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APRIL-JUNE 2025

# AEROSPACE AMERICA

Golden Dome's risks and the math that says it could work.

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# MISSILE DEFENSE 2025

AIAA


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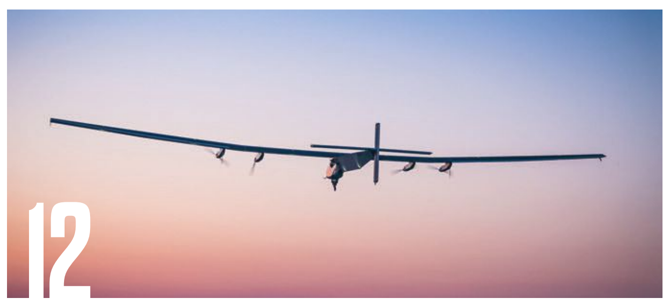
Notional depiction of space-based interception. Elements of this illustration were created in MidJourney, an artificial intelligence tool. THOR Design Studio



**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.

**ON THE COVER:** Our partner THOR Design Studio applied artistic license to a notional constellation of space-based interceptor satellites created by defense expert Fred Kennedy with the Satellite Tool Kit.

## EDITOR'S NOTEBOOK

# Supporting you with journalism and more

▲ A 2024 sunset photographed from the International Space Station. NASA

First, on a personal note, it's been an honor to lead this magazine to deliver impactful journalism to AIAA members for 11 years. With this issue, I conclude my time as editor-in-chief. As I chart my next step, I will always cherish my years at AIAA, whose mission is more vital now than it has ever been.

For those in the United States who have lost jobs or are living in fear of that, I am confident that AIAA will continue to do all it can to support you and equip you to adapt.

Perhaps the stories in this issue can be a welcome break for those who are stressed. For the cover story, we elected to dive deeply into a single topic that's arisen with the arrival of the Trump administration: the Pentagon's emerging Golden Dome plan. Jen Kirby looks at the strategic questions raised by the initiative [page 20] and provides insights from across a full spectrum of the think tank community, from the Heritage Foundation to the Union of Concerned Scientists. Fred Kennedy, the inaugural director of the Space Development Agency and now an entrepreneur, takes on the technical questions in an analysis piece [page 26]. He shows us how the plan could be doable, and he created a Satellite Tool Kit graphic to demonstrate his reasoning.

We also have a feature about the technology that, possibly as soon as next year, could empower the Nancy Grace Roman Space Telescope to detect the first pixels of reflected starlight from a Jupiter-sized planet beyond our solar system [page 34].

In the business realm, one of the great dramas unfolding is whether and how Boeing will be able to fully right itself. In "The Big Question," Cat Hofacker asked what more can be done, and she provides responses from four experts: a former Boeing chief engineer, a congressman who led one of the investigations into the MAX 8 crashes, an organizational culture expert and a researcher who participated on a panel that recommended safety improvements [page 16]. On the topic of aviation research and development, "perpetual" flight under solar power has long been a dream, and you can learn about the latest aircraft that's attempting to do it [page 12].

These and other stories in this issue, we hope, will provide some solace and perhaps inspiration. ★

Ben

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# FOR THE RECORD

# From our inbox

## Overstating the climate link

*Russ Paielli, an AIAA associate fellow in San Jose, California, took issue with Ben Iannotta's contention in his February/March column that the Los Angeles fires "painfully demonstrate" that the consequences of climate change are upon us ["Turning science into action against wildfires and climate change."]:*

"The recent Los Angeles area fires were the result of gross mismanagement, including empty reservoirs, negligent land management, and a late response even though they were warned well in advance of the hazard. 'Climate change' was most likely a minor contributing factor, and the notion that it made the disastrous effects of the fires inevitable is based on debatable science that I believe should be avoided in AIAA publications. We must be careful not to let 'climate change' be used as an excuse for mismanagement and negligence, both past and in the future as well."

## The case for the moon

*After reading the January Big Question ["Will humans ever permanently settle on Mars?"], Peter Turchi, an AIAA fellow in Santa Fe, New Mexico, wrote in to advocate for a lunar settlement:*

"The discussion of settling on Mars could benefit from some systems engineering: what problems are we trying to solve? We may readily grant the emotional urge to spread humanity off its fragile birthplace. But how best to answer challenges such as planetary defense, the development of high energy propulsion for space exploration and the search for extraterrestrial life?

"The Moon could serve as the base for a planetary defense system for at least some threats due to asteroid or comet impact. It could also provide an excellent site for nuclear propulsion technologies, unconstrained by environmental concerns for development on Earth. Most importantly, it would allow easier creation of a significant and self-sustaining portion of humanity away from potential hazards of catastrophe on Earth, e.g., super-volcanoes, plagues, war.

"Both the Moon and Mars offer constraints on visions that have been depicted for eight decades of astronauts frolicking outside shiny domes on the surfaces of other worlds. Now we know that radiation would force them to live below the surface. This would mean many thousands vs dozens of humans willing to live in an underground environment away from Earth. Human development may require periodic return to Earth's gravity. Would Mars offer this? What is the economic basis of activity for the colony? Special materials from Earth might be traded for advanced technologies from lunar laboratories.

"The case for the Moon is not merely a decision on an investment strategy for reaching Mars, but as a goal itself. Many of us have grown up on stories in which Mars is not too different from a cold, windswept desert. Reality is a lot harsher mistress. Living in an underground 'kiva' of Southwest traditions, I'd opt for an apartment with a real-time video view of the Earth and Sun shining on the Moon."

## Saving Kwajalein

*Philip Snyder, an AIAA senior member in Indiana, read the January cover story ["Can Kwaj survive?"] with interest but suggested an alternative use for the funds the U.S. Army plans to spend studying climate risk:*

"I would suggest that a legacy approach be applied to the current 11 cm, and potentially foreseeable 20 cm, rise in sea level at the site. In place of a $1.2 million study on mitigation, a civil engineering design and construction of a set of protective dikes at key locations would be a more cost effective action.

"While research on mitigating climate risk may be more attuned to 2020's thinking, such a study would likely be redundant to several already funded works and also fail to be in alignment with 2025 DOD policies and key missions going forward. No need to invite DOGE action."


**CORRECTION:**
The rocket graphic in the February/March cover story ["Two launches. Two companies. Two billionaires"] listed the wrong fuel type for the Falcon Heavy. Both stages are propelled by liquid RP-1 fuel, not liquid hydrogen. The online version has been updated.

## LET US HEAR FROM YOU

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

FLIGHT PATH

# Aerospace Leadership: A Strategic Imperative

Clay Mowry
AIAA CEO

As the world's preeminent aerospace power for more than a century, America's national security, economic prosperity, and public safety are directly tied to continued investment in our sector. Public and private capital spur technological development, develop engineering talent, and power critical scientific missions.

Our AIAA community includes the leading commercial companies, government agencies, nonprofits, and universities whose purpose-driven pursuits have broken barriers over the decades—including the sound barrier and the bounds of Earth's gravity—propelling humanity into the atmosphere and beyond the Kármán line. Collectively, we push the boundaries of what we can do in aerospace.

Our continued success in achieving great things depends on a strong workforce, cutting-edge research, and stable strategic investments in technology. Maintaining global leadership requires unwavering commitment from the government, as well as perseverance from industry and academia. We work with allies, partners, and customers around the globe. We enable safe and affordable travel. And we help the world to navigate, communicate, and investigate for the benefit of humanity.

The aviation, space, and defense sectors comprise over 2.21 million aerospace professionals generating over $900 billion a year in sales (**aia-aerospace.org/industry-impact**, Tracking State Data). Institute members are the brightest minds in aerospace from industry, government, and academic institutions. Their expertise and experience have led to groundbreaking research, unrivaled safety, unprecedented discoveries, and unique commercial products and services that power the global economy.

We've already witnessed several examples of aerospace leadership this year. These feats are built upon the deep technical foundation of aerospace leadership during the first 100 years of our Institute.

- Boom Supersonic's demonstrator aircraft, XB-1, successfully broke the sound barrier three times during its first supersonic flight on 28 January. XB-1 is the world's first independently developed supersonic jet, and the first civil supersonic jet designed and built in America.
- Two commercial companies put spacecraft on the south pole region of the moon in one week – Firefly Aerospace landed Blue Ghost on 2 March and Intuitive Machines landed Athena on 6 March. Both missions are part of NASA's Commercial Lunar Payload Services (CLPS) program with industry to move toward the broader goal of returning humans to the lunar surface.
- The U.S. Space Force landed its reusable X-37B spaceplane at Vandenberg Space Force Base, California, on 6 March, after orbiting Earth for more than a year. This seventh mission of the secretive vehicle tested space domain awareness technology experiments and sent back a striking view of Earth in the program's first released on-orbit photo.
- Blue Origin debuted its reusable heavy-lift space launch vehicle, New Glenn, reaching orbit on 16 January. New Glenn is unmatched with its heavy-lift volume in its large payload fairing, enabling freedom of design for satellite operators, customers, and government space agencies when the vehicle becomes commercially available.

In a recent message to members, AIAA President Dan Hastings shared how the Board of Trustees and headquarters staff are closely monitoring changes in government investment and actively working to chart a course of action and education with key decision makers in this rapidly evolving space. For our members who have been directly impacted by the recent government cuts, we also are opening new channels and resources to support you.

As the world's premier aerospace society, we have reached out to other professional engineering societies and industry organizations to join us in advocating for continued federal funding for the aerospace and defense sectors. It's more important than ever for the Institute to work with Congress and the administration to advance these priorities. We are known for our credibility when representing the voice of technical excellence in aerospace. It is our obligation to speak on behalf of our membership to ensure lawmakers understand the impact of aerospace on our way of life.

Our commitment to supporting aerospace professionals remains steadfast as we navigate this rapidly evolving space and position the Institute for its next century of progress. The remarkable aerospace achievements across defense, aviation, and space in just the past few months demonstrate the importance of what we do to shape the future. ★

R&D

# Applying AI to the language gap in air safety

BY STEVE LEE | stevel@aiaa.org

Poor voice communication has been cited in numerous air accident investigations as a significant contributing factor, the most deadly case being the 1977 runway collision of two 747s on Tenerife Island that killed 583.

Even though the United Nations' International Civil Aviation Organization mandates English proficiency for international aircrews and controllers, social media is replete with recordings of controllers and air crews having trouble understanding one another when strong regional accents or local slang is involved.

Bringing clearer voice communication to aviation is a top concern for Tor Finseth, a human factors scientist at Honeywell in Plymouth, Minnesota. Finseth leads a team whose members include researchers from Texas A&M University, the University of Texas Dallas and the University of Rochester. Their goal is to convert verbal exchanges into computer-generated voices in a highly understandable form. This would be done by combining artificial intelligence with today's natural language processing computer code.

Natural language processing is familiar to anyone who has encountered automated telephone call directories or dictated a message or music request to their car, smartphone or home speaker.

The Honeywell researchers are developing a digital test bed called RASP, short for Real-time Anonymization & Speech Protection. It will be the foundation for software and hardware that would instantly convert accents, local slang and other voice characteristics into standard, clearly enunciated speech in an anonymized voice that doesn't sound like a particular person. RASP is currently focused on English, and Finseth anticipates branching out into other languages.

Honeywell, as an avionics manufacturer, is interested in RASP for its aviation applications, but the project potentially benefits other sectors.

Clear voice communication technology could assist in reducing the number of air accidents, as traffic at U.S. airports continues to grow. The Hartsfield-Jackson Atlanta International Airport was the busiest airport in the world in 2023, recording 104.7 million passengers and 775,818 arriving and departing aircraft.

Darryl Brooks via Shutterstock

Members of the Spanish Civil Guard survey wreckage of two Boeing 747 jumbo jets at Los Rodeos Airport in Santa Cruz de Tenerife in the Canary Islands. The aircraft collided on the runway, killing 583.

AP/Ives

"Most research in this area is primarily looking at call centers," explains Finseth. "We're looking at human-to-human interaction in other high-noise environments like paramedics or manufacturing where the breakdown of communication is really going to cause some issues."

There might also be government intelligence applications, given that Honeywell is developing the technology under a "multi-million dollar contract" awarded last September by the Intelligence Advanced Research Projects Activity, or IARPA. This U.S. government agency sponsors "moonshot" technology development for the U.S. Intelligence Community, particularly in advanced computing. The contract spans 18 months.

While AI today is most often reserved for long-term analysis tasks with plenty of access to data, the RASP concept in part aims to take AI out to what computer scientists characterize as "the edge." IARPA asked the RASP team to develop the capability to process speech without connectivity with the cloud or a central server.

Finseth anticipates that advances in computer hardware and data communications will effectively and affordably make RASP suitable for existing airframes, control centers and communications architectures.

He also expects RASP and similar natural language processing applications to catch on with private aviators. "They could just put it on their iPad and just use it as they want for general aviation," says Finseth.

Which is not to say that the regulatory road will be an easy one for RASP and natural language processing. The developers expect that FAA and other civil aviation authorities will demand thorough testing of RASP with demonstrably consistent results across a dizzying spectrum of use cases.

Other industries' operational experience with natural language processing and testing will likely be key to industry and regulatory acceptance, Finseth says. ★

**Steve Lee** is AIAA's senior director of national security and summits.


ROBERT LONG, PRESIDENT AND CEO OF SPACE FLORIDA

# Florida's space man

Florida is home to the world's busiest spaceport, but retired U.S. Space Force Col. Robert Long wants you to know that Space Florida, the state-sponsored development authority he leads, is about fostering all sorts of private sector aerospace work — and not just on the state's Space Coast. I spoke to him by video from his office in Exploration Park, near the entrance to NASA's Kennedy Space Center. We talked about the funding tools at his disposal, Florida's partisan reputation and the "hivemind" that Florida has declared Washington, D.C., to be. — *Ben Iannotta*

## ROB LONG

**KEY POSITIONS:**
• Since 2023 — President and CEO of Space Florida
• 1997-2023 — Air Force and then Space Force officer
• 2021-2023 — Commander, Space Launch Delta 30, Vandenberg Space Force Base, California
• 2018-2021 — Senior military assistant to Mike Griffin, then undersecretary of defense for research and engineering at the Pentagon
• 2008-2010 — Squadron operations officer for National Reconnaissance Office launches from Cape Canaveral, Florida

**NOTABLE:**
**Led** Space Launch Delta 30, which operates the launch pad at Vandenberg Space Force Base, through a near quadrupling of the launch rate.
**Commanded** Space Launch Delta 30 during the termination of a commercially licensed Firefly rocket overland in 2021. The explosion sent debris raining down near Santa Maria, California, without injuries.
**Hosted** then-Vice President Kamala Harris at Vandenberg Space Force Base in 2022.
**Assisted** with the 2019 creation of the Space Development Agency, which manages military satellite development projects
**Early** in his career, he was an intercontinental ballistic missile launch officer.

**AGE:** 49

**RESIDES:** Viero, Florida

**EDUCATION:** Master of Science from the Dwight D. Eisenhower School of National Security and Resource Strategy, 2018; Master of Engineering from the University of Colorado, Colorado Springs, 1998; Bachelor of Science in electrical engineering from the University of Washington, 1997.

**Q: Thanks for speaking to me. Do you get out and meet with some of the companies that you help finance?**

A: We're the state's aerospace finance and business development authority. So, yes, we certainly are out talking to industry quite regularly, not just here locally around Brevard County and the spaceport, but all aerospace too. The Northrop Grummans, the Boeings of the world, and statewide. I was just in Miami last week, and I get out to the Panhandle and across the state. That's our team's role in terms of helping grow the company's presence here in the state. We get to have a lot of good interactions and understand the needs of the companies, understand what the economy and what the industry is looking like overall, and then work to make sure they can take advantage of the state tools and financial tools that we have to offer. At the same time, we listen to industry and make sure we can provide what industry needs, whether it's talent or otherwise here in the state.

**Q: We won't have time for a tutorial on financing, but is this free Florida tax dollars to the companies? Do the taxpayers come out in the black?**

A: We're not really interested in what I would call cash incentives. We are focused on entering into long-term partnerships with companies that are interested in growing over time. So initially, usually there's a move or an expansion, but then we can come alongside and then grow with them, or help them grow. Mainly, we act under a conduit financing structure where Space Florida becomes the legal owner of a facility or equipment, and there are certain tax benefits that come with that. It's very analogous to a port authority, whether an airport or a seaport. It's a very similar structure, not only from a tax perspective but also from a revenue-generation perspective and then bonding and some of the authorities that we have. And then we also partner with the Florida Department of Transportation. They're near what we call the Spaceport Improvement Program, which is more of a direct investment program, but typically that's based on company investment as well. So if the state was going to contribute $1 to a project, we usually see about $4.50 to $5 of private investment come alongside that. So we call it a leveraged match type of program.

**Q: You used the term "invest." Is it a literal payback to the state or is it in terms of jobs and growth?**

A: Could be both. We are allowed to do investing in the traditional sense, so there might be an excellent equity piece of that as part of the investment. Depending on how the company does, you'd see returns there. But to your point, really where we see the true benefit is on the economic impact. And the job growth then drives taxes — not income taxes here in Florida — but other contributions to the community. There's been something like about $6 billion worth of economic impact over the history of Space Florida. We forecast that to grow about a billion dollars a year. So, while there is revenue generated by Space Florida, it's relatively small compared to the overall, you know, economic impact of the aerospace industry across the state, really.

"There's been something like about $6 billion worth of economic impact over the history of Space Florida."

**Q: I notice the word "aerospace" as distinct from "space" on your website and elsewhere. So Space Florida is interested in more than space companies?**

A: That's correct. We actually deal with companies across the entire aerospace supply chain. If you were to look at the statute definition of aerospace, it's extremely broad. It deals with all aviation, all components of aviation, the space industry proper, the infrastructure that supports those industries, missile testing, the platforms that support those various platform and equipment that support those various industries also. So while we are called Space Florida, yeah, the statute that created this current version of Space Florida allows us to go across the entire aerospace industry.

**Q: I was reading that you have some connection with Eve Air Mobility. What's the nature of that?**

A: If you look at eVTOLs and advanced air mobility, there's several studies or reports out there that have noticed or designated that central Florida is one of the key markets, first markets for advanced air mobility, South Florida being another top market. When you look at Florida in general, it's ripe for investment in advanced air mobility. So, there are several companies that are obviously in that space. Eve is one of them. It happens to be headquartered here in Melbourne, and they are JV, or originally was connected to Embraer, who we have a long business relationship with here in Florida also. So we did enter into a strategic partnership with them, which included an investment, but there's several components of that partnership, with the intent to help them grow and really help the entire industry grow here in Florida.

**Q: I'm gathering that these activities aren't all about shunting stuff to Cape Canaveral to be launched.**

A: Yes, absolutely. We don't lose sight of the fact that we benefit from the world's busiest spaceport, and we certainly are focused on working with our federal partners — the DoD side and the NASA side — on making sure that the spaceport is maximizing its capacity and resilience and making sure the infrastructure investments are in place for years to come. But you're right that we look across the entire state, not only just for aerospace work. So you know, there's tons of work going on, from the Panhandle all the way down to South Florida. In the aviation world, a great example is the company CAE. It's a Canadian company, but they have their U.S. headquarters in Tampa. We helped them build that building and then expand it. They're one of the world's top flight simulator builders.

**Q: That said, I'm sure space launch is a pretty big part of the business. Is there a limit to how much growth the local community can accept in terms of the number of launches? Because, you know, waters get closed down, and you always have a little bit of risk of some kind of incident with debris or gases or whatnot.**

A: Our federal partners manage the overall operations on the complex itself. When I sit back and look at it from a Space Florida perspective, we've actually made tremendous strides. We collectively have in the last couple of years gone from, like, 30 launches just three years ago to 90, then to 150 last year, and hopefully this next year. A lot of that growth is by being smart, working more efficiently from an operational scheduling and process management perspective. Flight termination systems were a key part in reducing the systems that are required to launch. We've gotten better at working with FAA to manage air corridors and air traffic so that we're not impacting commercial airline travel too much. There's plenty of physical capacity here at Cape Canaveral to grow from. There's plenty of land area. But you're right, you're always looking at the processes. That's why we have the reviews that we have and we go through whether that's environmental or otherwise.

**Q: What effect is the change of presidential administrations having, or what effect do you think it will have?**

A: We haven't seen any effect, necessarily, and I don't know that there will be. There's so much interest and energy behind the space industry in general that I think we'll continue to see growth. Our job will be to keep managing that growth, regardless of where the demand signal comes from.

**Q: Do you know anyone at NASA or maybe FAA who's been let go or resigned?**

A: I don't have any direct connections to anything like that. Most of what I've seen is in the press.

**Q: Is Gov. DeSantis' proposal to shift NASA headquarters to Florida gaining any traction that you see?**

A: You might know that better just from looking at it publicly. I do know that when you look at the proposal that the state put together to highlight all the reasons why it would make a lot of sense in terms being away from Washington, D.C., which seems to be an interesting concept for several out there right now —

**Q: On your website is the document "Florida's NASA HQ Pitch," and it refers to the "bureaucratic hivemind of D.C." What does that mean?**

A: I think, at the end of the day, it seems like there's a lot of discussion about streamlining activities, and that's probably all associated with that. Most of the programs that launch, the vast majority come through Cape Canaveral at some point. Not all obviously.

**Q: Was the "hivemind" term produced by Space Florida or the state?**

A: That was in the state's document, yeah.

**Q: You were in the Pentagon, though, so you must know some people at NASA Headquarters. Is it really a "hivemind"?**

A: Here's what I would say. You always want to be able take advantage of all the talents you have access to. And there's some value in creating pathways for interesting ideas to take flight.

**Q: I chose to largely relocate here in the Space Coast during the pandemic. I love the industry, the people, the fishing. Like me, you probably hear "Florida Man" jokes when you get out and about. What do you want people to know about this area of Florida?**

A: When you look at the data, Florida leads in so many parts of the aerospace world, whether it's manufacturing, the space industry in general, the spaceport itself. It's generally a pro-business friendly state. When you really peel that back, you can see why in 2023, 2024 there were, like, around a thousand people moving to Florida a day. It's a great place to live. It's a very pro-business climate for companies to come and grow. You put all that together: great people, great education system, great talent across the state and a climate that is receptive of people, I think you get in a pretty good place.

**Q: Are investors or businesses that are looking to start up here at all worried about Florida's fairly partisan reputation?**

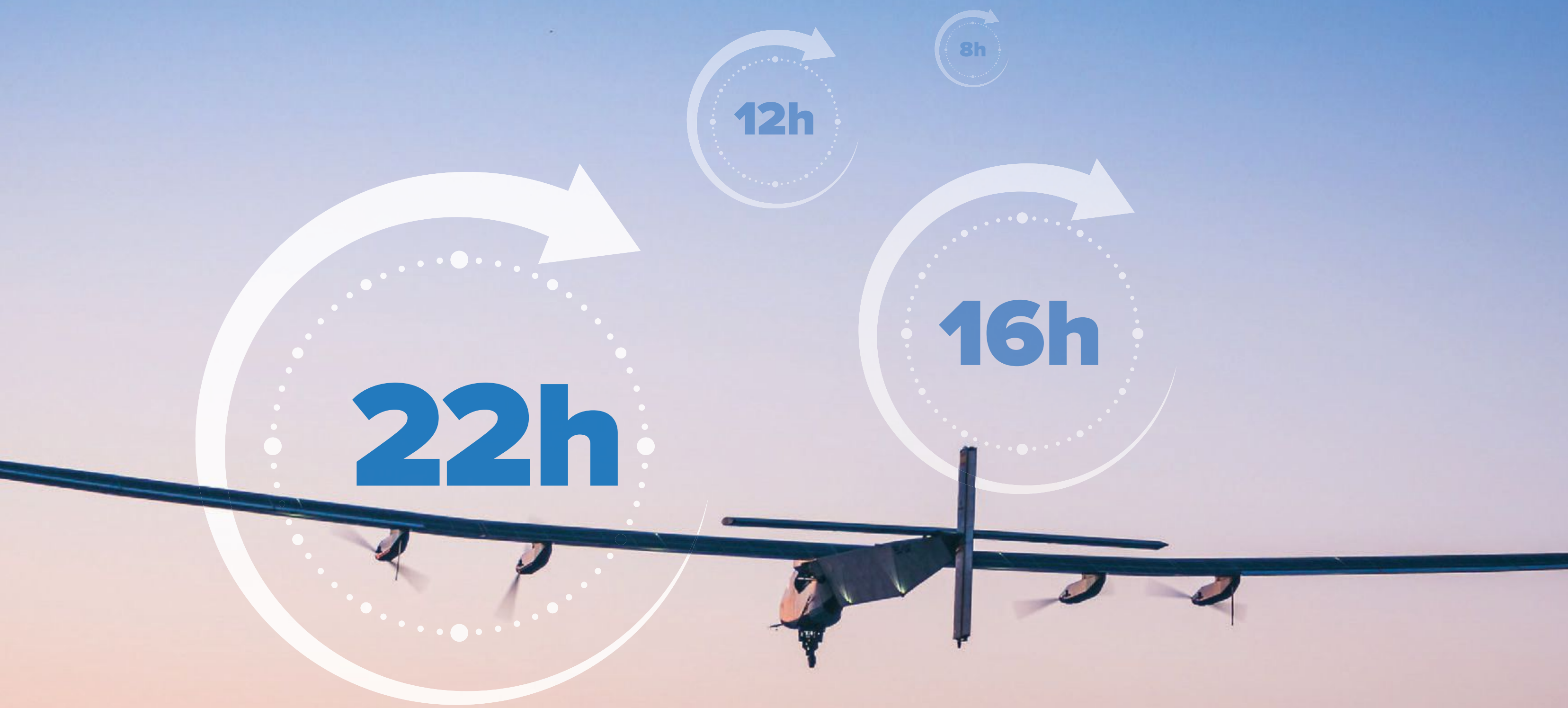
A: I don't think I've ever really heard anything along those lines. When we talk to companies, the things that we hear are: "What's the talent look like? What's our workforce population?" We typically don't hear too much about things outside of those, really, when it comes down to it.

**Q: If a company outside of Florida wanted to set up shop here and they had somebody very talented who is LGBTQ+, should they feel psychologically safe moving them to Florida?**

A: I would think so, and I don't know a reason why not.

**Q: Well, thank you for being part of our new print edition, Rob.**

A: Thanks, and let us know if there are any follow-ups. ★




# Building toward (almost) perpetual flight

# The longer a surveillance aircraft can stay aloft and on station, the less time it wastes in transit. But if the aircraft is too lightweight, it could flex and crash in the winds. The U.S. Navy is looking at a solar-powered design whose engineers have taken up the challenge. Keith Button spoke to the CEO of Skydweller Aero.

BY KEITH BUTTON | buttonkeith@gmail.com

The Skydweller solar-electric plane has a wingspan longer than a 747's but weighs just 2,500 kilograms. When this remotely flown craft lands at Stennis International Airport in Mississippi, two technicians riding electric scooters must grab short poles under the wings and steady the plane on its two center wheels as it slows. This prevents either end of the massive span from scraping the runway.

This wingspan and low weight are the key factors that have permitted the design to stay aloft for up to 22.5 hours so far, with 90 days being the ultimate aim. But the long span also makes Skydweller susceptible to wind gusts that could flex its wings and tear apart the carbon frame covered in solar cells on the upper surface.

"That's what's killed every other solar-powered aircraft to date," says Robert Miller, head of Skydweller Aero, the Oklahoma City company developing the plane. "You've got to understand aeroelasticity," he says, referring to the science of predicting the flexing of an aircraft's structure under aerodynamic and inertial forces.

Other contestants in the race to build a "perpetual flight" airplane that flies for months at a time have crashed because of the issue. AeroVironment's unoccupied Helios prototype broke apart and crashed into the Pacific Ocean in 2003 after encountering turbulence, and an unoccupied Zephyr prototype built by Airbus crashed in 2022 due to storm turbulence.

Now, in a new round of test fights from Stennis that began in February, engineers hope to prove that their solutions can keep Skydweller aloft for days at a time consistently. They want to show their sponsors, the U.S. Navy and U.S. Southern Command, that the plane could be a cheaper, longer-flying alternative to jet-fuel-powered drones for tracking drug-runners, smugglers and other nefarious characters at sea. Miller declined to provide the contract amount for this year's flights, but the 2024 flights were funded under a $5 million Navy contract.

The idea is to take another step toward the 90-day goal by demonstrating that the design can reliably operate its sensors and communication links and stay aloft for about seven days — roughly four times longer than can be done by MQ-9 Reapers, the remotely piloted drones that were commonly flown by U.S. forces over Afghanistan and Iraq. Miller envisons that someday, each Skydweller would carry 360 kgs of batteries, communications equipment, cameras and other sensors needed to link to satellite or radio signals. Like Reapers, they could be operated from anywhere with a keyboard and mouse, Miller says — but at a much lower cost. "If I've got internet, I can talk to it."

Last year, the plane was flown from Stennis in August and September for a series of tests that included the 22.5-hour flight over the Gulf of Mexico — or America, as President Trump has renamed it.

Miller saw surveillance potential in Skydweller's predecessor, the onboard-piloted Solar Impulse 2, and teamed up with venture capital backers to acquire it for an undisclosed price in 2019. Three years before, Solar Impulse 2 had become the first solar-powered plane to fly around the world, piloted on alternate legs of the journey by Solar Impulse co-founders Bertrand Piccard and André Borschberg. For Miller, the plane showed promise at the time as a lower-cost, longer-loitering alternative to conventional drones for sensor missions, such as those that required a "virtual hover" flight speed and a large payload capacity for carrying forest-canopy-penetrating radar.

Part of making Skydweller resilient in gusting winds involves flight control software, which Miller and his team built as they adapted the piloted Solar Impulse 2 to become autonomous. Skydweller's airframe is nearly unchanged from Solar Impulse 2. By designing the software to fly the plane through turbulence, the engineers could keep the carbon structure as light as possible without causing the wings to break apart when shaken by wind gusts.

**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.

◀ The unoccupied Skydweller aircraft flew autonomously for the first time in April 2024.

Skydweller Aero


They started by building a computer model of the aircraft, from which they developed an aerodynamic model and a structural model. The structural model showed how much the plane would twist or bend when it encountered loads, such as wind gusts. They also modeled how the aerodynamics changed when the plane's structure was deformed, such as when the wing tips tilted up at a certain angle.

Next, they needed to find out how the plane would respond to vibration caused by winds, so they performed ground vibration tests. They attached accelerometers to the wing, tail and fuselage to measure the response when the plane was vibrated by a shaker. They also recorded accelerometer readings when the plane's wings and control surfaces were tapped by a small hammer.

With these readings about the plane's responses to vibration, they updated their structural models. The readings also helped determine where to place accelerometers on the plane's wings for in-flight tests. Then they directed it into turbulence to see how it responded, and to verify that what their models predicted was accurate in flight.

"You go out and look for stuff to shake you up a little bit," Miller says.

At the same time that they were building their computer models of the plane and tuning them with measurements from actual flights, the engineers were also developing and tweaking the flight control software. Miller declined to go into specifics, but in general, the software moves the control surfaces on its wings and tail in real time to unload lift created by wind gusts. This prevents damage from extreme twisting or vibration by gusts, like the severe wing bend that occurred on AeroVironment's Helios before it broke apart and crashed. The software's flight adjustments also helps control Skydweller better, such as when it encounters crosswinds during a landing.

There are other unique techniques for flying a plane with the wingspan of a 747, Miller says: The plane needs to bank and turn slowly, for example, because of the difference in speed between the outer and inner wingtips. The plane's cruising speed is 43 kilometers per hour.

"As you get larger, and we're much larger, aeroelasticity doesn't scale," he says. "It gets much harder."

Skydweller flies as high as 45,000 feet as a means of energy storage, so it can descend slowly overnight and use up less of the battery power that drives its four propellers. Because the plane flies in the 5,000- to 30,000-foot "solar-powered aircraft death zone" of the atmosphere where weather occurs, avoiding turbulence has been another key issue to contend with, Miller says. The engineers needed to build an automated weather prediction and avoidance software package.

They developed cloud-based software that receives live feeds of weather data and predicts where thunderstorms and the resulting winds will occur so that the plane can avoid them. The software turns bad weather and dark clouds into obstacles for the plane's onboard flight software


▲ The solar-powered Skydweller plane on the runway at Stennis International Airport in Mississippi after a 2024 flight test. Skydweller Aero is designing the craft to fly for 90 consecutive days.

Skydweller Aero

to avoid, much like a 3D obstacle course.

"We encapsulate that bad weather and make it into a solid obstacle," Miller says.

Algorithms chart a flight path through the obstacles while also maximizing surveillance collection capabilities for a given mission and collecting enough sunlight for the plane's batteries for flying at a high enough altitude to make it through the night. Clouds that obscure the sun must also be avoided so that the solar cells that plaster the top surfaces of its tail, fuselage and wings can keep the batteries charged.

"You want to make sure in the morning you're not under a dark cloud," Miller says. "You may not want to descend below a certain point at night, because in the morning you want to be at a certain altitude to avoid the clouds."

As the plane becomes capable of flying longer and longer flights, another key issue will be redundancies: how to keep flying when something fails on the plane, Miller says. "Making an aircraft fly, by itself, is not that hard. It's making it fly when not one, not two, but three things go wrong, and you want to bring it home and land it," he says.

That's where Skydweller's large payload comes in. It can carry more backup communications, avionics and actuators than smaller-payload solar aircraft, Miller says. "There's no single failure that can bring down the aircraft."

"If you want to fly for 30 or 60 days, things are going to go wrong. It's a probability thing," he adds. For a plane to operate in real-world conditions and be more than "a science experiment," it has to carry redundant equipment, he says.

For example, Skydweller's engineers worked with actuator suppliers to develop backup motors to move control surfaces in the event the original motors failed. "That's probably the toughest thing to get highly reliable."

They knew they would need redundancy, but the question was how much. They built a systems integration laboratory in Oklahoma City consisting of a rack of servers with duplicates of the plane's avionics and flight control computers, along with a test rack for the actuator motors that move the wing and tail control surfaces. At the lab, they moved the actuators as they would be moved in flight, under specific aerodynamic loads, and simulated in-flight failures for the actuators, electronics and backup actuators and electronics as those failures might be predicted by probability models. They tested how the plane's backups would respond to, for example, an electrical component failing and rerouting power through another circuit. The simulations also helped them plan what less essential tasks could be abandoned in the event of a failure to keep the plane flying.

"Maybe you've got to shed some stuff that's not important anymore because you don't want to overload a power bus," Miller says. "You spend a lot of time worrying about 'Well, if this thing fails, how do I compensate and if that thing fails, how do I compensate?'"

They determined that quadruple redundancy — three backups for every potential failure point — would make the plane 99% reliable through a 30-day flight. Skydweller now has triple redundancies, and Miller is in the process of upgrading it to quadruple redundancies. Redundant flight computers "vote" when the logic in one fails, he says, and the majority determines which one is wrong.

"The most difficult thing is when you have two flight computers; it's like a man with two watches who doesn't know what time it is because he's never sure which one is right," he says.

Part of making Skydweller capable of flying longer has involved accumulating many small improvements in its solar cells, batteries, propellers, motors and weight reduction, Miller says. To decide whether the cost of a given improvement will be worth it, the engineers simulate how the update to, say, solar cells on the wings will improve the plane's ability to stay aloft longer. One metric is the latitude at which the plane can operate during the worst day of the year for a solar-powered plane. That's Dec. 22 in the Northern Hemisphere, the winter solstice and shortest day of the year. If a particular improvement would significantly widen the latitude band it could operate in year-round, then it might buy its way onto the plane.

"You slay this demon of perpetual flight by multiple cuts. It's not one thing that kills it. You've got to attack it from 15 different ways," Miller says. "Each one of those builds up a little bit more margin for you." ★


**Boeing is seeking to climb out** of the most difficult period in its 110-year history, which began with the 737 MAX 8 crashes that killed 346. Just when it appeared quality was improving, a door plug flew off an Alaska Airlines jet in early 2024. Today, production of the MAX and 787 remains below targets. In the space domain, the company hasn't said when another Starliner capsule will be flown. CEO Kelly Ortberg has promised to "fundamentally transform" the company culture, one of the pillars of the Safety & Quality Plan created after the door plug incident to remake its culture, among other changes. I asked experts from Congress, industry and academia what else should be done. — *Cat Hofacker*

# Peter DeFazio

Former Democratic member of Congress and a former chair of the House Transportation Committee. Oversaw a congressional investigation of the 737 MAX crashes and introduced the Aircraft Certification Reform and Accountability Act signed into law in 2020.

Congress can't legislate corporate cultural change, but the culture has to change. Boeing has to assure people that they are going to prioritize quality and safety and deliver on that message. What the House Transportation Committee found in its investigation was that during the design and certification of the 737 MAX, numerous people spoke up and said, "Hey, you can't design the MCAS software to activate with input from only one Angle of Attack indicator." And Boeing management said, "Oh yeah, we can. We got to get this thing out the door."

To shed that culture, there's probably a fair number of upper management people who need to go, and Boeing needs a new and active board of directors to push the management. They must have a system where the line workers, the engineers, the safety supervisors, the quality people all feel absolutely free to whistle blow and report problems — and be rewarded for doing so. I'd have all of management take a 10% pay cut and put that money in a fund for people who report quality or safety problems. You could change the culture fairly quickly that way, if it was clear that is the priority instead of "Watch the stock ticker," or "Jam these things out the door as fast as we can."

Kelly Ortberg may be the person who can get Boeing back to where it used to be, but the problems aren't limited to the MAX. There are also ongoing production delays and problems with the 787 in South Carolina. *[Boeing CEO Brian West told investors in January that plans call for increasing monthly production from five to seven "sometime this year." — CH]* Boeing should hire an outside group to come in and audit them. These experts could come in and say, "If you really want to make safety and quality your highest priority, here's the things you need to do internally to make that happen." Also, have the experts look at what their suppliers are doing and what needs to change there. *[Boeing in early 2024 appointed former U.S. Navy Adm. Kirkland Donald to "conduct a thorough assessment of Boeing's quality management system for commercial airplanes." The company says that review is ongoing. — CH]*

The other piece of this is transparency. I haven't seen Ortberg or anybody else in senior management give interviews where they talk at length about changes that they're making or have been made to increase the safety and quality culture. They need to essentially run a public relations campaign. Bring in the press. Let reporters walk the line and talk to the workers without a supervisor looking over their shoulder. Now, Boeing has done some retraining of workers with special emphasis on safety, so I would hope that things are better at the line. But they have to show the world that things really have changed, if they have changed.

Boeing can recover, but it's going to require a gargantuan and transparent effort. This was once the greatest aerospace manufacturing company in the world, and they need to get back to that gold standard.

"I'd have all of management take a 10% pay cut and put that money in a fund for people who report quality or safety problems."

**— Peter DeFazio**

# “What advice would you give Boeing?”

## Ashley Fulmer

Assistant professor at Georgia State University specializing in organizational culture and trust dynamics in organizations.

The first thing I’d like to see is some active trust building and trust repairing with the public. Take the February announcement that Stephanie Pope will now just be head of Boeing Commercial Airplanes instead of also having the dual role of Boeing’s company-wide chief operating officer. In statements to the press, Boeing indicated that this was done to focus on 737 MAX production, but it could have been explicitly discussed in relation to Boeing’s commitment to safety. Instead, the company has largely left the public to draw their own conclusions.

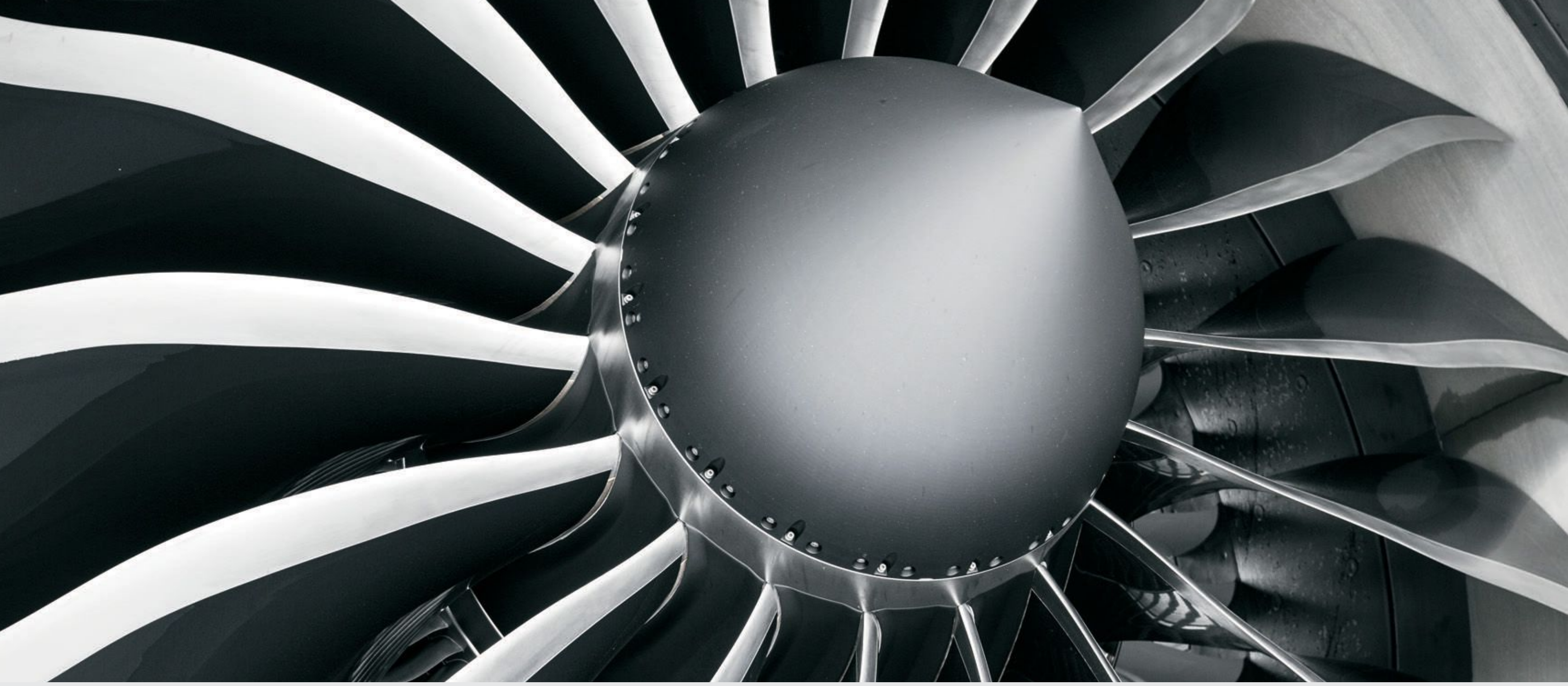
Trust is not just a cognitive assessment; there’s an emotional component to it, a gut reaction. That’s why the stories about Boeing’s machinists going on strike and the astronauts who rode on the Starliner capsule having to stay longer on orbit have gained so much traction — it’s the human element. And with all the aircraft-related incidents that have happened recently, the public is feeling very vulnerable. So this is an opportunity for Kelly Ortberg and Boeing to be transparent about the changes they’ve made, to show they understand those concerns and demonstrate that they take the public welfare seriously.

On the business side, there needs to be tighter control of production and quality assurance. In the past few decades, Boeing had started to rely on external suppliers a lot more, and its supply chain has become massive. That model works in other industries, but it’s difficult in a safety-critical one like aviation. I see Ortberg trying to correct this by reacquiring Spirit AeroSystems, for instance.

Strong control over production and quality should be reflected in the organizational culture as well. There needs to be a restructuring so all the decision making and information is coming from a central place. Boeing’s realignment of its engineering chain of command is a good example of this. *[Boeing in September 2019 announced this shift in its reporting chain, where every engineer would report to another, up to chief engineer Greg Hyslop. — CH]* If the employees see leadership taking that accountability, then the employees will start regaining their trust in the system and can provide powerful testimony to the general public. When leadership comes out and says “We’re trustworthy,” people will always take that with a grain of salt. But if it’s employees speaking out and saying “We’re proud of our work and the company we’re a part of,” that will help shift the public perception, especially in the age of social media.

On the other hand, employees are very attuned to any differences between the stated or publicly espoused culture — what leadership is saying — and the actual enacted culture that is occurring. Think of the news reports about employees reporting problems and getting passed over for promotions afterward. That culture is very at odds with what Boeing leadership has said about how people are encouraged to speak up. So if the employees don’t see evidence of a new way of doing things, they aren’t going to change their behavior and help bring about that culture change needed to improve safety and rebuild trust.

“With all the aircraft-related incidents that have happened recently, the public is feeling very vulnerable. So this is an opportunity for Kelly Ortberg and Boeing to be transparent about the changes they’ve made.” **— Ashley Fulmer**



# Greg Hyslop

Former Boeing chief engineer and chief technology officer. Retired in 2023 and is now a consultant. AIAA Fellow.

There are a lot of theories on why things got to where they were, and Kelly Ortberg has talked about those. We were chasing a delivery rate and as a result, work traveled to the right on the schedule and tasks were completed out of sequence. There were issues in terms of how we managed our subcontractors, and we let defects come into the factory and then we dealt with them there.

Boeing has all the right changes underway to address those problems, but it's a big company. It's like turning an aircraft carrier — it takes a long time, but it will turn. So the most important thing is to stay the course. In 2019, one of the things we did after the MAX crashes was realign the company so that every engineer reported to another engineer all the way up to me. That achieved a degree of independence for engineering and was important to strengthening the engineering culture of the company.

Continuing this culture change will require constant reinforcement all the way from the CEO and the board to the individual employees. Quality is a lot like having a security clearance: It resides with the individual and the choices they make. So the mission has to be owned by every engineer, every mechanic on the production floor, every quality inspector. Similarly, leadership has to create an environment where if people make a mistake, they believe that they can speak up without fear of punitive action. When I worked in Boeing's missile defense programs, we gave everybody a halt card that they could throw if they saw something they weren't comfortable with. Then work had to stop until that issue was dealt with. We've got to have that same attitude across the company now, where we're willing to miss a quarter's deliveries because somebody raised a question on the factory floor. Now, the nature of the work in our industry means there will always be pressure to meet deadlines, but we can't let that cause people to make bad decisions. The financials have to be a lagging indicator of progress but never take precedence over quality and safety goals.

A big near-term priority is to get 737 production stabilized, because that comprises the majority of orders waiting to be fulfilled. Then get the entire commercial airplane business stabilized. That will generate the cash needed to get a new airplane going. It's important for the business, but also so important for the workforce. You've got to build excitement and hope, and the best way to do that for a bunch of aerospace people is a new airplane.

I still believe Boeing has the best engineers in the world. Yes, there were bad design decisions made on the MAX based on bad assumptions. *[Former CEO Dennis Muilenburg told a congressional panel in 2019 that Boeing "made some mistakes" in designing the MAX, specifically in designing the Maneuvering Characteristics Augmentation System software to take input from only one of the two Angle of Attack sensors — CH]* We've learned from that. That's why you hear Kelly say that MAX production will be back at 38 a month when they're ready. Wall Street hates hearing that, but it's the right answer. I think they'll be successful; they've just got to stick with it even when the criticism comes.

> "The financials have to be a lagging indicator of progress but never take precedence over quality and safety goals."
>
> **— Greg Hyslop**


# Najmedin Meshkati

Engineering professor at the University of Southern California specializing in human factors. Member of congressionally directed panel that in 2024 made recommendations for improving Boeing's safety culture.

Boeing used to be the gold standard for human factors. Look at the 757 and 767 cockpits; pilots were directly involved in their development from the design to testing to deployment to training. Since then, the company has made a series of decisions that eroded and decentered human factors, and that in part is what led to the MAX crashes. The Maneuvering Characteristics Augmentation System that drove the noses of the planes down was poorly designed, it wasn't listed on the pilot manuals, and the Lion Air and Ethiopian Airline pilots never knew the software existed.

For our report, we reviewed 4,000 documents from Boeing, visited six of the company's facilities and interviewed 250 employees. Our 53 recommendations are a road map to building a strong safety culture with human factors at the center of it, so I'd advise everyone in Boeing leadership to read it. I was encouraged to hear that they implemented one of our recommendations last year by hiring a chief human factors engineer, former astronaut Nicholas Patrick. But for him to make a difference, he must be able to sit at the table with the chief engineer and have his voice carry equal weight. If the structure of the airplane is king, as they say at Boeing, then human factors has to be queen at least.

As far as regaining the public trust, the very first step is for Boeing to regain the trust of its employees and their unions. In our employee interviews, we saw a disconnect between the rhetoric of the C-suite and what people experienced on the shop floor. So even if the leadership believes that safety is a priority, it appears that message is not trickling down. We were wrapping up our report when the Alaska Airlines door plug incident occurred in early 2024, so it wasn't part of our review. But it amplified the expert panel's concern that the safety-related messages or behaviors are not being implemented.

"Give the executives offices in Renton on the shop floor so they're really close to where the technical work is happening."

**— Najmedin Meshkati**

Bringing Boeing headquarters back to Seattle would help tremendously with that. Give the executives offices in Renton on the shop floor so they're really close to where the technical work is happening. Change the makeup of the board of directors to reflect an emphasis on human factors and system safety. Don't just appoint lawyers, former governors or business people; get technical experts who understand the technology and have experience in safety management systems. Get people from other safety-critical industries — nuclear power and oil refining — with fresh ideas about how to improve the safety culture and provide lessons learned from their own experiences.

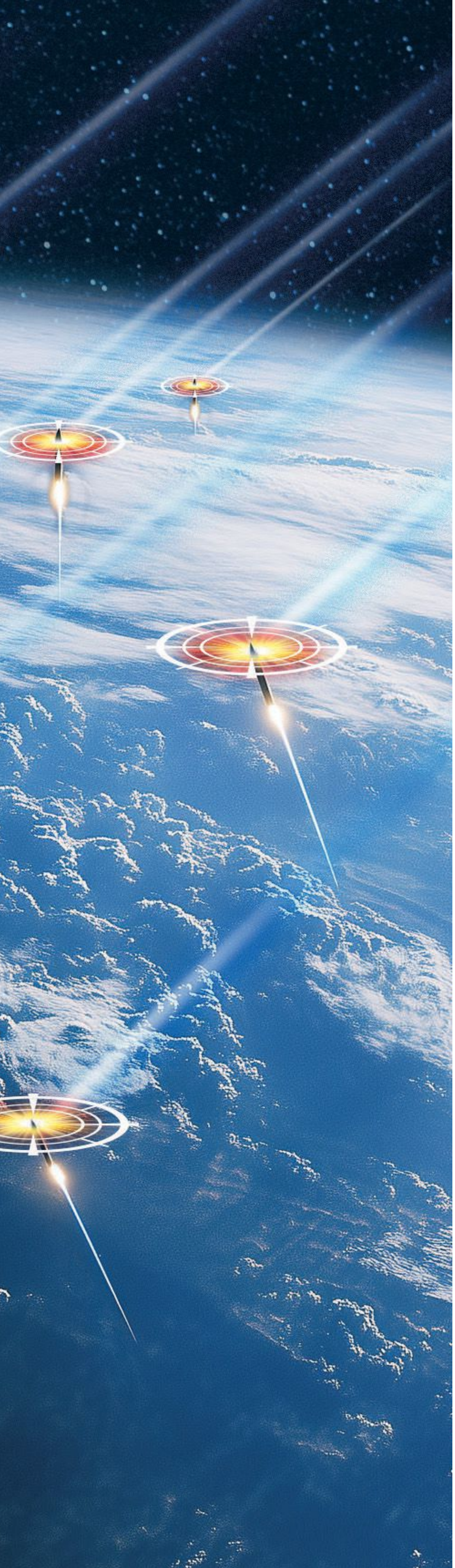
Change is possible, but only if it starts at the top, and only if the CEO and board of directors become personally involved. ★

GOLDEN DOME

# SMART STRATEGY OR RISKY BUSINESS?

**If the United States figures out how to shoot down missiles from space, will adversaries throw up their hands and stop making weapons? Or will they simply make more missiles? Jen Kirby digs into the Golden Dome plan.**

BY JEN KIRBY | jenkirby11@gmail.com



Imagine that tensions between the United States and a nuclear-armed adversary are intensifying. The threat of an all-out strike against the U.S., by miscalculation or intention, increases by the day.

Suddenly, U.S. satellites equipped with infrared cameras detect the flame exhaust from dozens and dozens of intercontinental ballistic missiles. Those tracking satellites summon the nearest interceptor carrier satellites, like the algorithm of a ride-hailing app finding the nearest driver. Interceptor rockets are fired off, and they accelerate to ram into the missiles, destroying them like bullets hitting bullets. The United States has prevented a catastrophic attack on its homeland and potentially averted a nuclear apocalypse for the entire world.

This is how the Trump administration's plan for a spaced-based missile defense, or "Golden Dome," might work, though it is still just a hypothetical capability. The program is the latest iteration of the decades-long vision to protect America from nuclear or conventional strikes. Whether or not Golden Dome is fully realized, the program may reshape U.S. defense and the global arms race.

"Strong believers in international norms, in the United States leading by example and forbearance, they probably won't be happy with this" Golden Dome approach, says Peter Garretson, a senior fellow in defense studies at the American Foreign Policy Council.

Whereas, Garretson adds, "anybody who's actually aware of how easily and unprotected we are against these threats, and I suspect the American people, probably are happy about this."

President Donald Trump's "Iron Dome for America" executive order, signed Jan. 27, says that the United States must "provide for the common defense of its citizens and the Nation by deploying and maintaining a next-generation missile defense shield." It specified that this defense should include "proliferated space-based interceptors capable of boost-phase intercept," meaning striking the missiles over enemy territory while they are still accelerating. The "Iron Dome" in the title was an unmistakable reference to Israel's missile defense capabilities for low-tech, short-range rockets — but the Department of Defense has since rebranded this entirely distinct and much more ambitious program with the "Golden" moniker.

The order directs the secretary of defense to produce and deliver a detailed "reference architecture" in 60 days, meaning late March. To get going, the Space Development Agency in early February announced the release of a "special notice" seeking ideas from industry for the architecture. It followed a "request for information" from the Missile Defense Agency seeking "innovative missile defense technologies" and ideas for accelerating an existing missile-tracking-satellite development program.

"We're going to protect our citizens like never before," Trump said about the Golden Dome during his joint address to Congress in March.

The proposal hearkens back to President Ronald Reagan's 1983 Strategic Defense Initiative. That "Star Wars"

**Jen Kirby** is a freelance journalist covering foreign policy, national security, politics, human rights and democracy. Based in New York, she was previously a senior reporter at Vox.

plan sought to build a space-based missile defense constellation that would protect America from a nuclear attack and so make nukes obsolete. It would shield the U.S. "from nuclear missiles just as a roof protects a family from rain," as Reagan described it in 1986. The concept soon evolved to include the pursuit of "Brilliant Pebbles," small spacecraft in low-Earth orbit that could collide with ballistic missiles and intercept them in boost phase. The collapse of the Soviet Union and the end of the Cold War removed the urgency for developing and paying for this kind of technology, and the U.S. scaled back the program before finally discontinuing it in 1994.

Defending the U.S. against such rogue actors became the cornerstone of its missile defenses. Today, there are 44 ground-based interceptors in Alaska and California that would protect the U.S. against a limited strike. In 2018, Congress authorized funding to develop a space-based missile interceptor layer, and the Trump administration's 2019 Missile Defense Review argued that space exploitation provides a missile defense posture that is more "effective, resilient and adaptable to known and unanticipated threats."

Project 2025, the Heritage Foundation's presidential policy outline, advocates for missile defense in the Pentagon chapters written by Christopher Miller, the former acting secretary of defense in the final months of the first Trump administration. Miller describes missile defense as a "critical component of the U.S. national security architecture" and argues that the country should "accelerate the program to deploy space-based sensors that can detect and track missiles flying on nonballistic trajectories."

He also advocates changing U.S. missile defense policy, which for some 20 years has focused on deterring attacks from rogue states, to one focused on competitors with the most advanced arms. Trump's executive order does this, explicitly referring to defending the U.S. against attacks from "peer and near-peer adversaries." That is, China and Russia. It represents a broad mission shift, says Cameron Tracy, research scholar at the Berkeley Risk and Security Lab.

"Trying to defend against a Russian or a Chinese hypothetical attack is a very different story — both politically and technically — than defending against a hypothetical North Korean attack," Tracy says.

Unlike a rogue actor that could send one or maybe a few ICBMs toward the United States, China and Russia have substantial arsenals of strategic missiles and could invest in building more.

"Given the increasing reliance on nuclear capabilities and on long-range missiles by our adversaries, we have to change what we've been doing," says Robert Peters, a research fellow in nuclear deterrence and missile defense at the Heritage Foundation.

Russia regularly issues coercive nuclear threats.

▲ Since 2011, Israel has relied on its Iron Dome short-range missiles (above) to intercept rockets and other weapons fired from within a 7,000-kilometer range. The image at right is of a May 2023 interception of rockets fired from Gaza.

Fatima Shbair/AP, Israel Air Force

China is rapidly and vastly expanding its nuclear arsenal; according to independent and defense intelligence assessments, China possesses approximately 600 warheads, with the aim of producing 1,000 nukes by 2030. "We have to open the aperture to include shooting down missile threats from China and Russia, given their behavior over the last 10 years," Peters adds. "That's the impetus."

But some see this policy shift of directly calling out peer adversaries as destabilizing, the start of a costly arms race to the bottom that will still fail to protect the American homeland from attacks — or could put the country at greater risk of a confrontation. A missile defense shield would scramble the calculus of mutually assured destruction, the idea that if one country nukes another, it's going to get nuked right back, which restrains either from striking first because that would mean game over for everyone.

The second-strike capability — the ability to set off mutual destruction — becomes a less potent nuclear deterrent if another country has robust missile defense that could seriously deter ballistic or hypersonic attacks. China, Russia or any other power will respond. They could, in theory, build their own shields, but the cheapest and fastest approach would be to build a heck of a lot more missiles to overwhelm such defenses, much as a 4-meter border fence can be defeated by a 4.5-meter ladder.

It is traditionally more expensive to design and field defenses than it is to design and field offenses. "That has been the lesson throughout the nuclear age," says Joe Cirincione, an independent nuclear national security analyst who was previously president of Ploughshares Fund, which is working to prevent the proliferation of nuclear weapons and their use. "Whenever one country tries to build a defense, the adversary just builds more offense."

Proponents of missile defense say their strategy would impose economic costs that an adversary would struggle to meet. They also argue that while more offensive weapons might overwhelm missile defense, that is more a gamble than a guarantee, and that unpredictability of success serves as a deterrent. Others also argue that missile defense could become a potent bargaining chip in negotiating arms limits, though others disagree, because it creates a power imbalance.

Garretson, of the American Foreign Policy Council, says missile defense speaks to an imperative to try to defend the populace: "You cannot count on an enemy choosing not to attack you."

These are long-standing policy splits on the idea of missile defense, but they've taken on a new urgency with Trump's order. Today's civilian megaconstellations and microelectronics have opened up new possibilities for the design of such space-based interceptors **[See analysis on page 26]**. The executive order solidifies these interceptors as a core part of ongoing missile defense efforts, adding a new layer to the existing and soon-to-be modernized warning and tracking constellations.

"Specifically asking for space-based interceptors and options, including nonkinetic options" — widely seen as a reference to laser weapons — "to go after the boost phase, this is a major, major policy shift," says Garretson.

The U.S. would detect missile launches with its existing Space-Based Infrared System satellites in geosynchronous orbit high over the equator. These satellites can tell where a ballistic missile is going and where its warheads are likely to fall, but the United States wants to develop better warning and tracking by creating a Custody Layer — satellites that will watch where all the other guy's stuff is — and a Tracking Layer that could also determine where more sophisticated weapons, like hypersonic missiles, are headed.

Consider the Hypersonic and Ballistic Tracking Space Sensor satellites, a portion of the Tracking Layer that Trump's executive order seeks to accelerate. HBTSS provides "the sniper's high resolution scope, precisely tracking hypersonic missiles in flight," Northrop Grumman, one of their manufacturers, wrote on its website in 2022.

Together, these components would form the Proliferated Warfighter Space Architecture constellation. Plans call for launching the satellites in "tranches," or batches, along with a communications or Transport Layer.

"I don't want to say quite 'no sparrow may fall,'" — a biblical reference to an all-knowing god — "but it's pretty close to that," says Fred Kennedy, a former director of DARPA's Tactical Technology Office and the founding director of the Space Development Agency.

Precision matters, especially when protecting against threats like hypersonic weapons, which can maneuver and operate in much lower altitudes. And, of course, these satellites need to be able to track potentially dozens or hundreds of missiles headed at a target, or at many different targets, at once. They must also communicate with other U.S. assets and interceptors — on the ground, on warships at sea and, someday, as the "Golden Dome" seeks to do, in space. Exactly how that will all work together in real time is one of the big questions of any sort of advanced missile defense.

The Golden Dome project is proposing an intricate system that is far beyond the anti-missile systems the United States currently has. Some of what the U.S. has is very good, but none of it is perfect. The U.S. has mobile ground-launched defenses, namely the Patriot batteries that have been fired with great success in Ukraine, and the Terminal High Altitude Area Defense, or THAAD, batteries that are deployed in various locations around the world. A THAAD delivered to the United Arab Emirates achieved its first successful combat intercept in January 2022 against a mid-range ballistic missile launched by the militant group the Houthis.

As for the homeland, U.S. defense is limited to those 44 ground-based interceptors in Alaska and California, which, again, were constructed to intercept rogue missiles from somewhere like North Korea. The U.S. keeps a lot of details of these tests under wraps for obvious security reasons, but the public record shows 12 successful intercepts out of 21 tests. But again, these are tests, not real-world scenarios, and the U.S. government is the one designing the conditions. A 2022 study from the American Physical Society found that after 70 years and expenditure of $350 billion, no "system thus far developed has been shown to be effective against realistic ICBM threats."

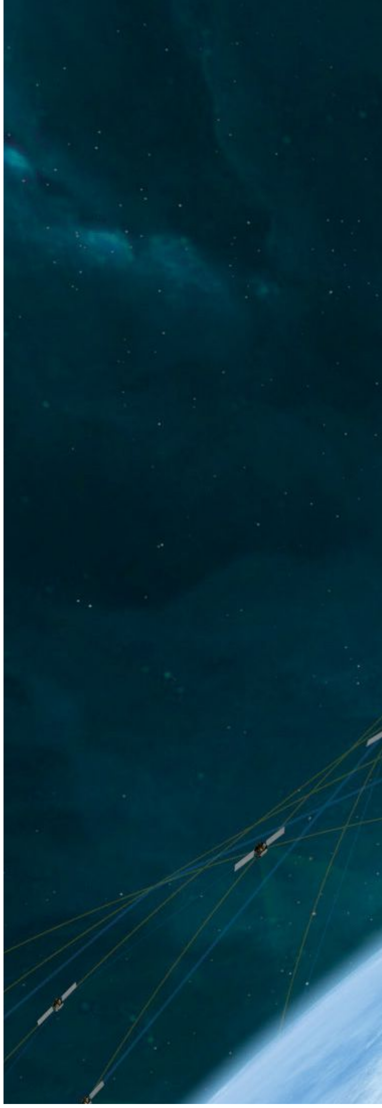
Such vulnerability is exactly why proponents believe it's time to go all in now and make a push for testing and technological development. As Peters says, technology has been improved since the SDI vision 40 years ago, specifically the U.S.'s ability to identify inbound threats. Also, space launch has vastly improved, with Elon Musk's SpaceX leading the way and competitors United Launch Alliance and Blue Origin now also making progress.

"Forty years ago, the only way to put something in orbit was to go through the government, and now we've got multiple independent companies that are able to put kilograms in orbit for not very much money," Peters says.

Not very much money is relative, of course. The executive order did not include cost estimates. The Defense Department is currently redirecting about $50 billion in funding to what it considers priorities, including this Golden Dome. U.S. Sens. Dan Sullivan (R-Alaska) and Kevin Cramer (R-N.D.) in February introduced the IRON DOME Act, which would put $19.5 billion toward missile defense.

Peters says this might be sufficient to get the program going, but it is unlikely to come anywhere near the actual costs needed to achieve a program of this scale. Todd Harrison, a fellow at the American Enterprise Institute, estimated in a January report that it would cost between $11 billion and $27 billion to launch an initial constellation of 1,900 space-based interceptors. "If this seems like a no-brainer to protect the United States from ballistic missile attack, there's a catch," Harrison writes. "The system described above is only sized to intercept a maximum of two missiles launched in a salvo."

America would be shelling out quite a lot of money, but it likely wouldn't be sufficient to defend against those peer adversaries, in this view. A more than decade-old study from the National Academies put the cost for an "austere and limited-capability" space-based interceptor system at $300 billion. A 2024 study published in the journal Defence and Peace Economics found that if an attacker were to send between 500 and 6,000 warheads toward the U.S. mainland, the best-case scenario for the U.S., if it had an effective two-layer ballistic missile defense, would be to intercept 90 of them. This would come at a cost of between $60 billion and $500 billion, and eight times more than the attacker would need to spend to stage the attack, according to the analysis. If defenses were half as effective — that is, only 50% of long-range missiles could be stopped — the U.S. would need to spend 70 times more



▲ The Trump administration plans to leverage the trend toward massive constellations of smaller satellites in low-Earth orbit for its planned "Golden Dome for America." Among the constellations already in development is the Space Development Agency's Proliferated Warfighter Space Architecture. This illustration shows satellites for the Tracking Layer that are to detect, track and target incoming missiles.

Northrop Grumman

than its potential adversary: $430 billion to $5.3 trillion for between 6,700 and 88,300 interceptors. That is more than the Pentagon's entire current budget of $850 billion, and with every warhead still having a 50-50 chance of reaching the U.S. mainland.

Anything in space, says Tracy of the Berkeley Lab, is just not a good value proposition. It is expensive and difficult to maintain and defend. For example, if the U.S. wants to defend against a Chinese ICBM, the ideal would be a satellite sitting over Beijing's launch sites. But that would require a defense in geostationary orbit, putting the interceptor far from Earth, meaning it would need to travel tens of thousands of kilometers to knock out a missile in the boost phase.

Solving the distance problem requires the interceptors to be in lower orbits, but that means they're moving relative to the terrain.

"If you want to maintain pretty consistent coverage of a certain location, say, Chinese ICBM fields, you then need a lot more satellites, so a lot more interceptors, because each one will only be covering that area for a fraction of the time," Tracy says. Even if there are a lot of satellites, and a lot of interceptors, they are vulnerable targets for an adversary, and this could accelerate the militarization of space.

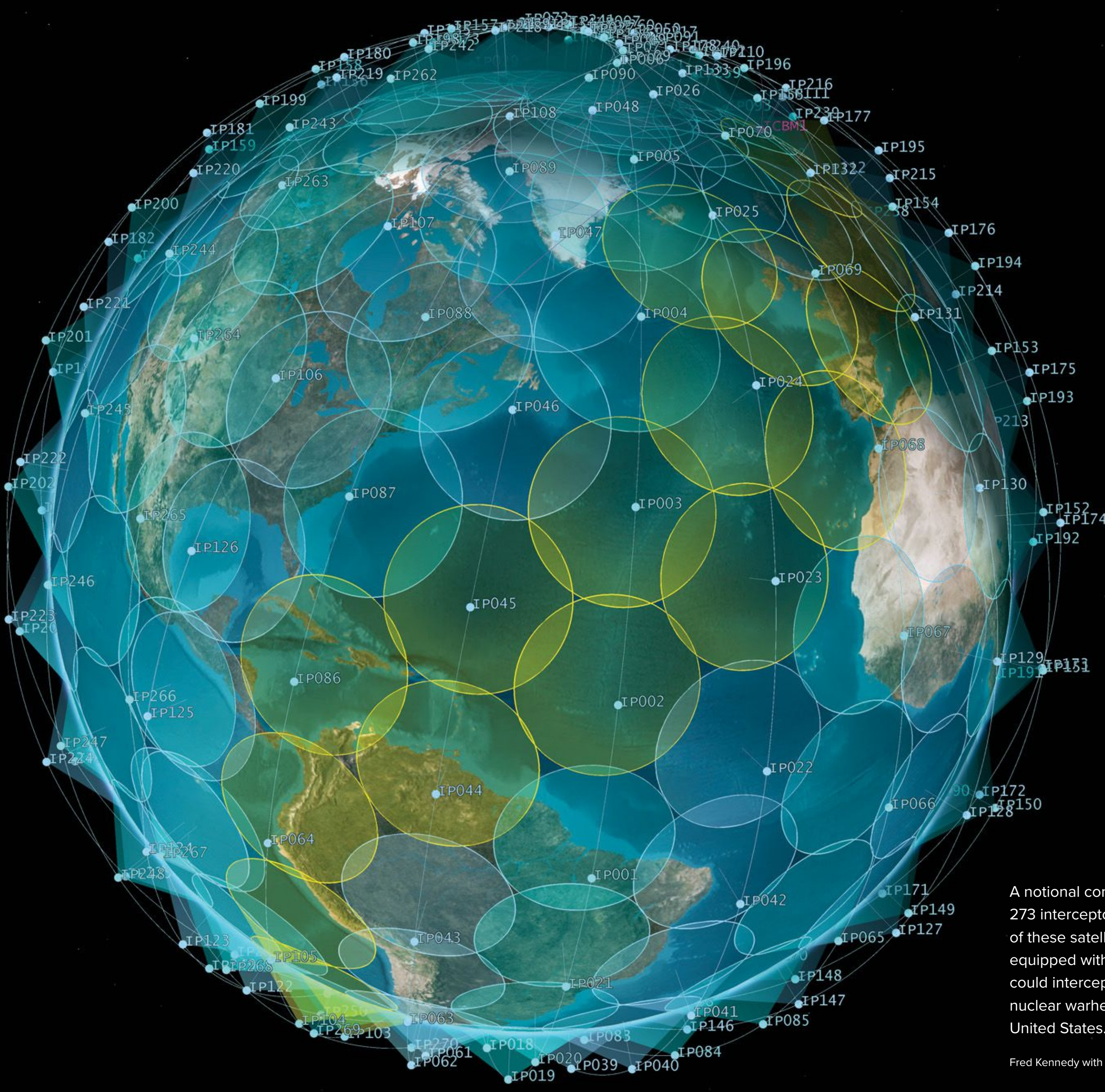
Some analysts and supporters of missile defense say space is already militarizing, and the United States is behind in this race. A space-based defense also would give the U.S. the ability to better protect itself and its allies, and, at least technically, it could also defend most anyone from a nuclear attack. Yet others see this effort as a cautionary tale. The Pentagon's cost overruns and development struggles — on ships and fighter jets — are well-documented. Now, the U.S. is talking about a space-based defense that requires untested and unprecedented coordination.

"The idea of an impenetrable missile shield over the United States is not achievable," says Laura Grego, senior research director for the Global Security Program of the Union of Concerned Scientists. "It's ruinously expensive and strategically unwise, because what you'll do is your adversary will just build more and it will always be much less expensive for them to spend a little bit more to make you spend a lot."

Grego suggests the United States could very likely outspend North Korea. But even then, there are no guarantees that doing so will protect America, and its allies, like a roof against rain. "We have not demonstrated yet that we can defend reliably, that the system we have has been demonstrated to work reliably."

# WHY THE PLAN COULD WORK

**U.S. defense planners and the industry have so many technologies they lacked in the 1980s that, this time, creating defenses to shoot down missiles and warheads from space could be the path to a safer world. Fred Kennedy examines the strategy and math behind the proposal.**




A notional constellation of 273 interceptor carriers. Each of these satellites would be equipped with six missiles that could intercept missiles or nuclear warheads targeting the United States.

Fred Kennedy with the Satellite Tool Kit

Forty years of advances in critical technologies undergird the Trump administration's audacious proposal to protect the U.S. homeland not just from rogue missile strikes by the likes of Iran or North Korea but from nuclear-armed peer adversaries, China and Russia.

In 1983, detractors rose up to deride President Reagan's challenge to American scientists to render nuclear weapons "impotent and obsolete." They questioned the feasibility and practicality of this Strategic Defense Initiative, branding it "Star Wars" because of the plan to orbit weapons in space that would shoot down missiles or the warheads they release. Over the next couple of decades, the SDI organization morphed through a succession of acronyms, arriving at MDA, the Missile Defense Agency, while the objectives simultaneously migrated away from "national" missile defense to something more prosaic and limited in scope: the ability to shoot down small numbers of missiles fired at the homeland by rogue nations.

My analysis of President Donald Trump's executive order, "The Iron Dome for America," in light of today's technologies strongly suggests that the math related to raid sizes and cost does in fact close. The goal of comprehensive though not entirely foolproof missile defense of the homeland from space looks to be both feasible and practical.

The order, published seven days after the inauguration, calls for development and deployment of some very intriguing components (see chart on next page). With these and other tools, Defense Secretary Pete Hegseth was instructed to submit a "reference architecture" for the figurative dome within 60 days of the Jan. 27 order.

It's only been weeks, and all the arguments that 1980s skeptics deployed against SDI are already back on full display. We're told that space-based interceptor missiles must be heavy and expensive and that they'll always be on the wrong side of the globe when you need them (the "absenteeism" problem cited by the Center for Strategic and International Studies think tank and others). We're also told this architecture of space-based weapons can't be scaled to meet the threat, because as the number of missiles per attack — the "raid size" — increases, the number of interceptors required to knock down the missiles and their payloads increases linearly. In this view, the adversary simply "adds another missile," and the architecture becomes impractical. Lasers and neutral particle beam weapons are dismissed as requiring too much power.

This warmed-over criticism misses how much the technical world has changed since the Reagan era. While I was helping stand up the Space Development Agency in 2018, we were all keenly aware of plans by OneWeb, SpaceX, Amazon and others to launch constellations of hundreds to thousands of satellites in low-Earth orbit to offer communications normally provided by geosynchronous equatorial satellites. Inspired by these large, or proliferated, architectures, Pentagon leadership in 2019 chartered SDA to rapidly procure and fly large numbers of inexpensive, relatively small satellites for missile defense.

We at SDA envisioned development of a Custody Layer, a constellation that would be equipped with moving target indicator radar, imaging radar and other sensors, to keep tabs on an adversary's offensive "internet of things." That was our term for their missile transporters, bombers, marine vessels — any nonstatic vehicle that might conceivably lob a missile at the United States. These satellites would be the equivalent of Joint Surveillance Target Attack Radar System and U-2 aircraft, but in space. To strike a missile, you have to know where it could be launched from, after all. Complementing the Custody Layer was the Tracking Layer, the satellites that would detect and track hypersonic or ballistic weapons after launch. A Transport Layer would connect sensors and shooters, while hosting battle management software to ensure that sensor data is interpreted accurately and orders are communicated efficiently and securely. As a start, SDA and its vendors deployed 23 Transport and Tracking Layers satellites in 2023. MDA, meanwhile, started planning its own proliferated constellation, the Hypersonic and Ballistic Tracking Space Sensor satellites. SDA and MDA joined forces to deploy four more Tracking Layer satellites and two HBTSS prototypes in 2024. SDA has yet to deploy any of its Custody Layer satellites, but plans call for a "Gamma" variant of the Transport Layer spacecraft — some of which are scheduled to be launched as early as 2026 — that will have some "add-on" features that address Custody Layer targets. Together, these layers will compose SDA's Proliferated Warfighter Space Architecture.

Why is the Defense Department so confident that the industry can deliver what's needed, if we've only launched a couple handfuls of our own birds to date? The answer boils down to the almost 650 OneWeb and 7,000 Starlink satellites orbiting overhead. Those show that mass-produced, relatively small spacecraft are both feasible and practical. What may not be as clear is how this lesson in mass-production and micro-miniaturization of electronics can be applied to space-based interceptors.

Let's start with some recent history related to that. Until about 10 years ago, big primes and their government managers often dismissed small satellites as toys. I've been in the room for these kinds of debates, which usually centered on how big, exquisite systems do vitally important things we just can't live without. Flash forward, and the same microelectronics revolution that gave us the iPhone 16 also permits us to launch kilogram cubesats with all the necessary guidance, communications, power and sensing capabilities to do much of the work of their larger brethren. So too with interceptors. But not everyone is on the same page. Todd Harrison, in a January posting on the website of the American Enterprise Institute where he is a senior fellow, pointed to a 2004 report stating that a space-based interceptor would tip the scales at an eye-watering 900 kg (just under a U.S. ton).

The thing is, there's been lots of progress since 2004.

**Fred Kennedy** was the inaugural director of the U.S. Space Development Agency and a former director of DARPA's Tactical Technology Office. A retired Air Force colonel and AIAA senior member, he holds a Ph.D. in electronics and physical sciences from the University of Surrey and degrees in aeronautics and astronautics from the Massachusetts Institute of Technology. He is CEO of Dark Fission Space Systems.

| ORDER LANGUAGE | EXPLANATION |
|---|---|
| *"Proliferated space-based interceptors capable of boost-phase intercept" via "kinetic" weapons* | "Boost-phase intercept" means destroying or disabling missiles while their main engines or upper stages are still firing. |
| *Satellite "custody layer" and the "Hypersonic and Ballistic Tracking Space Sensor layer" of satellites* | "Custody layer" is a term coined by the Space Development Agency seven years ago to refer to mass-produced spacecraft that would locate and track missiles and their host infrastructure on land, sea and air before launch. HBTSS would be tuned to track maneuverable hypersonic vehicles, whose heat signatures are harder to see than those of ballistic missiles and whose impact points can't be calculated like those of ballistic warheads. |
| *"Non-kinetic capabilities to augment the kinetic defeat of ballistic, hypersonic, advanced cruise missiles, and other next-generation aerial attacks"* | This is an allusion to laser and neutral particle beam weapons. |
| *An "underlayer and terminal-phase intercept capabilities postured to defeat a countervalue attack"* | "Terminal phase intercept" refers to launching missiles from land or seaborne platforms to strike warheads as they plunge Earthward, in the event space-based interceptors or lasers did not destroy the missiles in the boost phase or the reentry vehicles after the boost phase. Defeating a "countervalue attack" refers to protecting vital infrastructure. |

It's now well within our means for us to build a space-based interceptor that's no larger than an AIM-9 anti-aircraft missile (about 80 kg). Don't take my word for it. From 2011 to 2015, DARPA investigated rockets small enough to be carried by a modified F-15 that could place 45-kg satellites on orbit — part of its Airborne Launch Assist Space Access program. In 2018, DARPA kicked off Glide Breaker, an initiative to mature key components of a lightweight kill vehicle that could engage hypersonic weapons.

Now, here's the math: Put six interceptors into the orbital equivalent of the magazine of a Multiple Launch Rocket System, and attach this to a small satellite "front end." Launch 21 of these carriers on a Falcon 9 (or a competitor's vehicle). Do that 13 times, and you'll have 273 interceptor carriers hosting almost 1,700 individually targetable interceptors. Each carrier with its complement of six interceptors might mass as little as 750 kg (1,650 lbs). That's about the same as a second-generation Starlink satellite. Now, here's the interesting bit: Perhaps we approach SpaceX or OneWeb and ask them to sell us satellites off their existing production lines. A first-generation Starlink (260 kg or 572 lbs) or OneWeb (150 kg or 330 lbs) could serve as an inexpensive, reliable interceptor carrier's front end. If we conservatively estimate the unit cost of these spacecraft at $1 million or less (and a similar figure for the interceptor), we aren't breaking the bank. This is a $2 billion problem — not a $20 billion problem. The Defense Department just needs to leverage the economies of scale our commercial space industry is already bringing (they'd have to want to help, of course). And as launch costs continue to fall, owing to the advent of the Starship and New Glenn launch vehicles, the once insurmountable deployment problem goes away as well. SpaceX orbited 1,800 Starlink satellites in 2024 over 89 launches. This sort of launch rate would have been thought unattainable 20 years ago. A 273-interceptor carrier constellation could be fielded in months with just a small fraction of the launchers SpaceX flew last year.

What about absenteeism and scale? Well, let's revisit the physics. Our 273 carriers offer global coverage and the opportunity to address missile launches in both boost phase and midcourse (when ballistic missiles, reentry vehicles and countermeasures are coasting through space en route to their targets). My own modeling suggests that such a constellation would be robust against substantial raids. For a hypothetical attack emanating from Eurasia, up to 17 carriers (and their 102 interceptors) would be able to engage over the course of a 33-minute flight, despite tight constraints on geometry and achievable delta-V, the term for how much change in velocity the rocket needs to produce. For a raid size of five or 10 missiles, this is more than sufficient. Bump the raid size to 50, and it's still possible to achieve an attrition rate of 96% — that's 48 missiles — given certain assumptions about an individual interceptor's probability of kill.

Now, a critic might argue that such a missile defense isn't worth it because two nuclear missiles could still get through. And I concede, this would indeed be a tragic day for the United States and humanity. But — crucially — it would not end humanity. Back to raid sizes: For anything much above 50, we can expect the threat to come from multiple geographically dispersed regions. As a result, there would always be untasked interceptors ready to target them. That's absenteeism turned on its head: Capacity is always emerging over the horizon in the form of interceptor carriers.

As for scale, it's all about winning the war of one-more-missile versus two-more-interceptors. The math tells us the competition is no longer even close. An intercontinental ballistic missile is a big, complex, expensive piece of hardware designed to impart a delta-V of 6 or 7 kilometers per second to a large pallet holding reentry vehicles. ICBMs cost about $10-15 million each. Our interceptors and their carrier platforms will cost an order of magnitude less, and each carrier will be able to target two, three or perhaps even four missiles in flight before depleting its magazine. That's trading a few million of our dollars for up to $60 million of an adversary's ballistic missiles, payloads and related gear. The mantra that "one more missile" defeats your defenses just doesn't cut it in the New Space era.

That's the story of space-based interceptors, but I would close with the oft-heard lament over the shortage of available power that bedevils "speed of light" weaponry, such as the lasers that the administration is counting on to augment kinetic interceptors. This is something we've been quite remiss at addressing as a nation: namely, the adoption of nuclear power and propulsion on orbit. (Disclosure: the company I co-founded, Dark Fission Space Systems, is pioneering nuclear thermal rocket technology for travel through cislunar space.) With six orders of magnitude greater energy density than chemical energy storage and 1,000 times the power density of solar power, nuclear energy will enable not just laser weapons but communications, resource extraction, habitats, planetary defense and fast access to anywhere in the solar system. By getting missile defense right, we humans will still be around to do those things. ★

SPONSORED CONTENT

# Maxar Space Systems' Maxar 300™ Series Bus on Target to Enable Enhanced Missile Tracking for Proliferated LEO Military Network

BY ANNE WAINSCOTT-SARGENT, AIAA COMMUNICATIONS

The threat of advanced, low-atmosphere missiles like hypersonic weapons led the Space Development Agency (SDA) to expand beyond geostationary missile defense to a high-power low Earth orbit (LEO) constellation.

Called the Proliferated Warfighter Space Architecture (PWSA), this system consists of hundreds of optically linked small satellites in LEO, delivering rapid capability to warfighters. To develop the constellation's Tracking Layer for missile defense, the SDA follows a spiral development approach, working with industry in two-year "tranches," each improving capability from demonstration to full operational status.

In 2022, Maxar Space Systems was selected to build an agile bus for partner L3Harris' payload that will detect and track missile threats in real time using infrared sensors. Later this year, the partners will see their efforts culminate with the first of two launches of SDA's Tranche 1 Tracking Layer program.

"It's been a very successful relationship over the last three years of working toward launch," said Paul Wloszek, general manager for L3 Harris' Missile Defense product line, which is integrating Maxar Space Systems' bus with the overall payload. "Maxar Space Systems brought a long history of these high-power, low-jitter platforms with a commercial mentality that helps enable our overall space vehicle offering."

"It's been good for us to partner with L3Harris on Tranche 1. My counterpart and I talk virtually every day and they have an excellent relationship with the end customer and an in-depth knowledge of what they need to satisfy the mission," added Joe Foust, vice president of Commercial and National Security Programs at Maxar Space Systems.

At its core, the SDA program required an affordable spacecraft platform that can output a lot of power.

Designing a high-power bus and payload that meets the SDA's timelines for proliferated LEO required new levels of design and production agility, prompting Maxar Space Systems and its partners to rethink everything from manufacturing and infrastructure to supply chain resiliency. The result, said Foust, is "a very purpose-driven bus design" with the infrastructure and supplier base to deliver satellites in a high-rate production environment.

## Power in a Lightweight Package

"The Maxar 300 is designed to handle a relatively heavy payload in a very lightweight structure," said Foust. "We essentially developed the highest power capability for a bus within this class satellite."

He estimated that the bus achieves power gains of over 20% compared with current bus platforms supporting similar-type missions. "That means you can detect threats faster and with more resolution and follow the threats for a longer time period."

Depending on the mission, Maxar Space Systems can change the size of the physical bus to meet certain power levels, without increasing the price point or extending production schedules. That's important because Tranche 2 of the Tracking Layer Program calls for new mass requirements, going from identifying and following a target, to providing the required information closer to the point of taking action.

"As we move from Tranche 1 to Tranche 2, we can accommodate these changes and not change our bus," said Foust.

Building a bus with the capability for higher power while keeping development affordable required rethinking production and supply chain strategy. Maxar Space Systems converted part of its Silicon Valley facility into a high-rate production line for the product line, complete with new flooring and automation improvements that optimized workflows and streamlined the build process. "Our production line is sized to produce up to eight buses a month, easily meeting the rate required for both Tranche 1 and Tranche 2. We can also increase the rate further if necessary to meet the mission requirements," noted Foust.

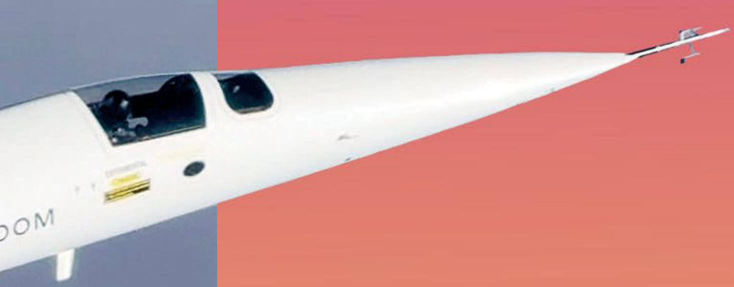
The first of 16 Maxar 300 buses for Tranche 1 has now been delivered to L3Harris' production facility in Palm Bay, Florida, where they have commenced Space Vehicle integration and test activities prior to delivery and launch. Additionally, the first of two custom dispensers for launching eight space vehicles per launch is in testing at Maxar Space Systems' Palo Alto, California, facility.

MAXAR
SPACE SYSTEMS

# BARRIER BREAKER

**Nearly 10 years after its founding, Boom Supersonic earlier this year broke the sound barrier with its XB-1 subscale demonstrator — without generating a sonic boom. Cat Hofacker spoke to CEO Blake Scholl about Boom's plan to automate this technique for its future passenger airliners.**

BY CAT HOFACKER | catherineh@aiaa.org



Bringing back supersonic passenger travel was always going to be a tall order, but Boom Supersonic CEO Blake Scholl has set the bar even higher for the planned 2029 debut of his company's Overture airliners: "I think everybody wants supersonic travel, provided it's safe, it's convenient, it's comfortable, it's sustainable and it's friendly to the passengers and the people on the ground. Oh, and it's got to be affordable," he told me by video from his office in Colorado.

By "friendly," he's referring to the sonic booms produced when an aircraft breaks the sound barrier. Boom's solution is one part flight planning, one part technology: Overture will only reach its top speed of Mach 1.7 over water. For overland flight — provided that FAA lifts the 1973 ban on civil supersonic flight — a collection of software algorithms in the flight computer must calculate the speed and altitude at which the sonic boom would be refracted away from the ground. Boom demonstrated this Boomless Cruise concept in January and February, flying its subscale XB-1 demonstrator silently over the Mojave Desert. [See graphic on next page.]

"The new era of supersonic flight is unlocked by carbon fiber composites and turbofan engines and advanced aerodynamics," Scholl says, "But it's also every bit as much unlocked by software and computers."

In terms of physics, Boom is leveraging the well-known Mach cutoff phenomenon recorded by NASA and other organizations in high-speed flight tests going back to the 1950s.

"I'm sure we've all seen the middle school science experiment where you got a glass of water and you drop a pencil in the glass of water, and it looks broken," Scholl says. Water is denser than air, so the light waves are bent, or refracted.

For aircraft, atmospheric conditions also factor in because of how the sound travels differently at colder, higher altitudes compared to the warmer atmospheric layers closer to the ground: "A boom as it travels through the atmosphere is going to curl, it's going to refract, and it's going to kind of turn upward. And if the angle is shallow coming off the airplane and the airplane is sufficiently high, [the boom] makes a U-turn in the sky and nobody on the ground hears it."

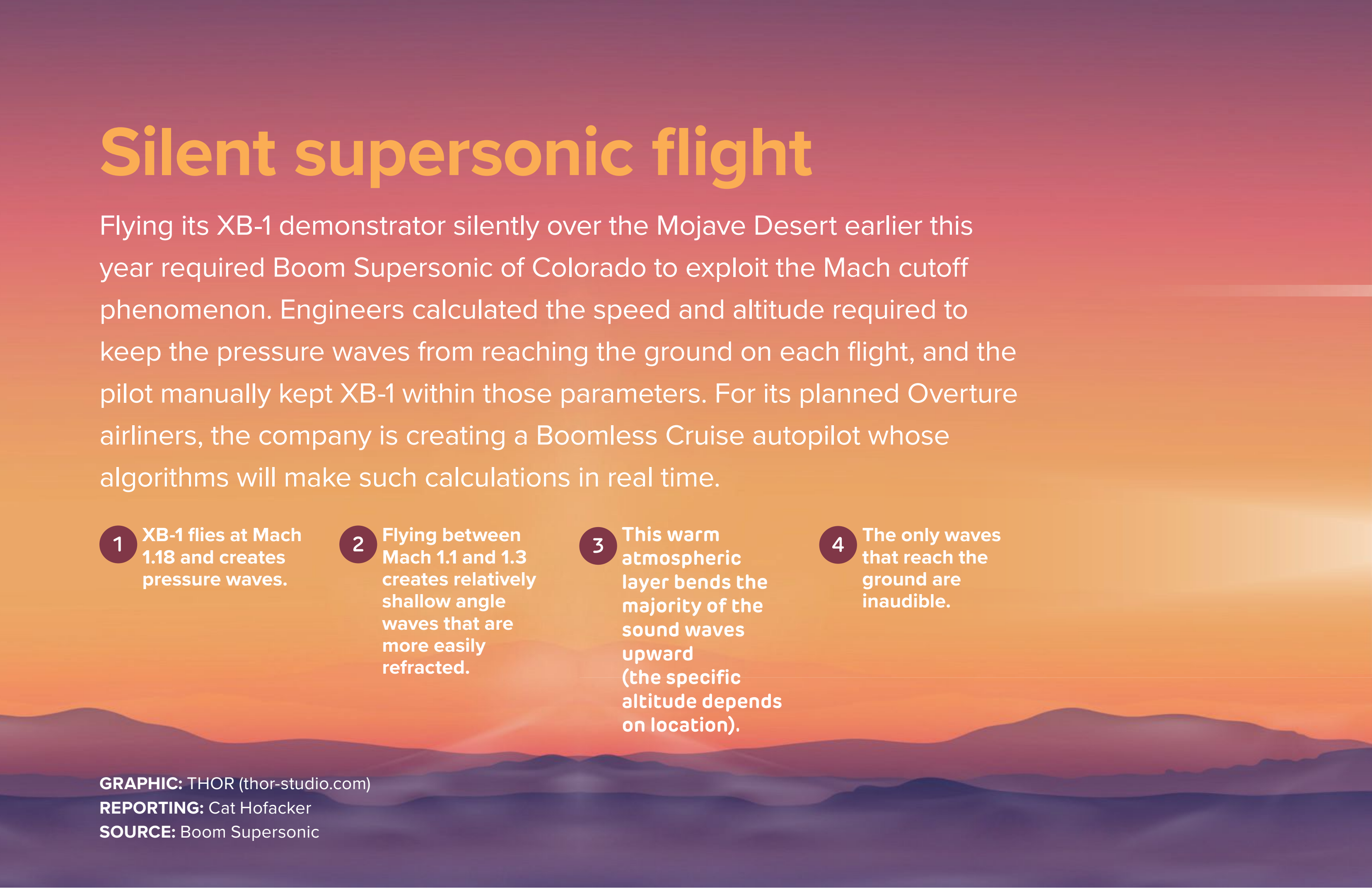
The XB-1 demonstrator doesn't have autopilot, so Boom engineers had to calculate ahead of time the required altitude and speed to achieve quiet supersonic flight over the desert. This isn't practical for Overtures taking off and flying all over the world, and so Boomless Cruise was born.

"You need good weather data, which basically the world has now. You need a computer that can run real-time sonic boom predictions and calculate the right speed and altitude for any given day. Check, we've got that," Scholl says. "And then number three, you need engines that can do it efficiently." He's referring to the Symphony engines that his company is designing in-house for Overture.

If the concept behind the flight control algorithms sounds familiar, that could be because Boom is not the only company to explore it. Nevada-based Aerion Supersonic announced its own boomless cruise concept in 2020 but declared bankruptcy about 18 months later, ending its plans to develop a supersonic business jet. Scholl acknowledges the similarities between the two concepts but points out that Aerion never flew an aircraft and "never actually proved they could do" boomless cruise.

# Silent supersonic flight

Flying its XB-1 demonstrator silently over the Mojave Desert earlier this year required Boom Supersonic of Colorado to exploit the Mach cutoff phenomenon. Engineers calculated the speed and altitude required to keep the pressure waves from reaching the ground on each flight, and the pilot manually kept XB-1 within those parameters. For its planned Overture airliners, the company is creating a Boomless Cruise autopilot whose algorithms will make such calculations in real time.




**GRAPHIC:** THOR (thor-studio.com)
**REPORTING:** Cat Hofacker
**SOURCE:** Boom Supersonic

The Overture flight deck design isn't finalized yet, but Scholl envisions "Boomless Cruise" being one of the Mach hold settings that pilots can select on the flight deck. "And what that will mean is [the aircraft] will fly the fastest, quietest Mach, and it'll speed up and slow down automatically in order to be as fast as it can be while not making a boom."

Maintaining Boomless Cruise might also require an Overture to change its altitude throughout a flight, but Scholl says this will closely resemble the way that today's aircraft make minor adjustments during cruise, which air traffic control deconflicts by giving each plane a "block clearance" of altitudes.

Overtures are being designed to cruise at up to 60,000 feet, so "we're going to be the only ones at that altitude," Scholl says. "And so you can imagine a whole row of Overtures, one after the other, but they're all going to be flying the same Mach so the spacing is actually easy. This is not ATC's biggest problem, not by any stretch."

Speaking of problems, the U.S. prohibition on overland supersonic flight poses a potential hurdle, but it's one that Scholl is confident will be removed well before 2029 because "everyone kind of wants to change it."

"There are a lot of things in D.C. that are controversial, but this isn't one of them," he says. "If you're going to have a sonic boom, people can argue about 'Is it quiet enough or is it too loud, and should the threshold be this many decibels or that many decibels?' Reasonable people can differ and will differ, but if there's no boom, it's really obvious."

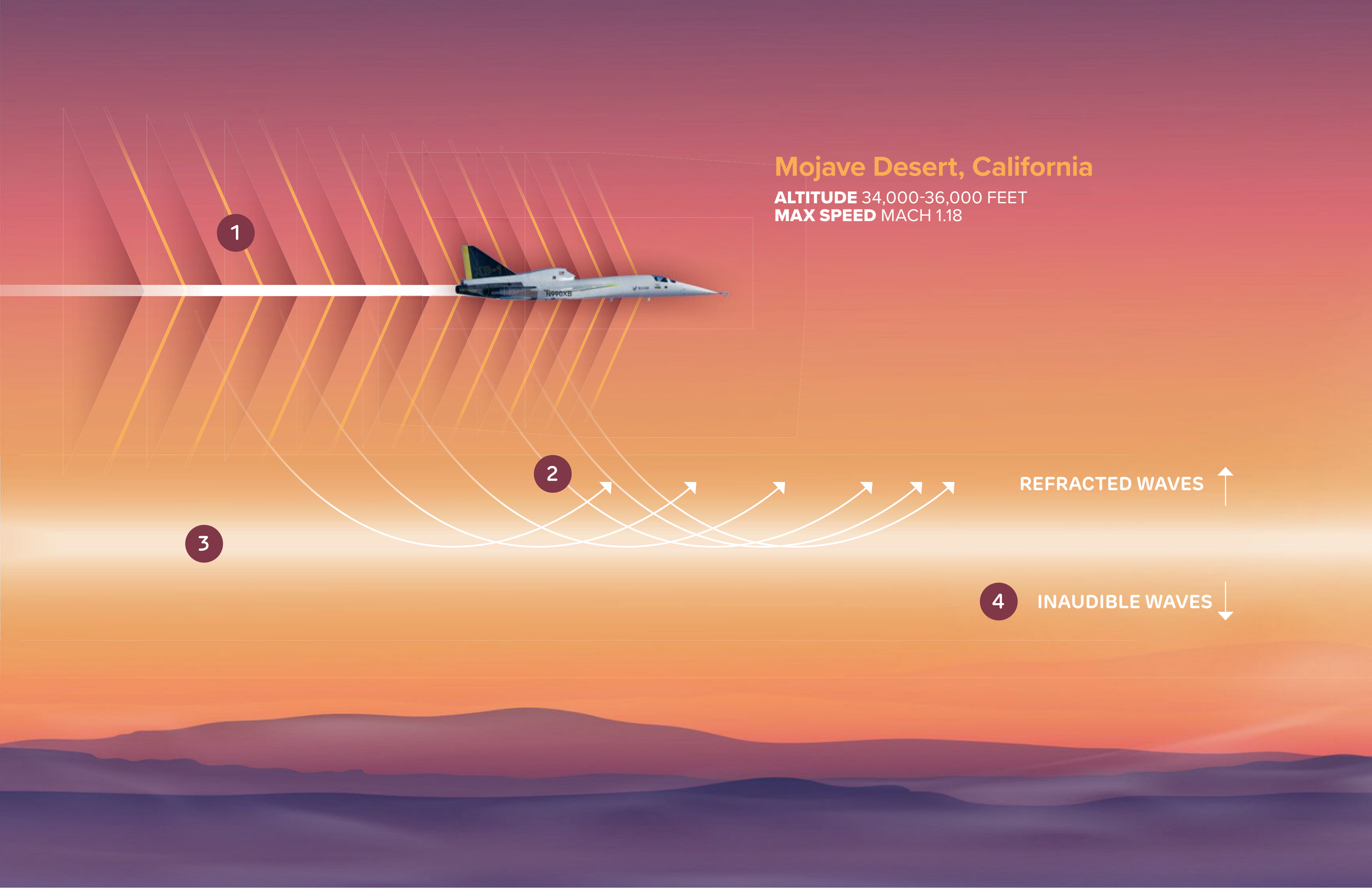
He adds: "Republican, Democrat, career staff or politician, I haven't found anybody who thinks [the ban] should stay like it is. I think it's going to happen really quickly."

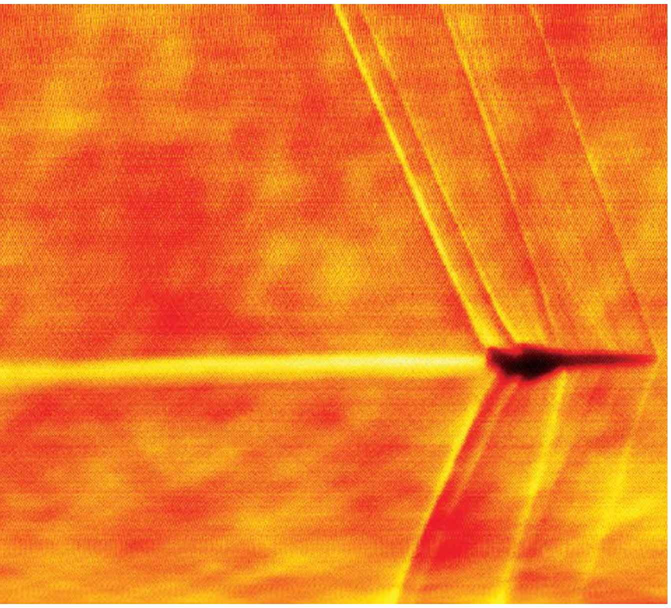
Even if the ban isn't lifted, Boom has plenty to do in the meantime. With XB-1's brief but eventful flight campaign concluded, it's on to constructing the first Overture components.

"The high-level airplane design is frozen, and it's all just a scale up of everything we learned from XB-1," Scholl says. So the first thing you'll see hardware wise is the engine. We're building engine parts. Around the end of the year, we're going to be engine running, and middle of next year, we'll start building the first full-scale airplane. We were in a very exciting phase with XB-1 flying, and now it'll go back a little bit to where XB-1 was a few years ago, where you're seeing parts coming together, things are getting built on an airplane."

As the airframe comes together, Boom will also finalize the Overture flight deck based on input from the company pilots and pilots from United Airlines, which has an agreement to purchase 15 Overtures.

"If we've learned anything from just watching the well-publicized disasters of commercial airplanes in the



Boom engineers worked with NASA scientists to capture this schlieren image during XB-1's final flight to visualize the shock waves the aircraft produced when exceeding the speed of sound.

Boom Supersonic

last 10 years, it's that pilots weren't involved," Scholl says. "So when we do technical reviews, United's pilot corps is part of it." On the flight deck, "they tell us what they like, what they don't like, and we keep tweaking it." He says Boom also sends its pilots for simulator training at United's Flight Training Center in Denver.

Scholl, who earned his private pilot license in 2008, also took a few turns in the simulator. "I flew the 787, and the biggest thing I was struck by is how much more complicated it is than Overture. People think, 'Oh, a supersonic jet, it's more complicated.' No, no, what's complicated is a flight deck that is 50 years of one idea on top of another idea on top of another idea, where nobody ever said, 'Hang on, let's rethink the whole thing.'"

He goes deep about the 787's attitude display: "It's got a head-up display, and it's got a primary flight display. Those both tell the pilot the same thing, but they've got different symbology. And the head-up display had like several different attitude indications. It's got this one that looks like a W, it's got another artificial horizon, and it's got this thing that the pilots are calling the pizza and the pizza pan — I'm so confused. How about you give me one way to tell what the airplane is doing?"

We're nearing the end of our allotted time, so I ask my final question: The first decade of Boom was devoted to achieving supersonic flight. Where does he want the company to be in 10 years?"

He has his answer ready: "Supersonic flight is commonplace. The initial supersonic flights, when you break the sound barrier, it's going to be really exciting. Champagne will be served. There'll be a celebration on board. But 10 years from now, so many people have flown supersonic so many times that the supersonic celebration is annoying. It's just how we fly." ★

# EXOPLANET HUNTER

## Slung to the side of the Nancy Grace Roman Space Telescope will be a new kind of coronagraph that could take planet hunting to the next level, on top of its main mission of shedding light on the mystery of dark energy and dark matter. Jon Kelvey spoke to the scientists in charge.

BY JON KELVEY | jonkelvey@gmail.com

At NASA's Goddard Space Flight Center, a floor-length window provides a view of an eight-story clean room. It's February, and I'm on the mezzanine watching bunny-suited technicians on a platform nicknamed a "surfboard." Below them is a cylinder turned on its side, and the technicians are checking its solar panel mounts.

Their tasks, though essential to the success of this $4.3 billion future space telescope, are likely more straightforward than those required when the action half of the James Webb Space Telescope was assembled here. While this clean room is the largest of its kind in the United States, it still could not fit the fully assembled Webb. Its segmented mirror, other optics and instrument module were put together here and flown to Houston for more testing, and then sent on to California, where Northrop Grumman joined it to the other half and sent it off on a journey by barge through the Panama Canal to French Guiana for launch.

The cylinder in front of me is the outer barrel of the Nancy Grace Roman Space Telescope, or Roman for short. It will be nothing like Webb, although it is destined to be NASA's next flagship space observatory. There will be no trip through the Panama Canal for Roman. Its primary mirror is a spare from a canceled spy satellite program, that measures 2.4 meters in diameter, compared to Webb's 6.5. From the mezzanine, I can see the shape of that mirror, protected by a shroud. It crowns a column of optics, instruments, electronics and reaction wheels that will be set inside the outer barrel. Ultimately, Roman will be flown to Kennedy Space Center for a ride to orbit on a Falcon Heavy rocket in, optimistically speaking, October 2026. NASA has set a target of no later than May 2027.

Technologically speaking, Roman might seem like an underwhelming follow-up to Webb, but my interviews with astronomers and the leaders of this program suggest that would be a severe misjudgment. The biggest reason is a baby grand-piano-sized box of optics that's among the hardware in the column of equipment. This is the Coronagraph Instrument, or CGI. Built at NASA's Jet Propulsion Laboratory in California, it was installed last year onto the Roman instrument carrier. Light from the primary mirror will be reflected into the CGI, and it will follow a back and forth path consisting of 31 masks and mirrors whose role will be to block the light of a chosen star before it reaches the Exoplanetary Camera, or EXCAM. If this technique works as planned, planets a 100 million to a billion times fainter than their host stars should suddenly become visible.

While it would take a much larger mirror to catch the light from a planet the size of our own, Roman's coronagraph is "ballpark about as good as it needs to be to be able to measure the reflected light from a nearby Earth-like planet," says Dominic Benford, an astrophysicist and Roman's top scientist, as technicians work in the clean room. "The coronagraph is possibly the most complex astronomical instrument that NASA has ever built," says Benford.

So, while scientists don't expect Roman's CGI to reveal an Earth-like planet — the best that's expected is a Jupiter-sized world — proving the technology in space could set it up for inclusion on a future space telescope that might be capable of doing so. That, says Benford, makes CGI a step toward one of the top goals identified by astronomers and astrophysicists in their 2021 decadal survey: "to discover worlds that could resemble Earth and answer the fundamental question: "'Are we alone?'"

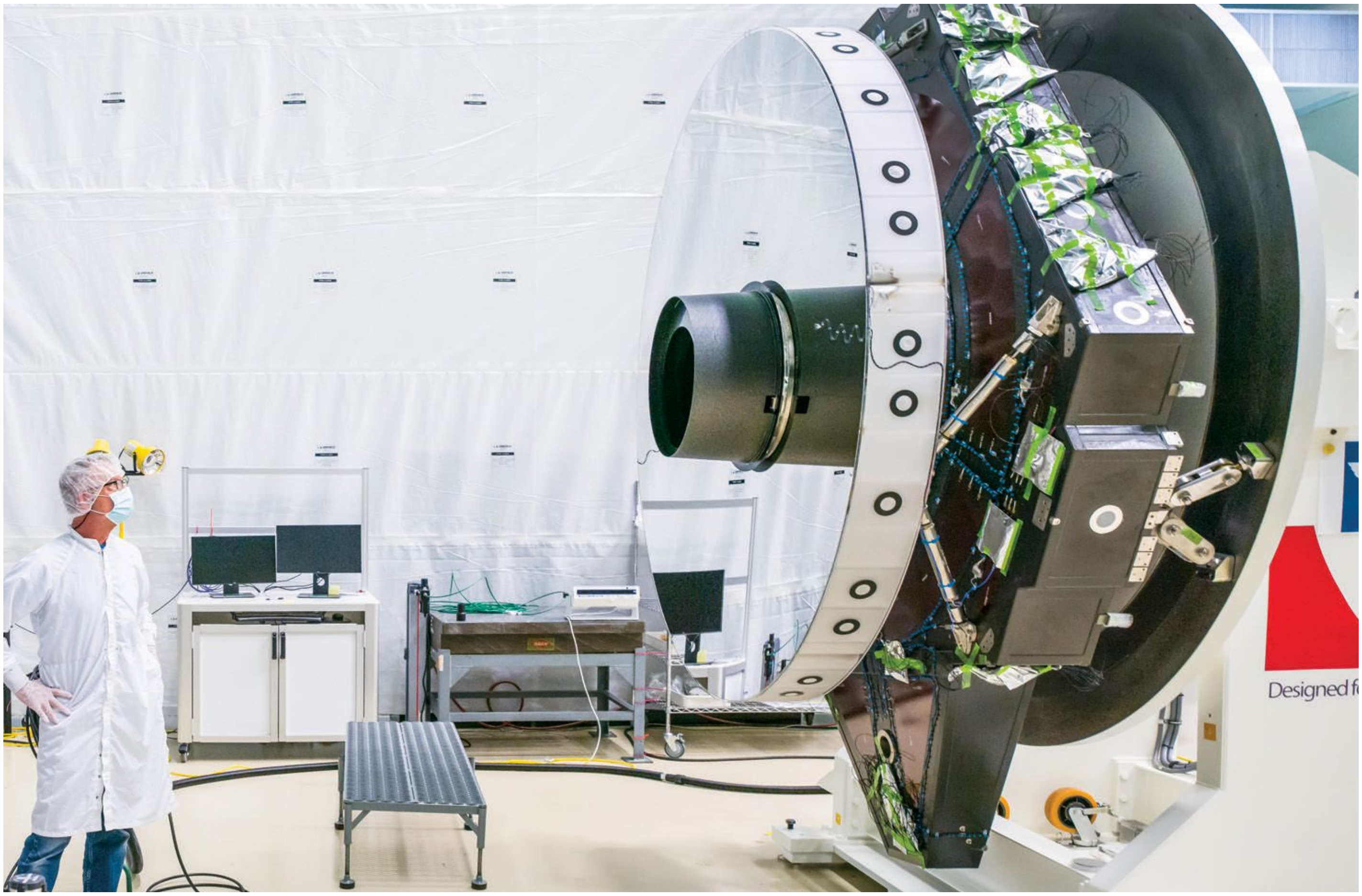
This coronagraph technology would not be bound for space in 2027 were it not for the mirror that was gifted to NASA in 2012. Initial design proposals for what's now known as Roman assumed a smaller primary mirror, and the resulting spacecraft would not have been large enough to accommodate the coronagraph. The larger mirror and spacecraft created an opportunity to test the CGI technology in space for the first time, hence CGI's designation as a technology demonstration.

Though it's a demonstrator, exoplanet hunters have high hopes for the science it will produce, and CGI is my main reason for wanting to see Roman and meet with Benford and his colleagues. I'll have other occasions to report on the telescope's main mission, which is to help unravel the mystery of dark energy and dark matter.

"This is called a Lyot stop," Neil Zimmerman, the lead Roman coronagraph scientist, tells me.

We're standing at the back of the Goddard viewing mezzanine to escape the din of a group of visitors that just swept in. He pulled out his laptop and is showing me a schematic of an opaque disk followed by an opaque ring in the light path of a generic telescope. In 1930, French astronomer Bernard Lyot placed a disk at the right point

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



in the light path of a telescope to block out the disk of the sun, not unlike what the moon does during a solar eclipse. He had created the world's first coronagraph. But Lyot wasn't finished. He realized that some amount of sunlight nevertheless passed around the edge of the disk — a diffraction ring — and that this could be further absorbed by a ring-shaped mask, yielding an even clearer view of the sun's corona.

Roman's CGI is a more elaborate version of Lyot's coronagraph. What makes the Roman instrument experimental is the addition of two "deformable" mirrors, about twice the diameter of a U.S. quarter, that will receive the light near the start of the light path.

Here's why they are needed: For an image to be clear and the spectra measurable, the coronagraph will need to control the light waves as they propograte through the instrument, sometimes ensuring they are aligned to increase the brightness, like two ocean waves cresting together into a single larger waver rolling onto the shoreline. At other times, the waves will be purposefully misaligned to create destructive interferance that eliminates unwanted starlight that has been diffracted around the masks.

The primary mirror will have subtle and shifting imperfections, changing shape slightly due to one side being slightly heated by the sun, so some form of correction is needed. The deformable mirrors and other filters will make those corrections. Each mirror assembly is backed by a grid of 48 by 48 actuators, constructed by Northrop Grumman out of layers of lead magnesium niobate. When high voltage from the spacecraft's solar panel array is applied to them, an electric field is generated that causes the actuators to lengthen and deform the mirror surfaces. They will be commanded to make adjustments as large as 500 nanometers and as small as 7.5 picometers to the shape of the mirror.

Because the mirrors can be adjusted, they constitute "active" optics. Roman will be the first NASA spacecraft to fly an active coronagraph. Plans call for downloading initial images, analyzing them and then deforming the mirrors to obtain the clearest possible image of an exoplanet — about 100 times better than previous coronagraphs.

The goal is deceptively simple: View exoplanets by catching the same kind of light that makes Jupiter, Venus or Mars visible to us on a clear night.

"That is, light from the star that is reflected off the surface of the planet," says Jason Rhodes, a Roman project scientist at JPL. By contrast, the Jupiter-sized exoplanets spotted by Webb with its passive coronagraph are "self-luminous — planets that are so hot they're giving off their own light," he explains.

These so-called "hot Jupiters" are relatively young. They orbit stars much larger than our own and at a much closer distance than the Jupiter in our solar system. The

▲ At 2.4 meters in diameter, Roman's primary mirror is the same size as the one on the Hubble Space Telescope. Light reflected into the dark hole in the center will be directed to the coronagraph and other instruments.

NASA/Chris Gunn

Roman coronagraph will attempt to take images and spectra of exoplanets much more like our Jupiter, a relatively cold gas giant orbiting much further out from its star.

"The Roman coronagraph represents our first opportunity to measure reflected starlight from a middle-aged Jupiter at a Jupiter sort of distance from a more sun-like star," explains Nikole Lewis, a planetary scientist at Cornell University whose research focuses on gas giant exoplanet. "They're really important for us to understand what other solar systems look like and if we are, in fact, really just very unique," she says.

An exoplanet would show up as a point of light in the images rather than as full disks, like the photos of planets in our own solar system. But images aren't all the coronagraph provides. Inside, the light remaining after filtering will also be directed through slits in a cylindrical spectrograph module. Inside this spectrograph, a prism will split the starlight into a spectrum of its constituent wavelengths. Elements and molecules of interest will produce characteristic breaks in the spectrum, black absorption lines corresponding to the frequencies of light that were absorbed by target elements and compounds rather than being reflected into space.

"The spectroscopy excites me the most, even though it will be a relatively simple mode for us," says Zimmerman, Roman's coronagraph lead. The team expects to be able to detect the spectral signatures of water vapor, oxygen and possibly methane, if they exist on the targeted planets. "I think there's enough uncertainty about how planets like Jupiter and Saturn evolved that just measuring abundances will be very valuable."

Astronomer Scott Gaudi of Ohio State University has studied just how much bigger a telescope would need to be to achieve the "Holy Grail" — images and spectroscopy of an rocky planet with liquid water and within the habitable zone of its star.

"Somewhere between 6 and 8 meters is probably the ideal," he says.

Webb's 6.5-meter-diameter primary mirror is about the right size, but without an active coronagraph to filter and delete starlight, Webb could not pick out an Earth twin in the glare of its star. Although an even larger, 12-meter-diameter mirror would be better, the cost and time constraints to build, launch and operate such a telescope make it an unlikely undertaking, cautions Gaudi.

NASA, however, already has a mission in mind that would meet the minimum size and resolution requirements. Plans call for the Habitable Worlds Observatory, currently targeted for launch sometime in the 2040s, to have a 6-meter-diameter primary mirror, segmented and folded for launch like Webb's was. The larger mirror alone should give the Habitable Worlds coronagraph a 10 to 100 times improvement over Roman's, according to Rhodes, and what scientists learn from Roman's coronagraph could yield further improvements. In an inversion of Roman's priorities, the primary mission of Habitable Worlds will

NASA/GSFC/Jim Jeletic

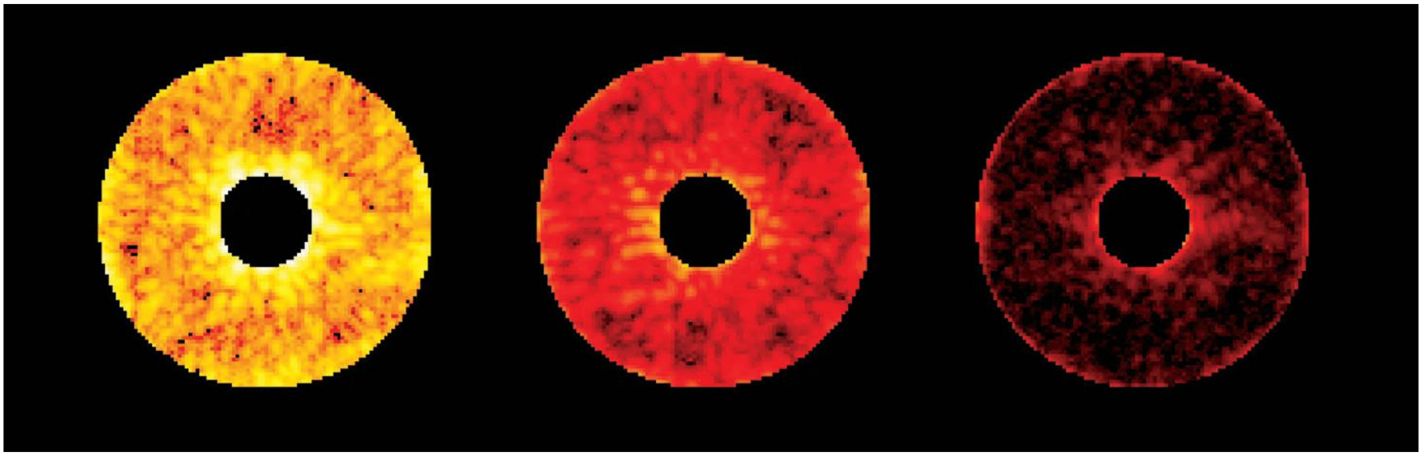
FACT

**THE TELESCOPE'S NAMESAKE:** The Roman project is named for pioneering astronomer Nancy Grace Roman, known as the "Mother of Hubble" for her advocacy of the history-making space telescope, whose anticipated costs ballooned by a factor of six, to $1.2 billion. The Roman concept was previously known as WFIRST, short for Wide Field Infrared Survey Telescope.

Roman earned her Ph.D. in astronomy from the University of Chicago in 1949, a time when few women held doctorates in the field. In 1959, after stints at the Yerkes Observatory and Naval Research Laboratory, NASA asked Roman to serve as its first program director for astronomy. Tasked with getting astronomers interested in working with the newly formed space agency, Roman advocated for construction of the Stratoscope II observatory that rode in a high-altitude balloon, and for the three Orbiting Astronomical Observatory satellites that NASA operated from 1966 through 1972.

She helped win funding for the observatory mission that would become the Hubble Space Telescope, and she helped found the Space Telescope Science Institute at Johns Hopkins University.

About 18 months before Roman died at 93, she was photographed in 2017, gazing into the Webb telescope's golden mirror from a viewing mezzanine at NASA's Goddard Space Flight Center in Maryland. The photograph is now displayed there.



▲ Viewing exoplanets requires blocking their host star's light so that the dimmer light reflected from the planets becomes visible. The black holes in the center of these rings were produced by masks that blocked the light from a simulated star, produced by laboratory lasers. The far left ring is bright because light has diffracted around the masks. The middle and right rings show less leakage because deformable mirrors and other optics have canceled out successively more light.

NASA/JPL-Caltech

be to find at least 25 potentially habitable exoplanets and analyze their atmospheric makeup.

Cosmology will take the back seat. "With the Habitable Worlds Observatory, the design goal is to have a capability of looking at 25 Earth-like planets," says Rhodes, with the hope of pursuing "NASA's big, overarching goal, which is to look for life elsewhere in the universe."

Habitable Worlds will search for biomarkers on exoplanets, such as large, persistent quantities of methane and oxygen in a planet's atmosphere that cannot be easily explained by nonbiological processes.

"We're looking for gases that are out of equilibrium with what you expect without life having evolved there," Zimmerman says, meaning only "extreme conditions" could produce similar footprints.

But even if Habitable Worlds detects clear signs of methane and oxygen on an Earth-like world, it won't be considered sufficient evidence of life without further study, according to Gaudi.

"We're not just going to get a spectrum and say, 'Oh look, there's life!' We have to do it in context," he says. Researchers will want to know the shape of the planet's orbit, its temperature ranges, whether there are other planets in the star system and how much radiation the planet's star emits. "What's likely going to happen is we're going to find something that's tantalizing, suggestive, and then we're going to build a bigger mission to study that planet even better."

In addition to pioneering the active coronagraph technique, Roman will contribute by surveying 200 million stars in the Milky Way, with a goal of discovering somewhere between 60,000 and 200,000 exoplanets. Why such a large range? "The uncertainty is based on planet formation models, so how many we see is itself an interesting piece of information," says Julie McEnery, an astrophysicist at NASA Goddard and the senior project scientist for Roman.

Lewis, the Cornell scientist, feels certain that Roman will yield discoveries about planet and solar system formation important to her work, and for capturing the attention of the public and ensuring support for future science missions. "Exoplanets have done nothing but challenge our imagination about what planets look like," she says. "And people really connect with them. The kids especially really love it when I tell them about all these bizarre worlds where it's raining glass." She's referring to discoveries made by Hubble, Webb and other telescopes, such as HD 189733 b, a Jupiter-sized world about 64 light years away whose clouds are laced with glass.

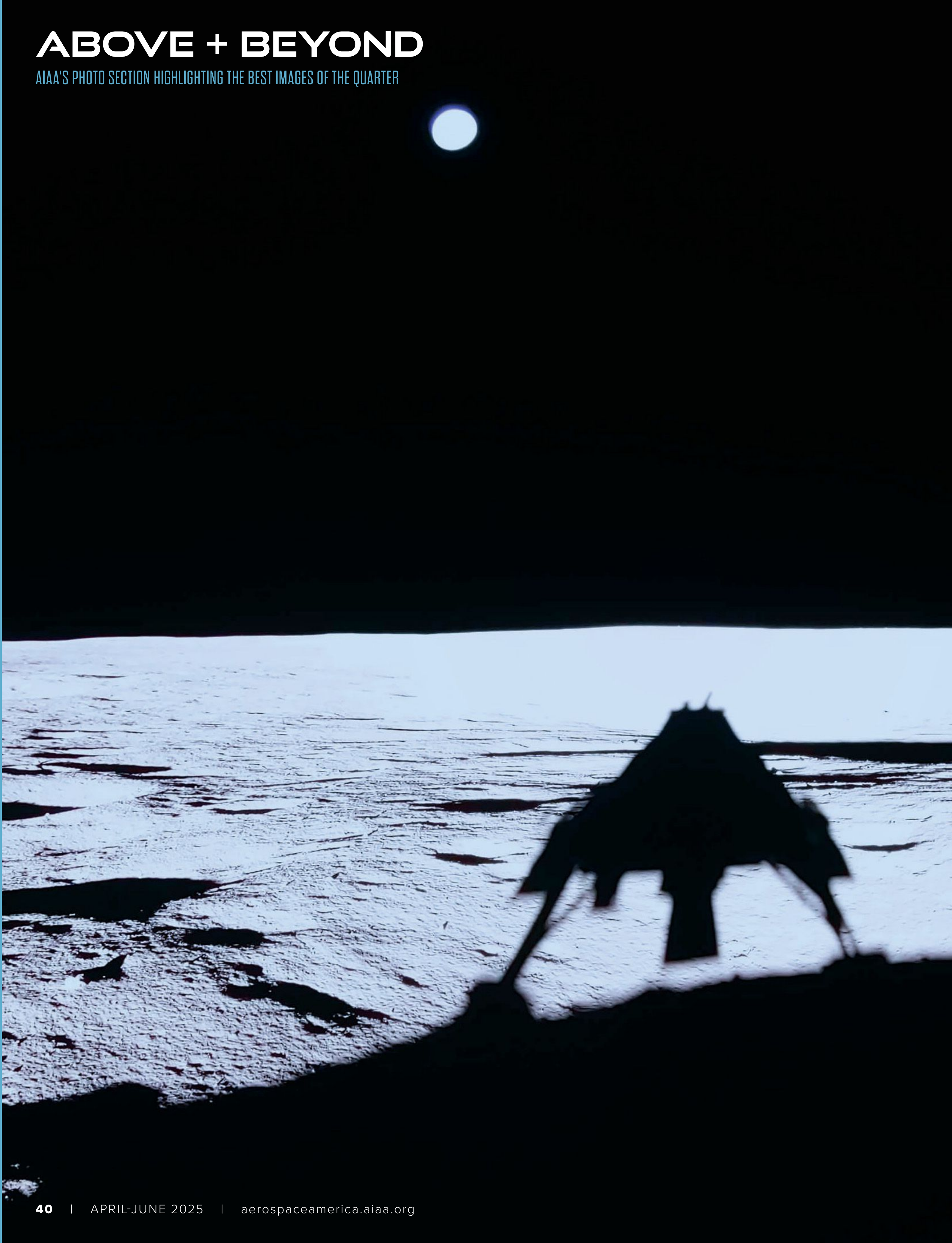
Operating the Roman coronagraph will also help Zimmerman and his team decide what improvements will be needed for the Habitable Worlds mission to maximize its odds of finding an Earth-like planet or planets. For one, during Roman they plan to experiment with the process for adjusting the optics, with an eye toward automating that process for the Habitable Worlds Observatory so that zones around stars can be examined more quickly. That telescope will need to adjust its coronagraph autonomously without back-and-forth downloading of images and uploading of instructions by a team of analysts on the ground.

"I think learning how to close that loop and do it efficiently is going to be the most valuable thing we get out of the Roman coronagraph," Zimmerman says.

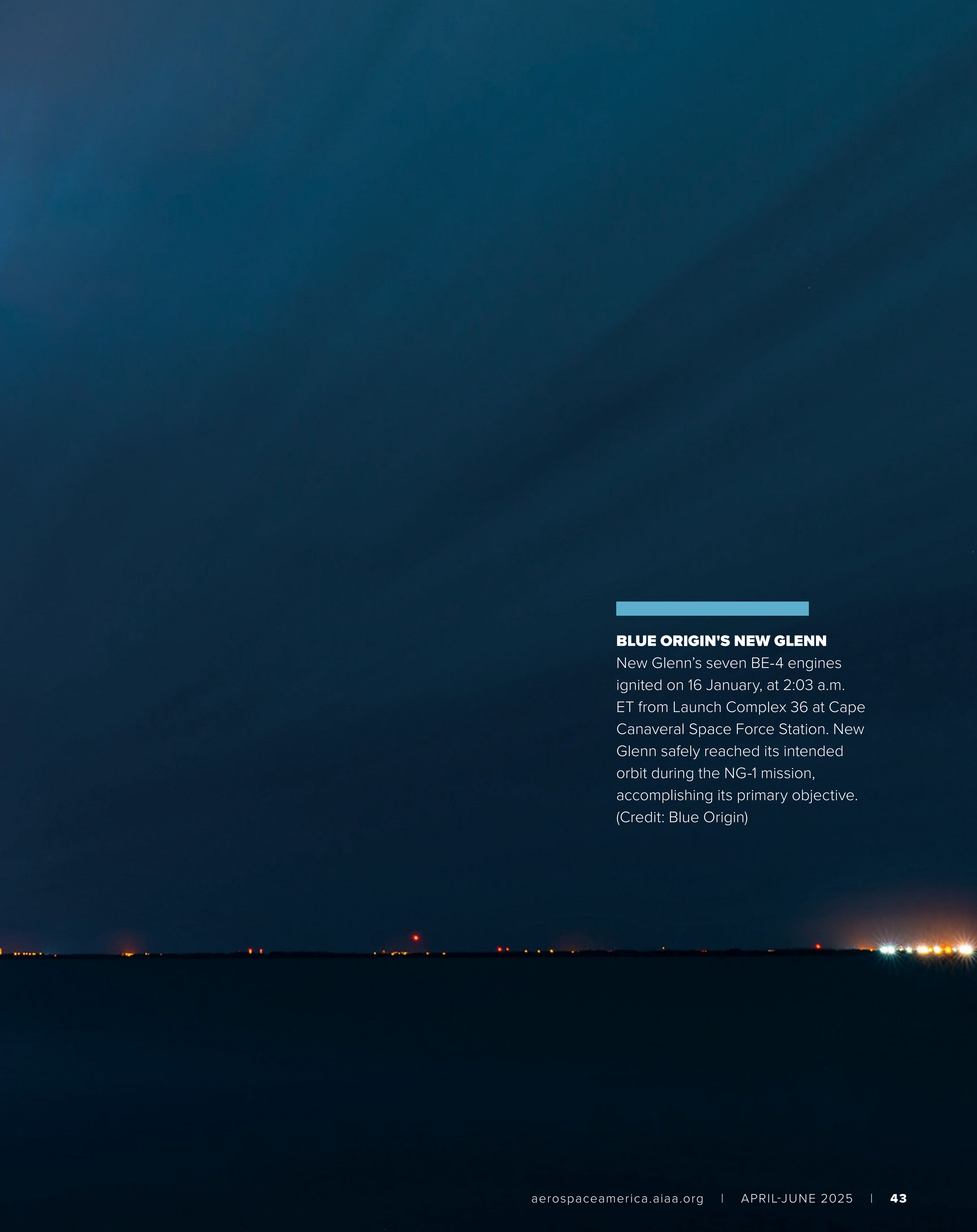
With Roman, scientists can also practice the types of studies they hope to do with Habitable Worlds, he adds. "So this is a stepping stone, yes. But it's a really big stepping stone." ★

FACT

**ROMAN'S ORBIT:** The telescope will orbit the Sun-Earth Lagrange Point 2, a position 1.5 million kilometers beyond Earth where competing celestial gravitational forces are such that a spacecraft can orbit with minimal propellant. By orbiting L2, Roman will maintain a near-constant position relative to Earth as they both orbit the sun. In addition to saving propellant, going to L2 keeps thermal disturbances on Roman's optics to a minimum.



**FIREFLY'S BLUE GHOST**
Carrying a suite of NASA science and technology, Firefly Aerospace's Blue Ghost Mission 1 successfully landed at 3:34 a.m. ET on 2 March, near a volcanic feature called Mons Latreille within Mare Crisium, a more than 300-mile-wide basin located in the northeast quadrant of the moon's near side. (Credit: Firefly Aerospace)



**BLUE ORIGIN'S NEW GLENN**
New Glenn's seven BE-4 engines ignited on 16 January, at 2:03 a.m. ET from Launch Complex 36 at Cape Canaveral Space Force Station. New Glenn safely reached its intended orbit during the NG-1 mission, accomplishing its primary objective. (Credit: Blue Origin)


BOOM
XB-1


**BOOM ACHIEVES SUPERSONIC FLIGHT**

The successful first supersonic flight of Boom's demonstrator aircraft, XB-1, took place on 28 January at the Mojave Air & Space Port in California. Boom designed, built, and flew the world's first independently developed supersonic jet—the first civil supersonic jet made in America. (Credit: Boom Supersonic)

# From the Institute

**APRIL-JUNE | AIAA NEWS AND EVENTS**

FEATURED EVENT


**21–25 JULY**
Las Vegas, Nevada

AIAA AVIATION Forum, held in Las Vegas, will explore the latest research and development innovations driving a new era of urgency for efficiency in aviation. The forum will deliver technical programs, workshops, and thought leaders, as well as admission to networking events and receptions, with more opportunities to connect with leading industry executives, government officials, and academia.

aiaa.org/aviation/registration

| DATE | MEETING | LOCATION | ABSTRACT DEADLINE |
|---|---|---|---|
| **2025** | | | |
| 1–10 Apr | Systems Engineering and Artificial Intelligence for Aerospace Applications Course | ONLINE (learning.aiaa.org) | |
| 3–4 Apr | AIAA Region II Student Conference | Greensboro, NC | 3 Feb 25 |
| 3–4 Apr | AIAA Region V Student Conference | Minneapolis, MN | 31 Jan 25 |
| 4–5 Apr | AIAA Region III Student Conference | Cincinnati, OH | 8 Feb 25 |
| 7–30 Apr | Aircraft Handling Qualities Course | ONLINE (learning.aiaa.org) | |
| 10–13 Apr | 29th Design/Build/Fly Competition | Tucson, AZ (aiaa.org/dbf) | |
| 15–18 Apr | AIAA DEFENSE Forum | Laurel, MD | 15 Aug 24 |
| 15–24 Apr | AI for Aerospace Applications: Ethics, Policy, and Society Course | ONLINE (learning.aiaa.org) | |
| 19 Apr | 17th PNW AIAA Technical Symposium: The Future of Aerospace Technologies | Seattle, WA | |
| 22 Apr–15 May | Fundamentals of High Speed Air-Breathing and Space Propulsion Course | ONLINE (learning.aiaa.org) | |
| 28 Apr–21 May | Flight Test Techniques for UAS Course | ONLINE (learning.aiaa.org) | |
| 29–30 Apr | Essential Model-Based Systems Engineering Course | ONLINE (learning.aiaa.org) | |
| 29 Apr–8 May | AI Design and Deployment Risks for Aerospace Applications Course | ONLINE (learning.aiaa.org) | |
| 29 Apr | 2025 AIAA Fellows Induction Ceremony and Dinner | Washington, DC | |
| 30 Apr | 2025 AIAA Awards Gala | Washington, DC | |

| DATE | MEETING | LOCATION | ABSTRACT DEADLINE |
|---|---|---|---|
| **2025** | | | |
| 5–14 May | The Digital Transformation of Test & Evaluation Course | ONLINE (learning.aiaa.org) | |
| 6–29 May | Advanced Flight Dynamics and Control of Aircraft, Missiles, and Hypersonic Vehicles Course | ONLINE (learning.aiaa.org) | |
| 12 May–9 June | Vibration of Periodic Structures in Aerospace Engineering Course | ONLINE (learning.aiaa.org) | |
| 12–15 May | Applied Space Systems Engineering Course | ONLINE (learning.aiaa.org) | |
| 13–22 May | Applications of Generative AI with Large Language Models in Aviation and Aerospace Course | ONLINE (learning.aiaa.org) | |
| 28 May–18 Jun | Optimal Control Techniques for Unpiloted Aerial Vehicles (UAVs) Course | ONLINE (learning.aiaa.org) | |
| 20–29 May | Aircraft Reliability & Reliability Centered Maintenance Course | ONLINE (learning.aiaa.org) | |
| 10–19 Jun | Guidelines for the Development of Civil Aircraft & Systems Course | ONLINE (learning.aiaa.org) | |
| 20 Jul | AIAA Regional Leadership Conference | Las Vegas, NV | |
| 21–25 Jul | AIAA AVIATION Forum | Las Vegas, NV | 21 Nov 24 |
| 22–24 Jul | ASCEND Powered by AIAA | Las Vegas, NV | 21 Nov 24 |
| 10–14 Aug* | AAS/AIAA Astrodynamics Specialist Conference | Boston, MA (https://www.space-flight.org) | |
| 14–19 Sep* | International Electric Propulsion Conference | London, UK (electricrocket.org) | 1 Mar 25 |
| 29 Sep–3 Oct* | 75th International Astronautical Congress | Sydney, Australia (iac2025.org) | 28 Feb 25 |
| 3–7 Nov* | COSPAR 2025 Symposium | Nicosia, Cyprus (cospar@cosparhq.cnes.fr) | 4 Apr 25 |
| **2026** | | | |
| 12–16 Jan | AIAA SciTech Forum | Orlando, FL | 22 May 25 |
| 1 Mar* | IEEE Aerospace Conference | Big Sky, MT (www.aeroconf.org) | |
| 1–9 Aug* | 46th Scientific Assembly of the Committee on Space Research (COSPAR 2026) & Associated Events | Florence, Italy (cospar2026.org) | |

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

AIAA Continuing Education offerings (rows shaded blue)

**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 2025 Election Results

AIAA has announced the results of its recent 2025 elections. The newly elected AIAA officials will take office in May.

### AIAA President-Elect

Dana "Keoki" Jackson, The MITRE Corporation

### Integration and Outreach Activities Division

**Director–Aerospace Outreach Group:** Sofia Russi, Denmar Technical Services
**Director–Integration Group:** Abdollah Khodadoust, The Boeing Company
**Director-Elect–Young Professionals Group:** Nathan Crane, Advanced Development Programs, Lockheed Martin Aeronautics

### Regional Engagement Activities Division

**Director–Region IV:** Ellen Gillespie, Jacobs Engineering
**Director–Region V:** James Guglielmo, Boeing Defense, Space & Security

### Technical Activities Division

**Director–Information Systems:** Michel Ingham, NASA Jet Propulsion Laboratory
**Director–Propulsion & Energy:** Rusty Powell, Axient

### Introducing the New Board of Trustees and Council of Directors Members

In January the Board of Trustees elected new **Members–At-Large** who will begin three-year terms in May.

**Michael Gazarik, University of Colorado Boulder**
**Tina Ghataore, Aerospacelab**
**Jill Marlowe, Retired**
**Ben Linder, Boeing Commercial Airplanes,** also was elected to fulfill an unexpired term.

Also in January, the Council of Directors elected **Jeanette Domber, BAE Systems, as Integration and Outreach Division Chief**. She will begin her three-year term in May.

## Get to Know Our New Board and Council Members

### Board of Trustees Members–At-Large

**Michael Gazarik, University of Colorado Boulder**

Gazarik currently serves as the Faculty Director of the Engineering Management Program for the College of Engineering and Applied Science at the University of Colorado. He is also a part-time Staff Member at Johns Hopkins Applied Physics Laboratory. He led the creation of the Space Technology Mission Directorate at NASA and served as the first Associate Administrator championing NASA's rapid development and incorporation of transformative technologies. Joining Ball Aerospace in 2015, Gazarik served over 8 years as the Vice President of Engineering providing overall strategic and operational leadership of engineering, program execution, and technology. Earlier in his career, he served as the acting director of the Engineering Directorate at NASA Langley Research Center and led programs developing an infrared camera for on-orbit shuttle inspections and entry, descent and landing instrumentation for the Curiosity and Perseverance Mars

## DIRECTORY

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

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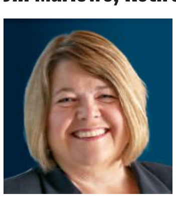
We are frequently asked how to submit articles about section events, member awards, and other special interest items in the AIAA Bulletin. Please contact the staff liaison listed above with Section, Committee, Honors and Awards, Event, or Education information. They will review and forward the information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

missions. Prior to joining NASA, Gazarik served as project manager for the Geosynchronous Imaging Fourier Transform Spectrometer project at MIT Lincoln Laboratory. He worked in the private sector on software and firmware development. Gazarik understands that diverse teams develop better solutions. Under his leadership, engineering at Ball Aerospace saw a marked increase in diversity at all levels of the organization. Gazarik earned a B.S. in Electrical Engineering from the University of Pittsburgh (1987). He earned an M.S. and a Ph.D. in electrical engineering from Georgia Institute of Technology in 1989 and 1997, respectively. He is an AIAA Fellow and former Chair of the AIAA Corporate Strategic Committee.

### Tina Ghataore, Aerospacelab

Ghataore joined Aerospacelab in 2023 as Group Chief Strategy and Revenue Officer, and CEO of Aerospacelab's new North American branch. Prior to this, she served as Chief Commercial Officer of Mynaric and President of Mynaric USA where she led the company's efforts to position Mynaric as the preferred laser communication provider for aerospace application for government and commercial markets. In 2022, Ghataore's contribution to the aerospace industry was recognized by both the public and industry peers alike when she was voted Via Satellite's "Satellite Executive of the Year." Before Mynaric, she was the Executive Vice President of Inflight Connectivity Solutions at Yahsat, where she was responsible for the overall strategy and execution of enabling the organization to launch into the Mobility Satcom Services business. In 2007, she founded The EKKAM Group, a strategic management consulting firm focused on serving clients in the aerospace/aviation and telecom industries. Ghataore held multiple leadership roles at Panasonic Avionics Corporation, where she was instrumental in efforts to launch the Panasonics Global Communications Services business. She also was charged to establish the strategy and grow the software, applications, and media business, serving the In-Flight Entertainment and Communications industry. Ghataore began her career at The Boeing Company's Satellite Systems business unit. Ghataore received her Bachelor of Honors Degree in Aerospace Engineering from Kingston University in the U.K. She is also a graduate of the International Space University.

### Jill Marlowe, Retired



Marlowe retired in December 2024 as the NASA Digital Transformation Officer, where she led the agency to conceive, architect, and accelerate enterprise digital solutions that transform NASA's work, workforce and workplace to achieve bolder missions faster and more affordably than ever before. In this role, she defined NASA's digital transformation vision, strategy, policies, and partnerships to accelerate NASA's transformation progress in four target areas: engineering, scientific discovery, program/project management decision making, and business operations. Previously, Marlowe was the Associate Center Director, Technical, at NASA Langley Research Center. In this role, she focused on accelerating Langley's internal and external collaborations as well infusing digital technologies critical for a modern federal laboratory to thrive in a digitally-enabled, hyper-connected, fast-paced, and globally-competitive world. In 2008, Marlowe was selected to the Senior Executive Service as the Deputy Director for Engineering at NASA Langley and went on to serve as the center's Engineering Director and Research Director. She began her NASA career in 1990 as a structural analyst developing space flight instruments to characterize Earth's atmosphere. Marlowe earned a B.S. in Aerospace and Ocean Engineering from Virginia Tech, an M.S. in Mechanical Engineering from Rensselaer Polytechnic Institute, and a Degree of Engineer in Civil and Environmental Engineering at George Washington University. Marlowe is an AIAA Fellow, and has received a Meritorious Presidential Rank Award, two NASA Outstanding Leadership Medals, election to the Virginia Tech Academy of Aerospace & Ocean Engineering Excellence and being voted the 2017 NASA Champion of Innovation.

### Ben Linder, Boeing Commercial Airplanes

Linder is Vice President, 777 Chief Project Engineer (CPE) within Boeing Commercial Airplanes (BCA). He is responsible for overall product integrity and safety of 777 airplanes. He manages design requirements, authorizes design changes and airplane configurations, and assures design quality and regulatory compliance. Previously, Linder held leadership positions as 777/777X Director of Engineering, Director of Propulsion Systems Engineering, Director of Flight Sciences, 777 Fleet Support Chief Engineer, Chief Engineer of Aerodynamic Characteristics and Flight Performance, 777 Safety, Certification and Performance Senior Manager, and Everett (747/767/777) Airplane Safety Engineering manager. Linder joined Boeing as an Aerodynamics Engineer where he enjoyed assignments ranging from product development, sales support, flight test, certification, and fleet support. He received his Bachelor of Science in Aeronautical and Astronautical Engineering from Purdue University, his Master of Science in Aeronautics and Astronautics Engineering from the University of Washington, and his Master of Business Administration from Seattle University. He is involved with AIAA, American Society for Engineering Education (ASEE), and formerly with Snohomish County Science, Technology, Engineering and Math (STEM) Executive Board. Linder enjoys continuous learning in the areas of aviation, international business, and engineering.

## Integration and Outreach Division Chief

### Jeanette Domber, BAE Systems

Domber is a Technical Fellow in the Payload Systems Engineering group in the Space and Mission Systems sector of BAE Systems, Inc. (formerly Ball Aerospace). She has over 25 years of experience in space systems and currently works as an advanced systems manager for national space early architecture development. Previously, Domber was the astrophysics mission area lead for BAE Systems' Civil Space business unit. She has served as the deputy program manager for Ball's efforts on the Wide Field Instrument for the Nancy Grace Roman Space Telescope, the payload manager for the Imaging X-ray Polarimetry Explorer (IXPE) Phase A study, and the program manager for the Membrane Optic Imager Real-Time Exploitation (MOIRE) program, and was the Ball lead for the STIS repair undertaken during Hubble Servicing Mission 4. Domber is a lifetime member of AIAA, having joined in undergrad. Her many AIAA volunteer leadership positions include Technical Activities Division (TAD) Aerospace Design and Structures Group (ADSG) Director; TAD ADSG Deputy Director for Forums, Structures; Structures Technical Committee (TC) Chair, Vice Chair, Procedures Subcommittee Chair; SciTech ADSG Technical Forum Chair; Structures, Structural Dynamics, & Materials (SDM) Structures Technical Chair; and JSR Associate Editor. She received an AIAA Sustained Service Award in 2021. Domber holds a B.S. in Aerospace Engineering from Case Western Reserve University. Her M.S. and Ph.D. are from the University of Colorado Boulder in Aerospace Engineering Sciences. Domber is an AIAA Fellow, a former member of the Structures Technical Discipline Team for the NASA Engineering & Safety Center, a Fellow of SPIE, a member of the American Astronomical Society, and attended the National Academy of Engineering's invited Frontiers of Engineering Symposium.

**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 Tuesday, 29 April 2025, at 8 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 Tuesday, 29 April 2025, at 1:30 p.m. ET.
Susan Silva, AIAA Governance Administrator

# Spotlight on the 2025 AIAA Pendray Aerospace Literature Award Winner

**AUTHOR**
Joseph M. Powers, Professor, Aerospace and Mechanical Engineering, University of Notre Dame; AIAA Fellow

**TITLE**
*Mechanics of Fluids* (Cambridge University Press, 2024)

**AWARD**
Presented for an outstanding contribution to aeronautical and astronautical literature in the relatively recent past. The emphasis is on the high quality or major influence of the piece and is an incentive for aerospace professionals to write eloquently and persuasively about their field.

**DESCRIPTION**
*Mechanics of Fluids* provides a modern approach to classical fluid mechanics, presenting an accessible and rigorous introduction to the field, with a strong emphasis on both mathematical exposition and physical problems. The book includes a broad range of fluid mechanics topics, including governing equations, vorticity, potential flow, compressible flow, viscous flow, instability, and turbulence.

## Why did you write this book?

I believed it was important for today's students to have a text that convincingly describes fluid behavior in the language of mechanics. With a set of course notes that had been in development since 1991, and a large block of time available at the height of the COVID pandemic, the time seemed right to capture these ideas within the pages of an actual book. One of my goals was to prepare students for computational fluid dynamics (CFD) for challenging multiscale problems by focusing on the underlying continuum mechanics that is the foundation of modern CFD methods. Many fluids texts are in a hurry to describe the motion of either simple ideal gases or incompressible liquids and they often include too few details of the underlying mechanics, geometry, and thermodynamics. There is a benefit to taking a general approach to describe the mechanics of a material, which could be either fluid or solid.

Considerable effort was given to present the basic tools of geometry, followed by the basic kinematics and dynamics of a general material. Specialization to a fluid allowed a presentation of potential, viscous, compressible, linearly unstable, and turbulent flows. Special attention was given to problems that fully couple mass, momentum, and energy conservation, along with thermodynamics and heat transfer so the fluid mechanics can be understood in a broader context. One such problem was natural convection, which was first studied in a low-speed limit with a classical similarity solution. Its linear stability also was examined. Next its weakly nonlinear dynamics were studied with the Lorenz model, and the book concludes with a direct numerical simulation of a fully turbulent natural convection problem.

## Who should read it?

The book is appropriate for first- and second-year graduate students in aerospace, mechanical, chemical, and civil engineering, as well as applied mathematics and physics. Several advanced undergraduates have found it useful as well. It also should be of use to those in the general research community who wish to acquire knowledge of the continuum mechanics of fluids. While the book does not explicitly delve into the details of aeronautics, it has nearly all the building blocks such as discussion of vortex dynamics, potential flow theory, compressible flows with shocks, boundary-layer theory, linear stability, nonlinear dynamics, and turbulence.

## What's next for you?

I plan to continue my work in combustion, high-speed flows, and education. I've written two other books, one on applied mathematics (2015) and one on combustion (2016). I must decide if there will be a fourth! If so, it might be an undergraduate text on thermodynamics, which is a beautiful subject.

## AIAA PUBLIC REVIEW

**AIAA S-155, Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) – Spacecraft Fiducial Markers**, has been issued for public review. This document outlines functional, physical, and operational requirements for fiducial markers used in proximity operations, capture, and servicing, including manipulation of in-space assets. It is intended to apply to a broad array of RPO/OOS industry participants from spacecraft equipment manufacturers, spacecraft operators, service providers, developers of RPO/OOS simulation, planning and safety tools, and insurers.

**AIAA S-158, Prepared Free-Flyer Capture and Release, has also been issued for public review.** This document describes best practices, functional requirements, operational requirements, and norms for the design, testing, and operations of prepared Free-Flyer Capture between Servicing Spacecraft and a Client Space Object. The intent is to ensure safe and reliable operations for prepared in-space capture, and to lay the foundation for future standards for prepared capture interfaces.

**Public review deadline for both drafts is 14 April 2025. For a copy of the drafts, submission of public review comments, or questions, please contact Nick Tongson (nickt@aiaa.org).**

# 2025 Sperry Award Winner Honored for Pioneering Research in Electrified Aircraft Systems

## Lawrence Sperry Award

Each year, AIAA presents the Lawrence Sperry Award to recognize a notable contribution made by a young professional, age 35 or under, to the advancement of aeronautics or astronautics. **AIAA Senior Member Gökçin Çınar** has been honored "for pioneering research and innovative contributions to electrified aircraft systems and sustainable aviation."

As noted in her award nomination, Çınar, an Assistant Professor of Aerospace Engineering at the University of Michigan, stands as a beacon of innovation and commitment in the realm of sustainable aviation and electrified aircraft propulsion. Her Ph.D. thesis is one of the inaugural works devoted to formulating a comprehensive methodology for hybrid-electric aircraft systems design and optimization. She has made significant contributions to the integration of energy management optimization for hybrid propulsion systems at the aircraft design stage that carved a distinctive niche in the academic and professional sphere. In addition, Çınar's innovative approach led to the creation of a unique co-design and optimization framework for aircraft sizing under diverse power management strategies, maximizing the environmental advantages of hybrid-electric aircraft.

### A Fascination with Flight and Computers Led Her to Aerospace

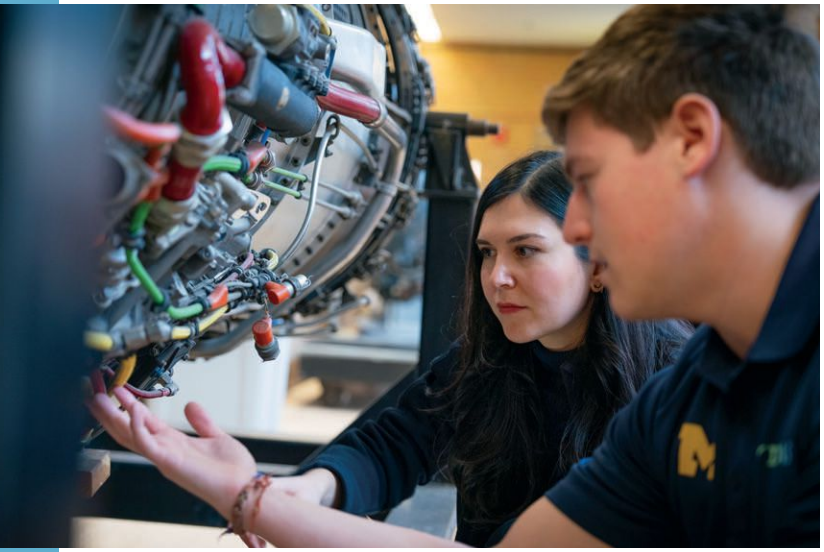
Çınar has always been fascinated by how things work. "My dad and both grandfathers could build or fix anything, and I grew up watching them work on DIY projects. By the time I was four, I had my own little hammer and built my first airplane—two wooden sticks nailed together for the body and wings, with an old drawer pull acting as a propeller. I developed an obsession with flight; I'd watch airplanes and wonder why they looked the way they did and how they stayed in the air. There was something magical about flying. And that sense of curiosity and fascination never went away."

Her fascination with computers also began at a young age when she began coding, experimenting with simple programs, and figuring out how computers could simulate, calculate, and solve problems that seemed impossible by hand. That passion continued to grow.

Çınar scored high enough on the national college entrance exam to choose any field of study. She noted, "aerospace engineering wasn't a common choice at the time, and people thought I was making a mistake by selecting it—back then, nothing major was happening in aerospace in Türkiye. But I had no doubts." Her choice, Middle East Technical University (METU), had a very strong aerospace program, and allowed her to work on cutting-edge aviation challenges. She added, "the field has since exploded in Türkiye, and aerospace engineering is now one of the most sought-after disciplines."

Çınar chose an academic research internship early on. "My cousin, who was doing a Ph.D. in physics at the time, encouraged me to apply to the Radio and Plasma Wave Group at the University of Iowa, led by the late Prof. Donald A. Gurnett. I spent the summer analyzing whistler mode emissions in Saturn's magnetosphere using data from the Cassini spacecraft. It was my first exposure to research methodologies and data processing, and I realized I loved tackling open-ended problems." She later interned at Turkish Aerospace Industries, where she developed an aircraft design tool for UAVs.

She had an amazing opportunity as a freshman to join the METU Paragliding Society and learn solo paragliding, deepening her appreciation for flight. Çınar also participated in student design competitions, such as AIAA Design/Build/Fly in her junior year. In her senior year, she led the METU group in a joint METU-Georgia Tech team for the AHS/Industry Student Design Competition, where they designed a Rotary Wing Pylon Racer and won first place. "That experience, combined with my growing interest in aircraft design, led me to Georgia Tech's Aerospace Systems Design Laboratory (ASDL) for my graduate studies."




## Rethinking the Traditional and Exploring Unconventional Propulsion Architectures

NASA programs have played a major role in shaping Çınar's research career. While pursuing her M.S. in Aerospace Engineering, she worked on the NASA Environmentally Responsible Aviation (ERA) project, which focused on developing integrated technologies to improve efficiency and reduce noise for future air vehicles. She said, "My contributions were in fleet-level analyses, evaluating how novel technologies could impact aviation at a broader operational scale. While electrification wasn't a focus at the time, this project sparked my interest in rethinking traditional design trade-offs and exploring how unconventional propulsion architectures could unlock new levels of efficiency and performance."

By the time she started her Ph.D. at Georgia Tech, electrified aircraft propulsion was still a niche topic in aerospace. She turned to electric vehicle (EV) research to build a foundation in component modeling and powertrain optimization. Çınar's dissertation was one of the first (if not the first) to develop a comprehensive methodology for electrified propulsion aircraft sizing and synthesis, introducing a propulsion-system-agnostic aircraft design and optimization framework. In addition, a major outcome of her Ph.D. was the computational aircraft design software she developed, which became a key enabler for system-level design and assessment of electrified aircraft. "This tool allowed us to analyze novel propulsion architectures, optimize their performance, and integrate power and energy management strategies into the aircraft design process—a crucial factor for hybrid systems. I feel fortunate to have worked on the right problem at the right time, creating methodologies that have since been widely adopted in our research community."

After completing her Ph.D., she worked as a Research Engineer at ASDL, leading research groups focused on electrified aviation. Electrification became a major research priority in aerospace, and Çınar became involved early in the NASA Electrified Powertrain Flight Demonstration (EPFD) project. "Contributing to this landmark initiative has been a defining moment in my career, and I'm fortunate to be continuing this work now at Michigan," leading the IDEAS Lab, where computational methods for future aircraft design and system-level optimization, combining physics-based modeling, data-driven approaches, and systems engineering, are developed. As part of the project, the lab developed FAST (Future Aircraft Sizing Tool), an open-source, multi-fidelity framework that enables users—from students to industry professionals—to explore and design novel aircraft. Çınar noted, "By making FAST open-source, we aimed to lower the barrier to entry for aircraft design and foster broader engagement in the field. While FAST provides a strong foundation for early-stage design and analysis, our lab also develops more sophisticated, high-fidelity methods for detailed system modeling and optimization. Building on this open-science initiative, we have since released FAST AEROBASE, a comprehensive aircraft and engine database, along with regression models to enhance predictive capabilities."

Çınar's team recently was selected for NASA's AACES 2050 initiative, a multidisciplinary effort focused on evaluating next-generation aircraft configurations. Collaborating with Electra.aero and other industry and academic partners, they assess future aircraft concepts, propulsion architectures, and operational strategies for mid-century commercial aviation. "Being part of this initiative allows us to apply our expertise in system-level design and optimization, ensuring that emerging propulsion technologies and novel configurations are evaluated with a holistic, fleet-level perspective."

## Aviation at a Turning Point

"For decades, aircraft design has advanced through incremental improvements, but now, emerging technologies are redefining what's possible. These breakthroughs aren't just about improving efficiency—they're expanding the design space and unlocking new levels of performance that were previously out of reach," expressed Çınar. "With innovations in propulsion, airframe design, and computational tools, we can now optimize aircraft beyond traditional trade-offs, leading to higher efficiency, greater operational flexibility, and enhanced overall capability."

She is most excited about how computational methods are evolving to match this complexity. "As aircraft architectures become more advanced—whether through electrification or other novel propulsion concepts—traditional design approaches alone aren't enough. We need more sophisticated modeling, optimization, and simulation techniques to fully understand system-level trade-offs and push the boundaries of performance."

She also noted, "At the core of all this is systems thinking. New technologies don't exist in isolation—their real impact depends on how they interact across an entire aircraft system. That's why a key focus of my



work is developing computational methods that incorporate systems-level insights to solve complex design challenges. I'm working on a range of future aircraft technologies, exploring how novel propulsion concepts, subsystem-level solutions, and unconventional configurations can be integrated into next-generation designs. By developing new frameworks and methodologies, I aim to quantify trade-offs, assess emerging technologies in a system-wide context, and optimize aircraft design across multiple dimensions. It's an exciting challenge, and I look forward to seeing how these advancements shape the future of aviation."

## Gaining Valuable Insights from Mentors

Çınar's career has been shaped by many mentors and collaborators. "At ASDL, I had the privilege of collaborating with brilliant researchers, gaining valuable insights and perspectives. My Ph.D. advisor and mentor, Dr. Dimitri Mavris, had a profound impact on me. He runs one of the most influential aerospace research programs in academia, and I was lucky to have his support throughout and after my Ph.D. I learned a great deal from him about hard work, resilience, and compassion—qualities that continue to shape my approach to my work."

She added, "NASA Aeronautics also had a major impact on my research journey. I'm grateful for the many projects I've worked on that were funded by NASA and for the people I've collaborated with along the way. These opportunities not only allowed me to contribute to high-impact research, but they also broadened my vision of what's possible in aerospace. Gaudy Bezos-O'Connor has been an outstanding leader in the EPFD Project, and I've learned a great deal from working with her. Another great collaborator from EPFD is Ralph Jansen, who stands out as one of the most technically impressive engineers I've had the chance to work with."

"Dr. Susan Ying's mentorship has been invaluable since the early days of my career—I'm inspired not only by her career path but also by her generosity in sharing her experiences with me. Looking back even further, Dr. Ilkay Yavrucuk and my cousin, Dr. Tuna Yıldırım, played a pivotal role in encouraging me to pursue my Ph.D. at Michigan; Dr. Joaquim Martins has been an incredible colleague and mentor. He is a globally recognized leader in his field, yet remains humble and generous with his guidance—something I deeply admire."

She expressed there were many others who have influenced her career, and that she's had the privilege of working with outstanding colleagues across industry, government, and top institutions, as well as mentoring talented Ph.D. students at Georgia Tech and Michigan. "This recognition reflects our shared commitment to innovation and collaboration." Çınar also acknowledged her family as her greatest source of support and inspiration. "Their unwavering encouragement has played a huge role in my journey, and I'm incredibly grateful for their belief in me every step of the way."

## AIAA Facilitates Connections and Broadens Perspectives and Impacts

Çınar became an AIAA member as a graduate student in 2012, recognizing the Institute as a cornerstone for aerospace research and professional development. "Over the years, AIAA has been instrumental in facilitating connections with academia, industry, and governmental bodies."

She noted, "My involvement with AIAA has played a major role in my career. I became involved in technical committee work during the final year of my Ph.D., joining the Aircraft Electric Propulsion and Power Working Group in 2018. That group evolved into the Electrified Aircraft Technology Technical Committee (EATTC) in 2020, and I've been actively involved since its founding, including servicing as TC chair. I initially served as the Publications and Policy Subcommittee Chair, working with colleagues to produce Year in Review articles and contribute to AIAA's knowledge-sharing efforts." She is proud of the EATTC's activities, organizing technical sessions at AIAA forums and bringing together experts from industry, academia, and government to discuss the future of electrified aviation.

Çınar has also been deeply involved in the AIAA/IEEE Electric Aircraft Technologies Symposium (EATS) since 2018, and it has become the go-to event for those working in electrified aviation, connecting aerospace and electrical engineers to exchange insights and tackle the challenges of electrified aircraft systems.

She concluded, "AIAA has broadened my network, my perspective, and my impact. Through my work in technical committees, conferences, and working groups, I've had the opportunity to collaborate with leading researchers, engineers, and decision makers who are shaping the future of aerospace. It's been a privilege to contribute, and I look forward to continuing to engage with the AIAA community."

# ASCENDxTexas Helps Navigate the Evolving Space Economy

**The fourth annual ASCENDxTexas event convened over 450 industry leaders and local stakeholders** to discuss commercial LEO destinations (CLDs), state-backed industry support, and the tangible hardware that make moonshots a reality—all with a Texas flair.

This unique one-track, one-room conference provided active networking and brainstorming opportunities with the 15+ CEOs and company presidents in attendance, as well as an interactive discussion where attendees provided anonymous feedback and concerns over critical topics in the industry. The proximity of the event to NASA Johnson Space Center (JSC) also afforded candid conversations with senior NASA leaders and the newly appointed NASA Acting Associate Administrator Vanessa Wyche.

"We stand at a point in time of opportunity, and I could not think of a more fulfilling theme than aligning stakeholders for giant leaps. I will say that the future is very bright," Wyche stated in her opening remarks.

## Discussing the Latest Topics, Opportunities, and Issues

The content—timely and relevant from critical industry leaders—as well as the format of this event were expressly designed to facilitate a path toward active outcomes in the local, national, and international space industries. Panelists discussed one of the hottest topics in technology—artificial intelligence (AI)—and commented on how AI is going to space with us. "When we go to space, we take everything we need with us—including information. AI will be a critical part of that journey," said one panelist.

Another panelist added, "We conducted an experiment in the Western U.S. where a team was isolated for two weeks. We mapped their activities and envisioned AI-enabled tools for future explorers—like AR goggles providing real-time terrain mapping to enhance situational awareness on the moon. AI will ensure astronauts don't step into hazards, especially when maneuvering in bulky gear."

Top executives from the five leading companies building CLDs—Axiom Space, Orbital Reef, Sierra Space, Starlab, and VAST—were bullish on recruiting top talent.

"The job opportunities in space are not just for the space geeks. We're welding stuff. We're rolling metal. We have IT departments and HR departments and more."

"I don't think there's a shortage of talent; you need a mix of people experienced in human spaceflight and people working on satellites."

"Enrollment in aerospace engineering is up. SpaceX has made space really sexy again. You see NASA meatball shirts everywhere now. I think we're in a really good place, and there are so many bright people who want to be involved in space—it's fantastic."

"As we all succeed, we will become magnets within the aerospace industry."

## Mars Is the Goal

AIAA CEO Clay Mowry had the chance to talk one-on-one with Amit Kshatriya, NASA Deputy Associate Administrator for the Moon to Mars

Program, who delivered one of three keynote addresses. Kshatriya shared his optimism for what the program represents for American competitiveness.

"What I really wanted to talk about to the team today is about all the amazing work that's going on right now, and all the amazing work that has to happen in this industry. It's the capacity in all the 50 states that are going to be used in all of our critical work in the coming century, which is going to be incredibly competitive. Really, what we're doing is taking the people's treasure and reinvesting it back in a way that can expand our capacity and our capability to do amazing things for the next 100 years.

"It's very important for us that we not only have been the leader in global space exploration, we need to continue to be that leader. It's about the way we do things, and we want that to be the light that shines on the world. For the countries that join us, they're participating and every interaction I've seen with all of them has been 'Wow, we just want to be a part of this,'" Kshatriya said.

He further shared his enthusiasm for getting to Mars. "Everything we've been doing, even in low Earth orbit, has been enabling Mars. For years on the International Space Station, we've been building life support systems and power systems and other really complicated things that we need. We've been building specified to a Mars-type design reference – three years of reliability, three years of capability, 98% of water reclamation, all of these standards. We have a commercial industry that can do reusable transportation in a lot of different ways. We have those learnings down now. We're really ready to make the push. Mars has always been the goal. It's extremely ambitious, but it can be done. I'm really optimistic that we can get there. It's so exciting!"

**Key takeaways from ASCENDxTexas include:**

- The commercial lunar market is booming—from landers to lunar terrain vehicles to resource utilization.
- The aerospace supply chain is driving engineering innovation, delivering the tools, technology, and capacity to support the production of our engineering designs and dreams.
- We're equipping the next generation to keep the United States competitive in space.

## Next Giant Leaps

The closing speaker, Chirag Parikh, former Executive Secretary of the White House's National Space Council, inspired attendees with a reference to the speech by the 1980 U.S. men's Olympic hockey coach featured in the movie, *Miracle*. "Great moments are born from great opportunity. That's where we are right now with respect to space," Parikh observed.

As the event concluded, organizers agreed that with open communication, technical acuity, and the congenial atmosphere at ASCENDxTexas, the next giant leap started here.

Join us at this summer's apex ASCEND event, 22–24 July, Las Vegas, to continue embracing the opportunities and addressing the challenges that come with increased activity in space.

## Transatlantic Space Initiative Announced Between Texas and France

**Texas-based Rice University, Stellar Access, and Houston Spaceport announced their new transatlantic space initiative with France's space agency CNES and Business France. They are aiming to help emerging French companies connect with industry leaders and essential resources, paving the way for their expansion into Texas and the United States while driving economic growth and innovation.**

**"By leveraging the strength of Texas and France, we are fostering an environment where innovation thrives and commercial space activities can flourish," said David Alexander, professor of physics and astronomy at Rice, director of the Rice Space Institute (RSI), and a Texas Aerospace Research and Space Economy Consortium member.**

READ MORE

**TEXAS-FRANCE SPACE HUB AIMS TO INNOVATE SPACE COMMERCE AND RESEARCH**

MAKING AN IMPACT

# 2025 Kahn Scholarship Recipients Announced

## 2025 Kahn Scholarship Recipients

**The AIAA Foundation was thrilled to see so many incredible high school seniors apply for this year's Roger W. Kahn Scholarship.** Each of these impressive students will receive a $10,000 scholarship to support their education. They will also receive a trip to Washington, DC, to attend the AIAA Awards Gala on 30 April, and an AIAA professional member mentor to help guide each of them on their career paths.

### Farrah Berry

**CURRENTLY ATTENDING: TRINITY EPISCOPAL SCHOOL, MIDLOTHIAN, VA**

I am a current high school senior interested in mechanical and aerospace engineering. I am a goal-oriented student-athlete and musician who performs all tasks with efficacy and grace, including the talent to utilize my abilities for a cause bigger than myself. A few of my skills include speaking Spanish and Chinese, playing the saxophone, solving Rubik's Cubes, and graphic design. I am also the captain of my school's FIRST Robotics Competition team: 539 Titan Robotics.

I became enthralled with aerospace after my airplane mechanic technician internship at Aero Industries. This experience inspired me to complete the Virginia's Space Grant Consortium Private Pilot Ground School and attend the Aim High Flight Academy this summer. I want to understand the mechanics of how to get to the stars and soar through the sky so that I can have a career in thermodynamic engineering or the aerospace defense industry.

### Kazi Afra Saiara

**CURRENTLY ATTENDING: CHANTILLY HIGH SCHOOL, FAIRFAX, VA**

I was born and raised in Bangladesh and moved to the U.S. when I was 13 years old. When I was young, I dreamed of being a pilot, soaring above the clouds, but I had no idea that aerospace engineering existed. As I explored aviation, aerospace engineering stood out to me. The complexity of the field pulled me in. Through the four years of STEM courses in high school, I discovered my interest in how engines operate. One of my favorite projects from my STEM class is designing CAD models of a four-cylinder car engine on Inventor.

I participated in the MIT Beaver Works Fall Program with an all-girls team, where I learned the fundamentals of designing, modeling, and principles of flying an aircraft while also building strong connections. This experience deepened my interest in women's contributions to aviation, which led me to volunteer at the National Air and Space Museum. There, I engage with visitors, sharing my enthusiasm for aviation and highlighting female pioneers in the field. My passion for aviation and strong feminism drive me to inspire others, especially young girls, to see the possibilities in aviation. Aerospace engineering is not just about building planes—it plays a crucial role in defense, disaster response, and global connectivity. I aspire to study Aerospace Engineering at George Washington University, where I want to deepen my understanding of plane engines and their mechanics, both in aviation and modern vehicles. The history and innovation in aerospace, especially the potential of supersonic planes to revolutionize air travel, inspires me, and I am eager to contribute to the future of aerospace innovation.

### Logan Speight

**CURRENTLY ATTENDING: JAMES B. DUDLEY HIGH SCHOOL, GREENSBORO, NC**

Outside of the classroom I am involved in my high school's NSBE Jr. Program, where I help increase STEM exposure through events and community service for our students and at surrounding schools. This past summer I worked as a research intern at the UNCG Joint School of Nanoscience and Nanoengineering. My research was on a project where I aided a graduate student in constructing 3D printed nanodevices and investigated their antibacterial properties for use in medical applications. I was certified to work in a cleanroom setting, trained on stereolithography processes, and designed my own nanodevice prototypes using CAD software. This experience culminated with a presentation to all participating lab mentors and the other members of the program.

Since I was a young girl, I have always been fascinated with space. My entire life, when I needed an escape or a reminder of hope, I always looked to the stars. I used to climb outside my childhood window and sit on the roof to see the constellations. Whenever I feel overwhelmed or am going through a tough time, I go out late at night and look into the sky. The vastness of the universe, the mysteries it holds, and the sneaking sense that I belong up there — that is what inspires me to pursue the field of aerospace engineering. Besides my personal attachment to the cosmos, I strongly believe many of the answers to humanity's biggest questions can be found through space exploration and its related technologies. Our struggles with resource scarcity may very well be solved with innovations devised outside of our small blue ball. My goal is to work in the space exploration sector, designing and building spacecraft. My ultimate dream is to own a space exploration company, carrying out government contracts and servicing private interests, and reaching out to the cosmos to advance humanity's future.

## Sowmya Venkatesh

**CURRENTLY ATTENDING: AMADOR VALLEY HIGH SCHOOL, PLEASANTON, CA**

My passion for aerospace began with stargazing. Tracing constellations and contemplating the vastness of the cosmos fascinated me, but what truly captivated me was the idea of baryogenesis, the tiny asymmetry between matter and antimatter that allowed our universe to exist. In order to further pursue my fascination, I joined the TriValley Stargazers, my local astronomy club.

Starting from this initial curiosity, I actively pursued aerospace throughout high school, developing both technical skills and hands-on experience. In the MIT Beaver Works Fall Program, I explored aerodynamics and built model aircraft. While at George Mason University's summer research internship, I analyzed models of the sun's coronal magnetic loops by measuring velocities using satellite data.

Beyond my own learning, I sought to share the excitement of aerospace with my peers and my community. As an officer of my school's STEP UP club, I helped organize our proposal submission to the NASA TechRise Student Challenge. We were selected to design and build the payload we proposed, culminating in a launch on a rocket-powered lander. At the Chabot Space & Science Center, I started as a volunteer facilitating demos for visitors and later became an intern, guiding volunteers and assisting the Exhibit Technician in repairing exhibits and designing new ones.

Through these experiences, I have found that I am most interested in the intersection between aerospace and sustainability. I have begun to pursue this intersection, through designing a drone with a customizable payload bay for use in natural disaster response and volunteering with the Space Frontier Foundation, where I produce monthly newsletters about Space Solar Power. I plan to expand on these endeavors at university, while also engaging in opportunities like research, to be at the forefront of innovation in aerospace.

**FOR MORE INFORMATION on the Roger W. Kahn Scholarship, please visit** aiaa.org/scholarships.

# Winners of 2025 Trailblazing STEM Educator Award Announced

Challenger Center and AIAA have announced **Kelsy Achtenberg, Allan Miller, and Kevin L. Simmons** as the winners of the 2025 Trailblazing STEM Educator Award. Each teacher and their respective schools will be awarded $5,000. Additionally, each teacher will receive free access to Challenger Center STEM programming, a trip to Washington, D.C., to be honored at the 2025 AIAA Awards Gala (30 April), and an invitation to attend a future space launch experience and VIP tour.

In its fourth year, the award celebrates K-12 teachers who go above and beyond to inspire the next generation of explorers and innovators. The three winners come from schools across the United States and were selected from a competitive pool of nominations. The nominations demonstrate the remarkable efforts teachers make every day to empower underserved and underrepresented students in STEM while using unique strategies, tools, and lessons in and out of the classroom to further energize students.

Each winner can select from Challenger Center's suite of hands-on, simulated learning experiences based on their classes' needs: Center Missions, delivered at Challenger Learning Centers around the globe; and Virtual Missions, delivered by Challenger Learning Center Flight Directors to students in and out of the classroom.

## Meet The 2025 Trailblazing STEM Educator Award Winners!

### Kelsy Achtenberg, STEM coordinator, math lead, and Dean of Students at The Innovation School, Bismarck, North Dakota

With 13 years of teaching experience, Kelsy has spent the past eight focused on STEM education. During this time, she guided The Innovation School to become a Yass Prize quarterfinalist, a VELA grant recipient, and a Canopy Project school. Her excellence in teaching has earned nominations for Junior Achievement Teacher of the Year, LifeChanger of the Year, Chamber of Commerce Teacher of the Year, and the prestigious Presidential Awards for Excellence in Mathematics and Science Teaching. Holding a Master of Education in Curriculum, Instruction, and Assessment, she crafts innovative, hands-on, project-based lessons. Her commitment to inclusivity in STEM shines through many of her initiatives, including a school makerspace designed specifically for students with dyslexia.

### Allan Miller, Applied STEM and Design Technology teacher at Williston Central School, Williston, Vermont

A distinguished educator with 40 years of experience, Allan currently guides 3rd-8th graders through project-based experiences focusing on hands-on STEM activities. He spent 25 years teaching in Alaska, beginning at a Tlingit community school in Yakutat. Now a NASA Solar System Ambassador, Allan has been a Mercury Messenger Fellow and Explorer School Project Leader, and helped establish the Educator Astronaut Teacher corps. His career extends beyond the classroom: as a 1989 Reagan/Gorbachev Fellow, he taught in a Soviet school; as a 2007 Einstein Distinguished Educator Fellow, he coordinated international projects for the National Science Foundation; and as a 2020 Fulbright Distinguished Educator Fellow, he trained over 500 Uzbekistan teachers on STEM education best practices. In 2023 and 2025, he led a Fulbright project in Nha Trang, Vietnam, training faculty and students at a teacher's college on building problem-solving skills through STEM. His awards include the 2005 Alaska Challenger Center Teacher of the Year, 2008 NSTA Mohling Aerospace Educator Award, and 2013 UVM Tarrant Foundation Educational Leadership Award; he is a 2022 Vermont nominee for the Presidential Award for Excellence in Science and Mathematics.

### Kevin L. Simmons, founder of the Wolfpack CubeSat Development Team (WCDT) and Aerospace and Innovation Academy, Palm Beach Gardens, Florida

Kevin brings 21 years of educator experience to engage middle and high school students in aerospace and STEM education. His WCDT program empowers students aged 10–18 to design, build, and launch CubeSats—two have already flown, with a third set for 2025 via Firefly Aerospace's DREAM 2.0. Under his leadership, WCDT students have produced over 110 technical papers and presented at major conferences such as the International Astronautical Congress and SmallSat. Kevin also works with his team to create educational resources—such as children's books and podcasts—to make space science accessible to a wider audience. His accolades include induction into the Space Worker Hall of Fame and the AIAA Educator Achievement Award, and he co-found the annual SmallSat Education Conference at NASA Kennedy Space Center. Kevin also is an advocate, mentoring students who have participated in AIAA Congressional Visits Day and Florida Space Day, helping them learn how to advocate for accessible STEM policies and connect with leaders.

# News

## 50th AIAA Dayton-Cincinnati Aerospace Sciences Symposium Held in March


Kevin Bowcutt

The 50th annual Dayton-Cincinnati Aerospace Sciences Symposium (DCASS) was held on 4 March, at the Sinclair Ponitz Conference Center in Dayton, OH. DCASS showcases cutting-edge scientific and engineering research and innovations in a one-day event through 200 technical presentations across multiple aspects of aerospace science and technology.  This year's keynote speaker, introduced by AIAA CEO Clay Mowry, was Kevin Bowcutt, Senior Technical Fellow and Chief Scientist of Hypersonics at The Boeing Company. Bowcutt, the 2025 winner of the prestigious AIAA Durand Lectureship, spoke about "The Evolution of Hypersonic Flight Over Seven Decades and the Technical Breakthroughs That Got Us Here." Attendees also were able to participate in the associated Art-in-Science competition by submitting videos and images that combine technical content and aesthetic appeal. Thank you to our organizers and attendees for 50 successful years!

**On 25 January the AIAA Carolina Section organized a group visit to the Shellenberger Aviation Museum in Charlotte, NC.** We had 43 attendees including 11 members, 10 guests, and 22 student members. Participating student branches included University of North Carolina Charlotte, University of South Carolina, and North Carolina State University.

## Los Angeles Section Hosts Annual Student Branch Mini-Conference


On 21 February, the AIAA Los Angeles Section held its University Student Branches Mini-Conference, an annual event gathering student branches in the area to showcase the projects they are working on. In addition to the presentations there was a great crowd turnout, amazing speakers and attendees, and a career panel and networking event. There was also an opportunity for student branch leadership to share best practices with each other on their branch activities. The section is grateful that Impulse Space gave the students a tour of their facility in Redondo Beach, showcasing in-space transportation and infrastructure they are developing.

# Obituary

## AIAA Fellow Lucas Died in February 2025

**William R. Lucas** died on 10 February. He was 102.

Lucas earned a B.S. in 1943 from Memphis State College (now University of Memphis). After enlisting in the U.S. Navy in 1943, he graduated from the Navy Supply Corps School at Harvard University and served as a Supply Corps Officer in the U.S., Caribbean, and the Pacific theater during World War II. After discharge from active duty in 1946, he served in the Naval Reserves. Lucas earned a Ph.D. (chemistry, metallurgy) from Vanderbilt University in 1952 and began his career at Redstone Arsenal in the Guided Missile Development Division under the direction of Wernher von Braun.

In 1960, Lucas began working at the newly established NASA Marshall Space Flight Center. His positions included chief of the Materials Division, director of the Propulsion and Vehicle Engineering Laboratory, director of Development, and deputy center director. From 1974 to 1986, he was director of the Marshall Space Flight Center.

His career extended from the early days of the U.S. rocket program through the foundation of the space station. He helped lead the development of the Saturn moon rockets and the lunar rovers. He also oversaw development of the Space Shuttle rockets and fuel tank. After the explosion of the Space Shuttle *Challenger* in 1986, Lucas admitted to knowing about the possibility of a failure with the O-rings on the rocket. The engineers at Morton Thiokol, the rockets' manufacturer, requested to stop the launch because of the freezing temperatures; they were overruled. In February 1986, Lucas defended the recommendation to proceed with a launch. Days before the report's release in June 1986, he announced his retirement.

Lucas was elected to the National Academy of Engineering and the Alabama Engineering Hall of Fame. In 2009, he received the Dr. Wernher von Braun Space Flight Trophy from the National Space Club for his distinguished career in rocketry and science. He was a Fellow of the American Society of Metals, and the American Astronomical Society and a member of the American Chemical Society, among others. He received many awards, including a NASA Exceptional Service Medal for his contributions to the Apollo 11 lunar landing mission and a NASA Distinguished Service Medal. An AIAA Fellow, Lucas was recognized with the Elmer Sperry Award, sponsored by AIAA, IEEE, ASME, SNAME, SAE, and ASCE, in 1986 along with George W. Jeffs, George F. Page, and George E. Mueller, for significant personal and technical contributions to the concept and achievement of a reusable Space Transportation System.

# SIMPSON'S VIEW

# Aircraft production in World War II should inspire us today

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

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

Last August, I had the unique, and quite wonderful, opportunity to pilot a North American B-25 "Mitchell" Bomber of World War II vintage.

While those of us in the aerospace field probably think of aircraft from 80 years ago as simple, when I began studying the manuals and procedures to prepare for the flight, I realized that there were plenty of operating systems and design choices that went into creating these medium-range bombers. That said, piloting the aircraft made me think about the contrast to today's advanced electronics, artificial intelligence, cutting-edge automation, lightweight composites and fly-by-wire controls.

There are lessons that can be drawn from this contrast.

One of them is that complexity comes with a big trade-off: the inability to react quickly and make large numbers of aircraft. The United States produced just over 2,000 total aircraft in 1939, but in 1942, the first full year of the war for the United States, production soared to 47,000 aircraft. Then to over 85,000 in 1943, according to the National WWII Museum. Our allies built another 50,000, and our adversaries built tens of thousands. Regardless of whether the aircraft were fighters, bombers or transports, each was designed for available materials, for manufacturing by moderately skilled workers, and to be operated and flown by quickly trained crews. Maintenance personnel had only the simplest tools, yet they were able to quickly return aircraft to service. The aircraft designs were straightforward and geared to accomplish specific mission objectives. Flight controls were cables. Flight instruments were air-driven. A couple of hydraulic pumps with shuttle valves operated the landing gear and flaps. Radios had vacuum tubes inside.

Flash forward to the present era, and the contrast is stark. On average, roughly 200 fighter aircraft (including those for foreign delivery) and approximately 700 transport aircraft are produced per year in the United States. Fewer fighters but about the same number of transports are produced in Europe. These aircraft are more capable, for sure, but also much more complex than their WWII counterparts. Their designs count on materials that didn't exist a couple of decades ago. Assembly line workers require a year or more of training beyond high school. Flight crews undergo years of training before ever seeing the flight deck of a transport or fighter aircraft. Avionics are so integrated into the aircraft that multiple layers of redundancy are necessary, because the aircraft won't fly without the avionics. Aircraft and engine maintenance is complicated, with some components taking months or years to repair.

In terms of performance, these aircraft are astounding compared to those of 80 years ago. But we have to ask ourselves: Are the aircraft, their avionics and their maintenance equipment becoming so exquisite that we soon won't be able to afford the planes in the numbers we need?

We should wonder what Kelly Johnson, the legendary World War II engineer and Lockheed Skunk Works founder, would say. In his day, Johnson touted the KISS principle: Keep it simple, stupid. He told his designers to aim for "results cheaper, sooner," and apply "common sense to tough problems," according to a biographical memoir written by his former colleague, Ben Rich. "If it works, don't fix it."

While Johnson was talking about aircraft design, the KISS principle also tells us that simple aircraft can perform significant operations. In 1987, a 19-year-old West German teenager flew a single-engine Cessna 500 miles (750 km) through Soviet air defenses and landed at the gates of the Kremlin in Moscow's Red Square. More recently, the war in Ukraine has repeatedly demonstrated that small drones are inexpensive yet effective weapon delivery systems. In the Middle East, Hamas began the Oct. 7, 2023, terror attack in part with commandos flying powered paragliders, according to reporting in the Haaretz newspaper. Like the drones in Ukraine, the gliders literally flew under the radar.

Judging by expenditures, KISS has been forgotten. The U.S. Air Force obligated nearly $17 billion for new combat aircraft in 2024, the Navy obligated another $15 billion for the Navy and Marines, and the Army obligated about $5 billion, according to USASpending.gov. This does not include the expense of training crews to operate and maintain the current fleets.

A place we could adapt quickly is in the realm of unoccupied aircraft. To date, the focus has been on complex systems so that each vehicle can accomplish a broad array of missions. An alternative would be to manufacture simpler, less expensive units in large quantities, each kind designed for a specialized mission goal. Strategists would count on overwhelming numbers to ensure completion of the mission. For that reason, these aircraft are sometimes labeled "attritable," but that's not quite the same as expendable. Some might make it back after striking targets to be reused. This basic concept of operations is not entirely new. It was employed by the Allies in World War II with piloted aircraft, including B-25s like the one I piloted. Dispatching lots of bombers ensured that some reached their targets and made it home.

The loss of life was, sadly, tremendous. Today, the Pentagon could be ready to employ the strategy with multitudes of small inexpensive mission-specific unoccupied aircraft. Kelly Johnson, I believe, would be pleased with the simplicity of this idea. ★

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# Divided we'll fail in space and on Earth

BY MORIBA JAH | moriba@utexas.edu

Indigenous peoples through history have something to teach us about prospering in austere environments. Many of their cultures recognized that humans do not exist above or separately from nature, but rather, they are deeply intertwined with it: coexistence rather than conflict. These peoples lived well for thousands of years by balancing resources, community health and the needs of the land that sustained them.

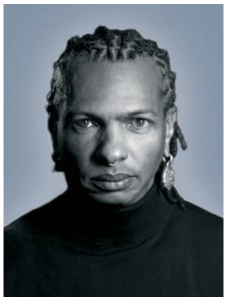
We should listen to them as we seek to settle on the moon, Mars and beyond. Overcoming our biological limitations will be challenging enough (See "Homo sapiens: making us suited for the stars," February/March). We'll also need the right culture.

That culture will be one that recognizes our interconnectedness. From that recognition comes inclusivity. This likely explains why many indigenous cultures, for example, embraced lesbian, gay, bisexual and transgender people. They depended on their two-souled or two-spirited compatriots.

Listen to Myron Long Soldier, an elder of the Omaha people. He recalled to journalist Bobby Caina Calvan in 2015 that "Native Americans treated two-spirited people with sacredness and reverence." The story is on the website of the Nebraska Commission on Indian Affairs. Or consider the Lakota winkte, described in some accounts as men with mannerisms more often identified with women. They, too, were viewed as "sacred or divine." Their wisdom and visions were sought by military commanders, according to an account on the website of the South Dakota Public Broadcasting radio station.

Reaching the moon and Mars and prospering there will require that kind of respect for everyone. Respect is the catalyst for teamwork and the freedom to voice bold ideas. It's what will inspire our leaders to look for the best and brightest throughout society, not just in their personal networks, in favored neighborhoods or at their alma maters. Success will rule out exclusionary policies like those we are seeing today in the United States, such as the ban on openly transgender people joining the military.

The history of space exploration so far also has much to teach us. We now know that landing astronauts on the moon six times involved contributions from a unit of African American women at NASA's Langley Research Center in Virginia, a story recounted in the book and 2016 film "Hidden Figures." Imagine what could have been accomplished sooner if these talented people had been proactively discovered, encouraged and elevated. Those who don't look like or live like the majority should not have to remain hidden. Lifting such people up was just starting to happen, but now it's being discouraged or banned in my country. If we are going to lead the way into space, we'll need to get back to that.



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

Of course, there is a countervailing view, one that says that by excluding certain groups of people, or pretending they don't exist, we can make things run more smoothly. Since no one is made uncomfortable by someone different from them, everyone thinks the same way, and there is no conflict. In mathematics, there is something called the trivial solution, which is a simple solution to one or more equations that is easy to find and is also not meaningful, like obtaining variables all equal to zero. Likewise, seeking to achieve coexistence by excluding everyone that doesn't fit a very specific demographic is the equivalent of the trivial solution: It's easy to find and is also not meaningful. In fact, it's flawed.

Excluding people based on their gender, identity or beliefs reduces the talent pool and crimps creative thought. Even more fundamentally, surviving in space will demand everything from us, including passion for our views. There will always be conflicts and disagreements about the best courses of action. It's inevitable. The way we handle those conflicts will determine whether we fail or thrive. Conflict resolution must be done in a manner that respects everyone involved, achieving coexistence. A space settlement built on exclusion and silence will be a ticking time bomb, waiting to implode under the pressures of isolation, stress and conflict.

Here, too, indigenous cultures have something to teach us. It's the concept of restorative justice in the cases when there are transgressions. Today's justice systems typically prioritize punishment over healing, while indigenous communities have historically focused on reconciliation and restoring balance. In a space settlement, a near-total focus on punishing transgressors will make everyone less secure by requiring scarce resources to be wasted on a vast prison system. Survival will depend on cooperation, empathy and understanding, so that as many transgressions as possible can be averted in the first place, and as many transgressors as possible can be reformed.

We would do well to begin practicing this now on Earth. If we can't manage conflict here without always resorting to punishment and exclusion, how can we expect to thrive in the extreme conditions of another planet?

In the final analysis, this issue isn't just about space exploration and settlement — it's about the kind of society we want to build. Do we want to carry Earth's dysfunctions into space? Or do we want to learn from the mistakes of the past and build something truly sustainable? Right now, we are not ready for Mars. We are not ready for space settlements. We won't be ready until we understand that inclusion, collaboration and restorative justice are required ingredients moving forward. In the meantime, we have no business reaching for the stars. ★

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

# LOOKING BACK

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

COMPILED BY FRANK H. WINTER AND ROBERT VAN DER LINDEN

## 1925

**April 2** A Douglas DT-2 torpedo bomber is launched via catapult from the deck of the USS Langley carrier, the first time the U.S. Navy demonstrates this technique. Lt. Cmdr. Charles Mason pilots the aircraft, with Lt. Braxton Rhodes serving as a passenger. **U.S. Naval Aviation, 1910-1970**, p. 57.

1 **April 13** Henry Ford's Ford Air Transport Service inaugurates the first regular air-freight service between Detroit and Chicago, flying 450 kilograms of cargo in a Stout Pullman single engine all-metal monoplane. The triweekly flights connect various Ford automobile plants with the main office in Dearborn, Michigan. **Aviation**, April 27, 1925, p. 468.

**May 1** The Imperial Japanese Army Air Corps is established. It comprises 3,700 personnel and about 500 aircraft. René Francillon, **Japanese Aircraft of the Pacific War**, p. 30.

**May 2** The first Douglas C-1 makes its inaugural flight. It's the first assigned to the U.S. army's new category of cargo/transport aircraft, designated with a "C" in the design name. René Francillon, **McDonnell Douglas Aircraft since 1920**, p. 96.

2 **June 25** NACA, the National Advisory Committee for Aeronautics, begins construction of a wind tunnel at Langley Aeronautical Field in Virginia. Later designated the Propeller Research Tunnel, or PRT, the 20-foot-diameter chamber could fit full-size propellers. NASA, **Aeronautics and Astronautics, 1915-1960**, p. 20.

## 1950

**April 18** The Convair XP5Y-1 flying boat makes its first flight. Designed for long-range search and antisubmarine patrol duties, XP5Y-1 has a laminar flow wing of high aspect ratio and high-fineness-ratio hull and fuselage. The design enters service with the U.S. Navy in 1956 as the R3Y Tradewind, but only 13 total are constructed, and all are withdrawn after two years of operation. **U.S. Naval Aviation, 1910-1970**, p. 181.

**April 24** De Havilland test pilot John Cunningham sets a point-to-point international speed record in a D.H. 106 Comet airliner. He flies from the de Havilland plant at Hatfield, England, to Khartoum and Nairobi in 5 hours, 6 minutes, 58.3 seconds at an average speed of 690.55 kph (429.09 mph). **The Aeroplane**, May 5, 1950, p. 514.

**May 10** U.S. President Harry Truman signs the "National Science Foundation Act of 1950," establishing an independent agency to "promote the progress of science" by funding research at U.S. colleges and universities. NASA, **Aeronautics and Astronautics, 1915-1960**, p. 64.

3 **May 12** U.S. Air Force Capt. Chuck Yeager pilots the final flight of the first Bell X-1 rocket plane, the same aircraft in which he conducted his record-setting 1947 supersonic flight. NASA, **Aeronautics and Astronautics, 1915-1960**, p. 64.

**June 25** The Korean War begins when the North Korean army, assisted by Soviet aircraft, invades South Korea. U.S. Navy planes and fighter planes flown by pilots of the newly independent U.S. Air Force are among the craft sent by the U.S. to bolster the South Korean troops. National Air and Space Museum webpage, **"Six Decades Since the Korean War."**

## 1975

4 **April 11** In a White House ceremony, U.S. President Gerald Ford presents the National Space Club's Dr. Robert H. Goddard Memorial Trophy to astronaut Gerald Carr, commander of the final crewed mission to NASA's Skylab space station. Carr accepts the trophy on behalf of the nine astronauts who inhabited Skylab from 1973 to 1974. NASA, **Astronautics and Aeronautics, 1975**, p. 64.

**April 19** India's first scientific satellite, Aryabhata, is launched from Kapustin Yar in the Soviet Union. The 360-kilogram spacecraft, named after the fifth-century Indian astronomer and mathematician, carries instruments to measure X-rays from celestial sources and to look for neutrons and gamma radiation from the sun. NASA, **Astronautics and Aeronautics, 1975**, p. 67.

**April 23** This is the 60th anniversary of the first meeting of the National Advisory Committee for Aeronautics, NASA's predecessor. NACA originally comprised 12 members, appointed by the president from the military and various scientific fields, who "supervise and direct scientific study of the problems of flight" and "conduct research and experiments in aeronautics." **NASA Release** 75-86.

**May 24** The second and final crewed mission to the Soviet Union's Salyut 4 space station begins with the launch of cosmonauts Pyotr Klimuk and Vitaly Sevastyanov. They spend 63 days aboard, continuing the biological, medical, and other experiments begun by the previous crew aboard the station, and taking some 2,000 photographs of Earth and 600 of the sun. Their mission sets a new endurance record for crewed Soviet spaceflight. NASA, **Astronautics and Aeronautics, 1975**, pp. 91-92, 227, 260. 282.

**June 8 and 14** Soviet Union launches its twin Venus probes, Venera 9 and Venera 10, each comprising an orbiter and lander. They arrive in orbit around Venus in late October, and the lander segments are released. Venera 9 touches down on the surface first and operates for 53 minutes, becoming the first spacecraft to transmit images taken on the surface of another planet. The Venera 10 lander touches down three days later and operates for 65 minutes, during which time it sends back additional images. The orbiter segments of both spacecraft operate for several months, transmitting information about the composition of Venus' atmosphere. **New York Times**, June 8, 1975, p. 1; June 17, 1975, p. 1 and Oct. 23, 1975, p. 1.

5 **Also in June** The Rocketdyne Division of Rockwell International Corp. conducts the first ignition test of the space shuttle's prototype engine, the Integrated Subsystem Test Bed. Lasting 0.8 seconds, this ignition is the first in a series of tests leading up to ignition of the first flight-ready Space Shuttle Main Engine. **Marshall Star** (Marshall Space Flight Center), June 20, 1975, p. 4.

## 2000

**April 4** Cosmonauts Sergei Zalyotin and Alexander Kaleri are launched to orbit in a Soyuz capsule for the final crewed mission to Russia's Mir station. Because of funding difficulties, the station has been orbiting without a crew for the last seven months. The cosmonauts spend two months aboard repairing components, including cracks in the station's hull, to restore Mir to working order. NASA, **Astronautics and Aeronautics: A Chronology, 1996-2000**, pp. 258-259.

6 **April 5** Adam Aircraft Industries unveils its six-seat M-309 light plane, developed with Scaled Composites. According to Bert Rutan, president of Scaled Composites, the all-composite twin-engine aircraft represents a breakthrough in aircraft manufacturing, having been designed and fabricated in seven months. **Flight International**, April 11-17, 2000, p. 6.

**April 24** This date marks the 10th anniversary of the deployment of NASA's Hubble Space Telescope. During its decade of operations, Hubble made some 271,000 observations. NASA projects it will operate until at least 2010. NASA, **Astronautics and Aeronautics: A Chronology, 1996-2000**, pp. 261.

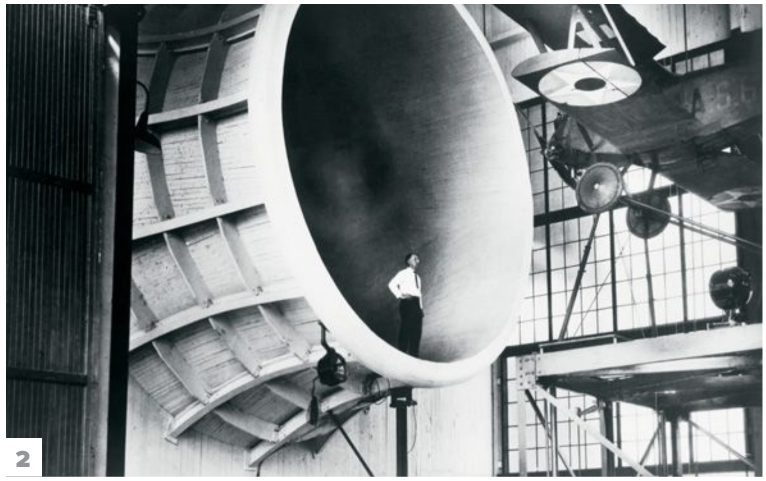
**May 24** Lockheed launches the first Atlas III. Propelled by two Russian RD-180 engines, the rocket sends the Eutelsat W5 communications satellite to geosynchronous orbit. This is the 50th consecutive successful flight of an Atlas. **Lockheed press release**, May 24, 2000.

**June 4** NASA's Compton Gamma Ray Observatory plunges into the atmosphere in a controlled reentry.

## LOOKING BACK+

MORE ENTRIES AVAILABLE ON THE WEBSITE

1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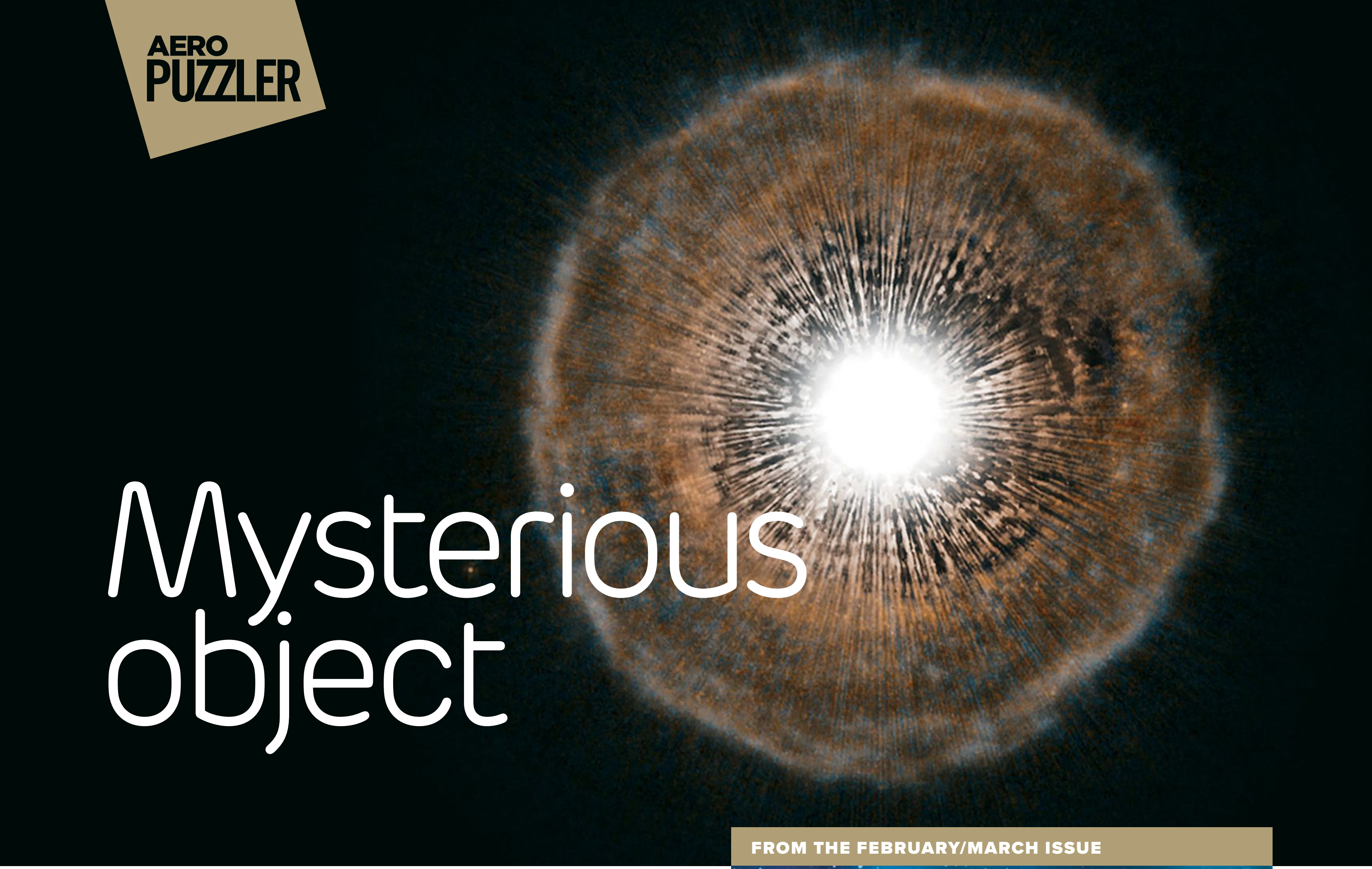
One of the four Great Observatories launched between 1990 and 2003, Compton operated for nine years until one of its three gyroscopes failed, leaving NASA unable to maintain the telescope's orbit. NASA, **Astronautics and Aeronautics: A Chronology, 1996-2000**, pp. 267.

**June 25** China launches its final Long March 3A rocket, sending the Fēngyún 2B meteorological satellite to orbit. **FAA Office of Commercial Space Transportation**, Quarterly Launch Report, 3rd Quarter 2000.

AERO PUZZLER



# Mysterious object

**Q:** What cosmic feature is pictured above, and how do such features figure into research related to the expanding universe?

**SEND A RESPONSE OF UP TO 250 WORDS to aeropuzzler@aerospaceamerica.org. By responding, you are committing that the thoughts and words are your own and were not created with the aid of artificial intelligence. DEADLINE: noon Eastern June 2.**

Scan to get a head start on the next AeroPuzzler

**FROM THE FEBRUARY/MARCH ISSUE**

## DRIP, DROP:

We asked you to explain the physics of rain drops and radio waves that define the best satellite link for watching a movie on a rainy day.

---

WINNER The composition of rain (water drops) is such that it causes attenuation (loss of strength) of radio frequency signals. The raindrops absorb some of the transmitted energy, just as the food placed inside of a microwave is heated by absorption of some of the microwave's energy. The attenuation depends on the link frequency and tends to increase with frequency. Hence, the lowest-frequency signals would experience the least attenuation, and the X-band between 8 and 12 GHz is preferable to Ku-band (12 to 18 GHz) and the Ka-band (27 to 40 GHz).

**Don Edberg**, Associate Fellow

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Don is a professor emeritus of engineering at Cal Poly Pomona.


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