he joined the laboratory of Professor Mark Cappelli to study mechanical engineering. "Mark taught me how plasmas behave, how to diagnose them, and how to control them. He introduced me to spacecraft propulsion and the principles that govern the design of plasma engines. More importantly, he shaped how I think about research. He gave me the freedom to pursue problems that I found compelling," allowing Underwood to develop his own process and creativity. And although independence may be difficult to sustain as a faculty member with proposal deadlines and deliverables, he remains convinced that it is essential for students to grow into original thinkers.

Moving to Harvard he entered a very different research environment. "I worked with Professor George Whitesides, who taught me how to frame research questions. George's creativity spans disciplines, but what stood out most was his insistence on asking a simple question: 'Who cares?' We have asked that question in every aerospace project in my group. If we cannot answer it clearly, we rethink the problem. The question is deceptively difficult, but it forces clarity and purpose in research. Simple questions set the foundation of innovations that make real and lasting impact."

After graduate school, Underwood wrestled with whether to start a company or build a laboratory in academia. "Ultimately, I chose to join UT Austin, and it has been an incredible journey. I have been able to engineer new technologies and propulsion systems while also mentoring students who are discovering their own passions. Watching them grow, seeing their confidence develop as they tackle hard problems and go on to make an impact of their own, has been just as meaningful as any technology we have built."

Rethinking the Limits of LEO and Expanding What Missions Can Carry

Underwood's research career has taken him in directions he did not anticipate. "That's the fun part about technology development and operating on the cutting edge of science. As ideas and opportunities present themselves, you are free to pivot toward what you believe solves the problem."

He began graduate school studying electromagnetic propulsion; the work focused on extending a device known as a Cheng plasma gun. These thrusters use electromagnetic forces to accelerate plasma to high exhaust velocities through a magneto-deflagration wave. High exhaust velocity is directly tied to fuel efficiency in spacecraft propulsion that makes such systems attractive for missions with strict payload constraints. "At that stage, I was focused almost entirely on the physics of plasma acceleration and propulsion performance."

At Harvard he focused on "how plasmas can be used to selectively convert molecules into value-added chemicals. That experience broadened my perspective. I began thinking not only about how to accelerate propellant, but how to generate or transform it. The idea that fuels could be converted or produced on demand opened new possibilities for propulsion systems. It also suggested intriguing opportunities for interplanetary missions, where propellants might be produced from local atmospheres rather than carried from Earth."

As Underwood started his faculty career, these threads converged into air-breathing electric propulsion. This concept reimagines the constraints of traditional electric propulsion. Instead of storing propellant onboard, the vehicle harvests atmospheric particles at very low Earth orbit altitudes where atmospheric drag is significant. The challenges are substantial. Can a plasma be sustained at those pressures? Can sufficient propellant be harvested to compensate for drag? How do electric propulsion systems operate efficiently on reactive species such as atomic oxygen and nitrogen? These questions pushed his research into new regimes of plasma physics and system design that would be self-replenishing.

Through the Air Force and the DARPA TALOS program, Underwood's team designed and tested an air-breathing thruster based on a modified electromagnetic magneto-deflagration concept. The system demonstrated compensation for drag at altitudes of 200–300 km using propellant that harvested at those altitudes and is now approaching final prototype testing at the Naval Research Laboratory.

Underwood's group has expanded into carbon-free fuels and plasma-enabled molecular conversion building directly on his Harvard experience. "The idea is to leverage electrical energy to convert molecules[with] longer term applications to convert the atmosphere of Mars into fuels with world of opportunities of missions no longer constrained by what you can bring [with you]."

The next steps, through the NASA Early Career program, are concepts to develop a high specific-power, high specific-impulse electromagnetic accelerator that leverages magnetic nozzle compression to heat plasma to extreme temperatures, with the long-term vision of fusion-assisted propulsion. The approach avoids permanent magnets and emphasizes scalability for interplanetary travel.

Mentorship Focuses Career Path

"My career path has not followed the trajectory I once imagined," Underwood noted, "I did not plan to become a professor. I believed the greatest impact might come from building a company. Instead, I joined the Department of Aerospace Engineering and Engineering Mechanics at UT Austin in 2021. Building a laboratory has been both challenging and deeply rewarding."

This transition from student to faculty was shaped by the mentorship received from colleagues active within AIAA, including Noel Clemens, Karen Willcox, L. Raja, Philip Varghese, and David Goldstein who provided guidance and perspective during the early stages of his career. Now "I have had the opportunity to mentor a growing number of graduate and undergraduate students. Watching them develop their own research identities has become one of the most meaningful aspects of my work."

AIAA Offers a Place to Learn, Share, and Connect with the Broader Community

Underwood's first exposure to AIAA was presenting a research paper back in 2011. Today AIAA SciTech Forum is the primary venue for the electric propulsion community to share advances and define where the field was heading. "If you want to understand the state of the art, or help shape it, that is where the conversation happens."

Over time, he has become more involved with AIAA, serving on the Electric Propulsion and Plasmadynamics & Lasers technical committees. "These communities are where ideas are challenged, collaborations are born, and the future of our field quietly takes shape. Today, as the Fundraising Chair of the Electric Propulsion Technical Committee, I work to help sustain and grow that ecosystem."

An equally important role for Underwood is serving as the faculty advisor for the AIAA student branch at UT Austin. "I remember what it felt like to be that student looking for direction, mentorship, and belonging. Helping students discover their own path is one of the most rewarding parts of my involvement. AIAA shaped my professional identity, and I am proud to help shape that experience for the next generation."

While AIAA offers a venue to communicate progress on technologies, he noted "it has also become a place where I go to learn new things and connect with the broader community.... It is where I see what other institutions and researchers are building. And over the years, it has become a place of friendship and where colleagues have become collaborators. "I became an AIAA member to connect with the broader research community. I have remained a member because of the people, the shared mission, and the sense that together we are pushing aerospace forward."

AIAA Annual Joint Meeting of the Board of Trustees & Council of Directors Notice

Notice is hereby given that the Annual Joint Meeting of the Board of Trustees & Council of Directors of the American Institute of Aeronautics and Astronautics (AIAA) will be held in person on Monday, 18 May 2026, at 11 a.m. ET.

AIAA Council of Directors Meeting

Notice is hereby given that an AIAA Council of Directors Meeting will be held in person on Monday, 18 May 2026, at 3:00 p.m. ET.

– Susan Silva, AIAA Governance Administrator

Recognizing Top Achievements an AIAA Tradition

AIAA is committed to ensuring that aerospace professionals are recognized and celebrated for their achievements, innovations, and discoveries that make the world safer, more connected, more accessible, and more prosperous. From the major missions that reimagine how we use 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 2025 and April 2026.

AIAA SciTech Forum 2026
12–16 January 2026
Orlando, Florida

PREMIER LECTURES

2026 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.

Brian M. Argrow
Glenn L. Murphy Distinguished Professor
Ann and H.J. Smead Department of Aerospace Engineering Sciences
Director, Integrated Remote & In Situ Sensing Program (IRISS)
Lecture: "Aerospace Engineering for Science and Public Safety: Aerial Robots to Explore Tornadogenesis"

2026 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.

Thomas C. Corke
Clark Chair Professor of Engineering
University of Notre Dame
Lecture: "Active Drag Reduction with Net Power Savings in Turbulent Boundary Layers – Physics and Scaling"

EDUCATION AWARD

2025 Abe M. Zarem Graduate Award for Distinguished Achievement – Aeronautics

Luke Busse, University of Cincinnati
Paper: "Multi-Sensor Based Adaptive Fusion Scheme for Position Estimation of Multirotor UAV Systems in GPS-Denied Environments"

Faculty Advisor: Manish Kumar, University of Cincinnati

2025 Abe M. Zarem Graduate Award for Distinguished Achievement – Astronautics

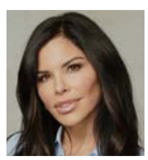
Patrick Eid, Auburn University
Paper: "Evolution of the Bidirectional Vortex in a Capped Ellipsoidal Cyclonic Rocket Engine"

Faculty Advisor: Joseph Majdalani, Auburn University

LITERARY AWARD

2026 AIAA Elementary Children's Literature Award

This award is presented for an outstanding, significant, and original contribution in aeronautics and astronautics literature for youth.



Lauren Sánchez Bezos
Book: The Fly Who Flew To Space

2026 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.

Sean Seyer
University of Kansas
Book: Sovereign Skies: The Origins of American Civil Aviation Policy

PARTNER AWARD

2025 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.

Ashwani K. Gupta
University of Maryland
For sustained contributions to student education using experimental research and advanced diagnostics for contributions to aerospace literature on combustion, energy and propulsion to support advanced novel concepts development.

TECHNICAL EXCELLENCE AWARDS

2026 AIAA Aerodynamic Measurement Technology Award

This award is presented for continued contributions and achievements toward the advancement of advanced aerodynamics flowfield and surface measurement techniques for research in flight and ground test applications.

Mark P. Wernet
NASA Glenn Research Center
For the continued advancement of LDV,

PIV, Raman thermometry, and real-time BOS technology into facility-hardened techniques that provide validation data for CFD assessment.

2026 AIAA Aerospace Guidance, Navigation and Control Award

This award is presented to recognize individuals that have made important and substantial contributions in the field of guidance, navigation and control.

Kathleen Howell
Purdue University
For seminal contributions to the theory and practice of the trajectory design and operation of spacecraft in the Earth-moon system.

2026 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.

Jeffrey Hojnicki
NASA Glenn Research Center (retired)
For exceptional technical contributions in spacecraft power systems analysis and for outstanding leadership in the design of photovoltaic power systems for multiple human spaceflight programs.

2026 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.

Eric J. Ruggiero
GE Aerospace
For shaping propulsion technology starting with fundamental research in cooling features of gas turbines leading to product development of propulsion systems for advanced military platforms.

2026 AIAA Atkinson-Ball Survivability Award

This award is presented to an individual to recognize outstanding achievement or contribution in design, analysis, implementation, and/or education of survivability in an aerospace system.

Timothy L. Williams
Boeing Defense, Space, and Security
For visionary leadership advancing multi-domain platform survivability, integrating resilient technologies across global defense systems, and shaping the next generation of aerospace engineers through mentorship & innovation.

2026 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.

E. Bruce Jackson
Adaptive Aerospace Group, Inc.
For leading standards for check-cases and model exchange of six-degree-of-freedom simulations, and for developing software frameworks for crew training, handling qualities, and vehicle subsystems development.

2026 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.

Kemal Hanjalić
Delft University of Technology, University of Sarajevo, Bosnia and Herzegovina
For pioneering and outstanding contribution to the modelling of turbulent flows, heat, mass transfer, and its application for the advancement of energy and process technologies.

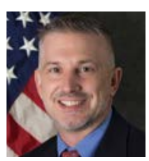
2026 AIAA Intelligent Systems Award

This award is presented to recognize important fundamental contributions to intelligent systems technologies and applications that advance the capabilities of aerospace systems.

Mary "Missy" Louise Cummings
George Mason University
For outstanding and sustained contributions to human supervision and control of intelligent autonomous aerospace vehicles.

2026 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.



Michael Bolender
Air Force Research Laboratory, AFRL/RQQA
For outstanding contributions to the development of control-oriented models and flight control methods for air-breathing hypersonic vehicles, which serve as the foundation of many computational models used in research and industry.

2026 AIAA Microgravity and Space Processes Award

This award is presented for significant contributions in microgravity science, space processing, or in furthering the use of microgravity for space processing.

Steven Collicott
Purdue University
For unique leadership in research, advocacy, and education supporting spaceflight activities in ISS, commercial sub-orbital rockets, parabolic flights, drop-towers, and commercial satellites.

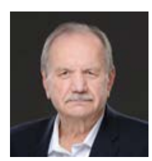
2026 AIAA Propellants and Combustion Award

This award is presented for outstanding technical contributions to aeronautical or astronautical combustion engineering.

Fokion Egolfopoulos
University of Southern California
For outstanding contributions in studies of flames, including flame theory and fundamental flame property measurements and simulations especially at engine-relevant conditions.

2026 AIAA Wyld Propulsion Award

This award is presented for outstanding achievement in the development or application of rocket propulsion systems.



Vladimir J. Hruby
Busek Co. Inc.
In recognition of outstanding technical contributions in the field of spacecraft electric propulsion, and foundational influence on the industry.

2026 ICME Prize

"Multi-scale ICME to Optimize the Bondline Performance of Adhesive Joints"

Stephanie TerMaath, University of Tennessee; Marcias Martinez, Clarkson University; Kinan Bezem, University of Tennessee; Nilanjan Mitra, Johns Hopkins University; Marcus Stanfield, Southwest Research Institute; Todd Mull and John Erdman, Clarkson University; and Corey Arndt, Hiren Balsara, and Daniel Hart, Naval Surface Warfare Center Carderock Division

Five Years of Inspiration: 2026 Trailblazing STEM Educator Award Winners Announced

This year marks the fifth anniversary of the Trailblazing STEM Educator Award. AIAA and Challenger Center launched this prestigious award to celebrate K-12 educators who go above and beyond to inspire the next generation of explorers and innovators in science, technology, engineering, and mathematics.

MEET THE 2026 TRAILBLAZING STEM EDUCATOR AWARD WINNERS!

Laurie Hamzik, Saint Ambrose Catholic School, Brunswick, Ohio

For over 35 years, Laurie Hamzik, a middle school science teacher at St. Ambrose Catholic School, has helped her students gain experience beyond the classroom and served as a bridge between students, parents, educators, engineers, and other STEAM professionals.

Since 2011, many of her young students discovered aerospace careers and developed a passion for space exploration by participating in Young Astronaut Day, an event co-sponsored by AIAA Northern Ohio Section and NASA Glenn Research Center. She has organized and accompanied her students on tours of aerospace facilities at NASA Glenn and has provided valuable insight to the NASA Glenn Office of STEM Engagement by providing feedback on NASA's "Sound Off Engineering Design Challenge" before NASA made this activity available to students nationwide in 2023.

She regularly provides opportunities for her students to perform experiments and present the results at St. Ambrose School science fairs, the Northeast Ohio Science and Engineering Fair, and the Ohio Science Days events. Hamzik was recognized in 2015 with the Cleveland Plain Dealer's Crystal Apple Award and the 2024 Ohio Academy of Science's The Governor's Thomas Edison Award for Science, Technology, Engineering and Math (STEM) Education and Student Research.

Hamzik has mentored early-career teachers and helped her school to receive STEAM designations from the Ohio STEM Learning Network by serving on the St. Ambrose School STEAM Committee.

Kenji Nomura, Virginia Space Flight Academy, Wallops Island, Virginia

Kenji Nomura is a STEM educator and program leader committed to expanding access to hands-on, high-quality STEM learning. With experience teaching mathematics, astronomy, robotics, computer science, and engineering, he has helped students engage deeply with STEM through interactive, project-based experiences that build curiosity, confidence, and problem-solving skills.

Throughout his career, Nomura has developed makerspaces, designed innovative STEM programming, and secured funding to expand opportunities for students. As an Albert Einstein Distinguished Educator Fellow supporting NASA Science Activation, he has contributed to efforts that connect students and educators with meaningful, real-world STEM learning experiences. He is especially passionate about helping young people see themselves as explorers, creators, and future innovators.

His work has included creating authentic engineering experiences that connect STEM learning to real-world application, including projects in which students build data loggers, launch rockets, and analyze their own flight data. Currently, Nomura is focused on assisting students through career and technical education, helping create pathways that connect classroom learning with future opportunities. By blending aerospace, engineering, and data analysis with hands-on learning, he creates engaging experiences that encourage students to think critically, solve problems, and see STEM as a field where they can belong and thrive.

Lillian Reynolds, Voyager Public Charter School, Honolulu, Hawaii

Lillian Reynolds introduces students to STEM careers and connects classroom lessons to current and future ambitions for space exploration and aerospace innovation by using current events and research. Reynolds designs her units based on current events that students can then use to apply science concepts. Live launches, broadcasts, and articles are frequently the starting point of developing a lesson or unit.

Some of the bigger projects Reynolds has worked on over the years with her students include five Challenger Center of Hawaii missions, the International Astronomical Union Exoplanet Naming Campaign, conducting a hydroponics plant research project as if they were on the International Space Station, MarsTrek (researching & ranking the best landing sites on Mars given weather and terrain concerns), solar panel design for Earth and space, rover design, and design thinking for radiation concerns in space.

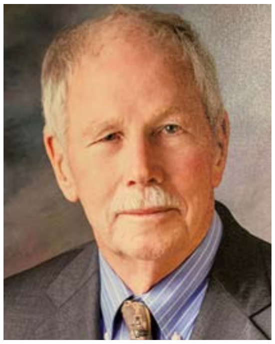
Reynolds promotes active learning and encourages students to think critically by facilitating these open-ended projects where students must come up with a design that allows them to use their creativity while actively engaging with concepts of human survival on the moon or in space.

Reynolds works hard to motivate and excite students by using a variety of instructional techniques She uses a balanced mix of teacher-to-class teaching, peer-to-peer collaboration, and independent learning. Reynolds frequently reminds her students that the moon and Mars missions are happening now, and they don't have to leave Earth to be part of it.

Obituaries

View complete obituaries

AIAA Honorary Fellow Liebeck Died in January 2026



Robert H. Liebeck, a world-renowned authority in the fields of aerodynamics, hydrodynamics, and aircraft design, died on 12 January 2026. He was 87 years old.

Liebeck studied aerospace engineering at the University of Illinois at Urbana-Champaign, where he earned his B.S. in 1961, his M.S. in 1962, and a Ph.D. in 1968. His Ph.D. thesis focused on the maximum lift an airfoil could generate. Liebeck developed a design method that produces an airfoil shape with the maximum lift for specified conditions. Liebeck airfoils represent the limit of achievable performance.

After finishing his Ph.D., Liebeck worked at Douglas Aircraft and made many contributions to aerodynamic design and analysis of commercial jet transport and high-altitude reconnaissance aircraft. He remained with the company as it became McDonnell Douglas and then Boeing.

In the 1990s, his creative insights led to the Blended Wing Body (BWB) configuration. The BWB concept promises dramatic improvements in fuel efficiency and environmental performance. The U.S. Air Force tasked startup JetZero with building and flying a full-scale BWB prototype, with a target flight date in 2027. Major U.S. air carriers have partnered with JetZero on this development, and Liebeck served as a technical advisor.

In addition, he designed aerodynamic wings for Indianapolis 500 and Formula One racing cars. Through wind tunnel testing Liebeck identified the aerodynamic principles of the blunt edge Gurney airfoil flap that was subsequently employed on the MD-11 and other aircraft.

Liebeck was an NAE member and honored with many of the highest honors in his profession, including the 2005 Spirit of St. Louis Medal and 2010 Daniel Guggenheim Medal. He also was recognized with the 1987 AIAA Aerodynamics Award, 2005 AIAA Aircraft Design Award, and 2016 AIAA Dryden Lectureship in Research.

Deeply committed to education, he served as Professor of the Practice of Aeronautics at MIT and was part of the UCI engineering faculty for over 25 years, where he taught courses in aerodynamics, aircraft performance and design, and advised students at both the undergraduate and graduate levels. He served as faculty mentor for the Design/Build/Fly and Human-Powered Airplane teams.

Correction: In the January–March 2026 issue, an error appeared in "AIAA Fellow Saric Died in April 2025." The information regarding his education should have read: Saric graduated from the Illinois Institute of Technology with a bachelor's degree in mechanical engineering (1963) and a Ph.D. in mechanics (1968). He earned a master's degree in mechanical engineering from the University of New Mexico in 1965.

We regret the error.

AIAA Fellow Heil Died in February 2026

Michael Heil, Colonel, USAF (Retired), died on 8 February. Heil graduated with a degree in engineering from the U.S. Air Force Academy (1975) before earning a master's degree in flight structures from Columbia University on a Guggenheim Fellowship (1976), and a doctorate in aerospace engineering from the U.S. Air Force Institute of Technology (AFIT) (1986). He retired from Air Force active duty in 2005 after serving as Director of the Air Force Research Laboratory's Propulsion Directorate with responsibilities for propulsion and power research at Wright-Patterson and Edwards Air Force Bases.

Following his retirement from the Air Force, Heil served as President and CEO of the Ohio Aerospace Institute from 2007 to 2016. After retiring, he ran M.L. Heil Consulting as an independent aerospace and defense consultant.

Heil was an integral part of the aerospace community at the local and national levels and he was a very active member of the Northern Ohio Section. He spent time as the Northern Ohio Section Public Policy Officer where he won the first-place Public Policy Section Award in 2022, 2023, 2024.

AIAA Fellow Yousuff Hussaini Died in February 2026

Mohammad Yousuff Hussaini, Ph.D., died on 16 February 2026. Yousuff Hussaini graduated from the University of Madaras, India, where he received his bachelor's and master's degrees. In 1970, he earned his Ph.D. from the University of California, Berkley, after which where joined the Indian Space Research Organisation (ISRO), ultimately serving as Acting Division Head for Aerodynamics.

In 1976, he became a Senior Research Fellow at NASA Ames Research Center before joining the Institute of Computer Applications in Science and Engineering (ICASE) at NASA Langley Research Center, where he served as its director from 1992 to 1996. He later joined Florida State University (FSU) where he held the Thinking Machines Corporation Eminent Scholar Chair in High Performance Computing and the Sir James Lighthill Professor of Mathematics and Computational Science & Engineering. He retired from FSU in 2021.

At ICASE, he focused his research on developing spectral methods for accurate simulation of fluid dynamics phenomena including laminar-turbulent boundary layer transition. The book *Spectral Methods in Fluid Dynamics* (Springer, 1987) by Canuto, Hussaini, Quarteroni, and Zang grew out of this several-years effort to establish spectral methods solidly in computational fluid dynamics. Hussaini and collaborators also developed subgrid scale model for compressible turbulence and performed large-eddy simulation (LES) of compressible homogeneous turbulence. They performed large-scale direct numerical simulation (DNS) of compressible isotropic and homogeneous shear flows.

Hussaini was a Fellow of AIAA, American Physical Society, ASME, and the Institute of Physics. He received several NASA awards, including the NASA Medal for Exceptional Scientific Achievement.

SIMPSON'S VIEW

Happy anniversary — so what's next?

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

2026 brings plenty of anniversaries, perhaps most notably the centennial of Robert Goddard's first test flight of a liquid-powered rocket. It also marks the 65th anniversary of the first human in space, when Yuri Gagarin rode a liquid-powered rocket on his 108-minute orbit of the planet, and the 25th anniversary of the first space tourist, when AIAA member Dennis Tito traveled to the International Space Station. In that vein, it's been five years since the establishment of routine commercial suborbital flights.

It's interesting to look back and acknowledge how developments over the decades build upon one another. We are now witness to commercial orbital flights, on the precipice of commercial space stations and Tito has signed a deal to orbit the moon with his wife and 10 others when SpaceX's Starship is ready.

To realize this progress, consider that the space shuttle Columbia, the first reusable spacecraft, made its inaugural launch only 45 years ago. Today, such craft are common: the European ATV, Japan's H-II, the Chinese reusable experimental spaceplane, the X-37B OTB, and SpaceX's Cargo and Crew Dragons. Looking ahead, Sierra Space's Dream Chaser spaceplane awaits its first flight and, though they have already flown, we'll start to see reuse of Starships and Orion capsules. The list grows when you factor in the Falcon 9 and New Glenn launch vehicles.

Key to many of these milestones has been cooperation. Indeed, this year marks 51 years of international space cooperation, which began with the Apollo-Soyuz mission. In the last 25 years of continuous human presence in space, representatives of at least 47 different countries have traveled to space — 55, if you include suborbital and commercial flights.

However, cooperation in space hasn't always been key to progress. Initially, it was a race between nations that pushed advances in space travel. Today, we are seeing competition among private companies pursuing different approaches that is advancing human presence in space. This is akin to how progress was made in early aviation, where such competition spurred the capabilities we take for granted today.

On that note, aviation is marking the 115th anniversary of the first transcontinental flight, which took Perry Rodgers 49 days and over 70 stops (including more than 16 crashes) in the "Vin Fiz" biplane. Soon after, airlines including American and Lufthansa were founded; they will all celebrate their centennials this year. Similarly, it's been 100 years since widespread U.S. airmail service was initiated, connecting major cities including Chicago, Detroit and Cleveland.

Many of these anniversaries are themselves built upon prior achievements. Even before those airlines were established, there was the first aerial refueling, which paved the way for longer and longer flights. For

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The first aerial refueling in 1921.

The Peter M. Bowers Photograph Collection and Papers/The Museum of Flight

that initial demonstration 105 years ago, wing walker Wesley May climbed out of a Lincoln Standard biplane with a 5-gallon can of fuel strapped to his back and walked along the wing to a Curtiss JN-4 "Jenny" plane flying in formation. He then poured the fuel into the tank of the Jenny. Two years later, refueling was demonstrated with a hose between aircraft.

Today, aerial refueling is a key enabler to projection of air power by militaries across the globe, and technology is being developed to conduct refueling in orbit to extend the operating life of satellites. It also could be critical to the future of human exploration of the universe.

Yet another anniversary reminds us of the days when refueling wasn't always an option: the 95th anniversary of the first nonstop, non-refueled flight across the Pacific. Clyde Pangborn and Hugh Herndon Jr. flew from Japan with more than 900 gallons of fuel onboard to Washington state in 41 hours. We also celebrate the 40th anniversary of the Rutan Voyager, designed by AIAA Fellow Burt Rutan and piloted by his brother, Dick, along with Jeana Yeager, which circumnavigated the globe without refueling on a flight that took a little over nine days.

Those and other efforts to extend the range of aircraft were crucial to ensuring that air travel could connect the continents. This year, we are set to reach the ultimate goal of range expansion with the first delivery of aircraft for Project Sunrise. That initiative's goal is a 240-passenger airliner with the range to connect any two commercial airports in the world — flights that may take up to 22 hours.

2026 also brings several key speed anniversaries, including 50 years since regularly scheduled supersonic service began with the Concorde, connecting continents in only a few short hours. We are now on the cusp of the reemergence of commercial supersonic flight, with NASA's flight tests of the X-59 demonstrator and Boom Supersonic's development of its Overture airliner.

"Today, we are seeing competition among private companies pursuing different approaches that is advancing human presence in space. This is akin to how progress was made in early aviation, where such competition spurred the capabilities we take for granted today."

If these endeavors succeed, we could see the expansion of hyper-fast travel, including hypersonic ambitions. This holds the prospect of both range and speed.

These anniversaries, whether in aerospace or elsewhere, matter because they remind us to reflect on the path that got us to where we are. They are landmarks toward the future that we have envisioned. They validate that advancements are made in incremental steps.

We are encouraged to remember the motivations that led to the status we have achieved, acknowledge the challenges overcome to reach each milestone, and reflect upon the aspirations we had then for the future — and perhaps reinvigorate those aspirations again. ★

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Orbital safety needs independent eyes, not centralized trust

BY MORIBA JAH | moriba@utexas.edu

Earth orbit has long been a sparsely populated territory, but this shared ecosystem is increasingly under stress.

SpaceX now operates more satellites than the rest of the world combined, and in January announced plans to begin offering Stargaze, a free conjunction screening service built on its own on-orbit sensing network. At the same time, the U.S. Office of Space Commerce is proceeding with development of TraCCS, a vendor-neutral traffic coordination system, and Chinese space leaders are publicly warning about megaconstellation risk while accelerating their own deployments.

Safety services are allegedly expanding in parallel with congestion — I say "allegedly" because so far, there's more talk than substance. But these plans also reveal a structural risk we have not fully addressed: The space community is drifting toward a coordination model that depends on a small number of dominant sensing and screening layers, which is, any way you slice it, biased.

When an event like a traffic accident or violation occurs, arriving at what's true is based upon a number of eyewitnesses and evidence. Each offers one interpretation of what happened. Diversity and independence of observers yields the most accurate and precise perspective, a holistic one where consensus and mutual agreement can surface and divergence can be explored.

But if the number of independent and diverse observers decreases, the amount of unchecked biases rises and becomes dominant. It's not just the number of observers that matters, but the diversity of perspectives. If we have many observers, but they're all the same — the same values, same models, same type of sensor — then systematic biases go without verification. Truth is what surfaces from tension and scrutiny. We should require that for our own safety.

A more resilient approach would be to make disagreement among independent tracking systems visible and actionable, instead of quietly collapsing it into a single fused picture. Orbital safety should be built on structured divergence across many diverse actors, not soft dependence on any one of them. A Lord of the Rings approach — one space situational awareness system to rule them all — would be irresponsible.

Large constellations generate not only traffic but data. Operators with thousands of spacecraft have dense telemetry streams, frequent orbit updates and onboard sensing. When an operator provides conjunction

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screening to others at no cost, the benefits are obvious immediately: Smaller satellite owners gain access to higher cadence alerts and better situational awareness than they could build alone. Entry barriers drop. Coverage improves. So, this part is good — "a rising tide lifts all ships" sort of thing.

The danger is that dependency risk grows concurrently. When many operators rely on one operator's screening outputs, that entity's models, assumptions, and blind spots propagate through the ecosystem, unchallenged by the scrutiny that naturally occurs as the result of having numerous independent and diverse opinions.

My point isn't that Stargaze is bad or that SpaceX is acting in bad faith — quite the opposite, in fact. Rather, the risk I see is in killing off plurality and independence of evidence if we sit back and let SpaceX become the sole, or dominant, provider of space situational awareness services. When safety becomes shaped by one dominant epistemic layer, that is fragile by design. Free screening improves access, yet it also concentrates coordination influence in ways the current governance model does not offset. Who's going to check SpaceX's answers or opinions? Many safety-critical fields already guard against this kind of fragility by design. Aviation, cybersecurity, finance, and weather forecasting all rely on independent verification and multimodel or multisensor cross checks, not because the leading provider is suspect, but because resilience requires plural, competing lines of evidence rather than a single dominant epistemic source.

Most of the current and proposed space traffic coordination concepts assume that safety improves as more raw data are pooled and fused. In practice, many operators can't share full measurement data, covariance details or processing pipelines. National security limits, proprietary algorithms and liability exposure all restrict disclosure. Fusion works best in high-trust environments, and orbit is not one.

I propose a different model. Instead of pooling measurements, each operator would publish bounded uncertainty envelopes around its own satellite orbital estimates. These envelopes express what remains plausible and what is excluded, without exposing raw inputs. Coordination is triggered when independent envelopes diverge beyond safe limits for a conjunction assessment. Here's an example: Operator X has one space situational assessment of a conjunction, Operator Y another. Each can provide plausibility bounds on its assessments. That is to say, each can state that a given conjunction can occur within some window of time and place, with no mention of likelihood or probability and with no attribution of responsibility or correctness.

The operators would then reconcile differences through a structured envelope-comparison protocol: When plausibility bounds overlap within agreed safety margins, coordination proceeds conservatively; when they conflict, a predefined escalation path triggers targeted follow-up observations, model reruns, or third-party arbitration to shrink the envelopes until operational agreement is reached. This keeps proprietary data private while still enabling cross-checking, convergence, and accountable resolution through independent evidence streams.

Technically, this is lighter weight than full data fusion and more compatible with mixed civil, commercial and defense participation. Architecturally, it avoids a single clearinghouse of truth. Coordination can be driven by shared uncertainty bounds and visible divergence, without requiring universal raw data disclosure.

"Orbital congestion is now a present condition, not a future scenario. Safety will depend less on whether we can produce one perfect picture and more on whether we can recognize when our pictures don't match."

Today, disagreement between tracking systems is often hidden inside fused catalogs and averaged solutions. Operators see a recommended miss distance and a confidence metric and never see the spread of underlying model outputs. When estimates suddenly shift or alerts arrive late, the prior divergence becomes invisible. Making divergence explicit changes behavior. If independent tracking pipelines disagree beyond defined thresholds, that signal surfaces early. Analysts investigate sooner, and operators coordinate sooner. Model weaknesses are exposed before they become operational surprises.

Orbital congestion is now a present condition, not a future scenario. Safety will depend less on whether we can produce one perfect picture and more on whether we can recognize when our pictures don't match. Independent sensing, independent estimation and shared uncertainty bounds allow coordination without forced transparency and without concentrated epistemic control. In a crowded orbit, many eyes with visible differences form a stronger shield than one dominant "eye of Sauron" view. ★

LOOKING BACK

100, 75, 50, 25 YEARS AGO IN APRIL–JUNE

COMPILED BY FRANK H. WINTER AND ROBERT VAN DER LINDEN

1926

During April and June U.S. airmail service by commercial airlines begins in earnest. In April, Florida Airways opens the Miami-Jacksonville air mail route, and Western Air Express opens a route between Los Angeles and Salt Lake City. In June, Northwest Airways opens service between Chicago and the Twin Cities of Minneapolis and St. Paul, by way of Milwaukee. **Aviation**, May 3, 1926, p. 665; May 10, 1926, pp. 704-705; July 26, 1926, p. 125.

1 **May 9** U.S. Navy Lt. Cmdr. Richard Byrd claims to have completed the first flight over the North Pole. His Fokker F.VII-3m trimotor, with pilot Floyd Bennett at the controls, reaches the pole at 9:04 a.m. Greenwich time. After circling the Pole for about 14 minutes at an altitude of roughly 2,000 feet, the aviators return to their base at Kings Bay, Spitzbergen, completing the round trip in 15.5 hours. Initially under dispute, Bryd's claim is later verified by the National Geographic Society after a review of his navigational records. **Aviation,** April 19, 1926.

May 20 U.S. President Calvin Coolidge signs the Air Commerce Act into law, introducing regulations to the budding civil aviation industry. The law directs the Commerce Department to certify aircraft for airworthiness and is the direct predecessor to the Federal Aviation Act of 1958 that creates the Federal Aviation Administration. **U.S. Air Services**, July 1926, pp. 22-24.

1951

April 21 The first U.S. jet transport, the Chase XC-123A, makes its inaugural flight in Trenton, New Jersey. Four pod-mounted General Electric J-47 turbojets power this modification of the YC-123 piston-powered airplane. **Aviation Week**, April 30, 1951, p. 16.

May 18 The U.K.'s first four-jet bomber, the Vickers 660, makes its first flight. This is a prototype of the Valiant, which is to replace the Avro Lincoln and Boeing B-29 bombers in service with Bomber Command. The design uses an all-metal stressed-skin construction with a sweptback wing. William Green and Roy Cross, **The Jet Aircraft of the World**, p. 124; **Aviation Week**, June 4, 1951, p. 15.

2 **June 20** Test pilot Jean "Skip" Ziegler completes the first flight of the Bell X-5 variable-sweep-wing testbed from Edwards Air Force Base, California. Subsequent flights demonstrate the usefulness of variable wing sweeping, but the craft proves too complex and heavy for service use. A.J. Pelletier, **Bell Aircraft Since 1935**, pp. 94-96.

June 30 U.S. testing of captured German V-2 rockets ends. Under Project Hermes, sponsored by the Army Ordnance and managed by General Electric, 67 missiles were launched over five years from White Sands, New Mexico, and Cape Canaveral, Florida. The V-2s generate extensive knowledge on the launch and operation of large high-altitude liquid-propellant rockets and set several flight records. Eugene M. Emme, **Aeronautics and Astronautics, 1915-1960**, p. 67; Willy Ley, **Rockets, Missiles, and Space Travel,** pp. 450-451, 458-460.

1976

3 **April 5** Aviation pioneer and mogul Howard Hughes dies due to medical problems aboard a private plane en route to Houston, Texas. He learned to fly while directing and producing the 1930 film "Hell's Angels" and set a world speed record in 1935 and transcontinental speed record in 1937. Hughes goes on to design the Spruce Goose flying boat and other aircraft at his company, Hughes Aircraft, and also contribute to the designs of the Lockheed P-38 fighter and Constellation transport. **New York Times**, April 6, 1976, p. 1.

May 12 NASA announces the first use of a satellite to relay medical data from a moving ambulance to a hospital receiving station. Developed by the National Space Technology Laboratories in Mississippi and General Electric's Science Services Laboratory, the special portable transmitter and antenna continuously communicate voice and medical data, including electrocardiograms. **NASA Release 76-86**.

4 **May 24** Concorde airliners operated by Air France and British Airways touch down at Dulles International Airport outside Washington, D.C., commencing commercial supersonic trans-Atlantic service. About 8,000 people gather to watch the planes, which arrive about two minutes apart. The Air France flight carries 80 passengers; the British Airways flight carries 75. **Aviation Week**, May 24, 1976, p. 1.

June 6 A Grumman A-6 Intruder attack bomber test fires the tactical version of the Tomahawk missile using the Terrain Contour Matching, or TERCOM, guidance system. Tomahawks could be launched from tactical and strategic aircraft, surface ships, submarines and land platforms as long-range weapons. Roy A. Grossnik, **United States Naval Aviation 1910-1995**, p. 316.

2001

5 **April 7** A Delta II rocket launches NASA's Mars Odyssey probe, named after Arthur C. Clarke's 1968 novel "2001: A Space Odyssey." Odyssey enters orbit around Mars in October, commencing a detailed geological mapping and chemical survey. The probe's significant finds include the abundance of subsurface water ice, which indicates life may have once existed on the red planet. **Flight International**, Nov. 6-12, 2001, p. 30.

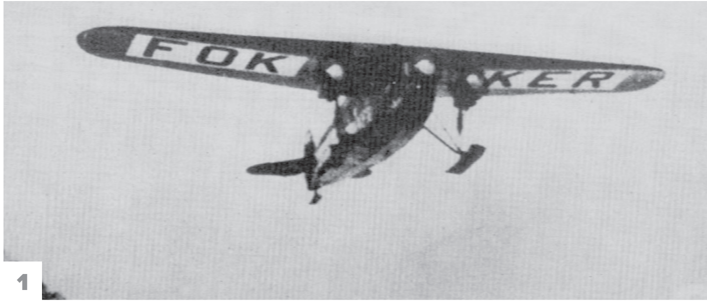
April 18 India's inaugural Geosynchronous Satellite Launch Vehicle (GSLV) lifts off from Sriharikota, putting the GSAT-1 communications satellite into a geostationary transfer orbit. A previous launch attempt in March was aborted when one of the four liquid-fuel Vikas strap-on engines lost thrust shortly after ignition, prompting the main engines to shut down before the rocket lifted off. **Flight International**, April 3-9, 2001, p. 30; April 10-16, 2001, p. 30; and April 24-30, 2001, p. 6.

6 **April 28** American millionaire Dennis Tito flies aboard a Soyuz TM-32 spacecraft with two veteran cosmonauts, becoming the first paying "space tourist." He pays $20 million to spend nearly eight days aboard the International Space Station, during which he primarily takes photographs and videos. Tito holds a degree in aeronautical engineering and spent five years at JPL helping craft Mars mission trajectories. **New York Times**, April 29, 2001, p. 6.

June 23 The X-35B, the prototype of the Lockheed Martin Joint Strike Fighter, completes its first vertical takeoff and landing during a flight test campaign in Palmdale, California. The following day, it completes its first sustained hover. **Lockheed Martin release**, June 23, 2001.

LOOKING BACK+

MORE ENTRIES AVAILABLE ON THE WEBSITE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Chris Reynolds, Lockheed Martin, 31

For Chris, his love of engineering started with tinkering with homemade rockets. Despite struggling to find accessible aerospace-related opportunities in high school, he developed a passion for concept aircraft design, which led him to pursue degrees in aerospace engineering. A first-generation college graduate, he now works as a program manager for Lockheed Martin's power and propulsion portfolio, also focusing on hypersonic technologies. — *Aspen Pflughoeft*

What's your aerospace origin story? ▶ I grew up going to air shows and wanted to fly planes. Because I came from a lower socioeconomic background, I thought being a pilot was a more attainable career than being an engineer. I always knew that going to college would be a pretty big lift for me because I'd be the first in my family to go.

Later, I got hooked on engineering while helping with my dad's small aerial photography business. I remember trying to build rockets with what I had, like sugar and cat litter. When the time came to think about college, I worried a lot about getting in and getting funding. The University of Michigan was the place that recognized my potential and gave me a scholarship that made attending possible. I worked really hard and kind of flourished from there.

Favorite thing about your job? ▶ The breadth of programs I've been able to work on and experiences I've been able to have. I've been fortunate to have so far worked on everything from hybrid airships — the slowest of moving vehicles — to hypersonics. It's only at Lockheed that I can consult on a space program in the morning and do hypersonics work in the afternoon. Being able to move from research and development to advanced programs keeps me going back to work.

What motivates you? ▶ It's kind of two parts. There's the Lockheed mission of protecting our warfighters and deterring conflict. And then there's the people connection, the community. I really enjoy that each day I get to work with people from all different backgrounds, whether it's working in the lab, on the manufacturing floor or with the company executives. I try to bridge the divide we often have between blue- and white-collar. I find some of the most interesting conversations and innovations happen at the intersection of those two categories.

What tech outside your field fascinates you? ▶ Space exploration. I love when I can read more about that. Outside of aerospace overall, it's biomedical and biotech.

What will the world look like in 2050? ▶ I see three areas of major change: AI will be more at the birth of future efforts, and many of us will be AI practitioners. Quantum will transform the way we communicate, sense and maybe even compute. And the one I'm most excited about — energy grid transformation — will give us a modern architecture with different ways of getting energy from place to place and a chance to rethink the grid we take for granted today. ★

MORE ABOUT CHRIS

AIAA RECORD: Joined as a student member in 2012 and became an associate fellow in January. He credits attending SciTech Forum and networking with helping him secure a Lockheed Martin internship, and eventually a "dream job" stint with Skunk Works in 2019. "It really allowed me to meet a bunch of people who believed in me early on. AIAA sort of looked beyond the experiences I didn't have and gave me a chance."

EDUCATION: Bachelor's degree in aerospace engineering, University of Michigan, 2016. Master's degree in aerospace engineering, University of Michigan, 2017.

GIVING BACK: He co-founded the Aerospace Robotics Competition (ARC) in 2014, a nonprofit that provides low-cost drone kits to encourage underrepresented students and schools to participate in flight competitions. Stemming from an AIAA working group on STEM K-12 education and initially funded by the AIAA Foundation, ARC hosts regional competitions where students can learn about software development, unmanned aerial vehicles and flight autonomy. "At first, my motivation was my shared experience growing up in a lower socioeconomic status with a school that didn't have these experiences. After our first program, we got notes from the students about how it really opened their eyes to aerospace. Hearing those stories — that's what motivated us to keep going."


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