AEROSPACE

★ ★ ★ AMERICA ★ ★ ★

No one will be happy to see ISS go, but its fate may be written. Here's how the story could end. PAGE 26

The last chapter?

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This unoccupied Boeing Starliner touched down in early September at White Sands Space Harbor in New Mexico. NASA in August decided the capsule would undock autonomously from the International Space Station without astronauts Butch Wilmore and Suni Williams aboard. The astronauts are to remain on ISS until February, when they will return in a SpaceX Crew Dragon capsule with two other crew members. Boeing

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EDITOR-IN-CHIEF
Ben Iannotta
beni@aiaa.org

ASSOCIATE EDITOR
Cat Hofacker
catherineh@aiaa.org

STAFF REPORTER
Paul Brinkmann
paulb@aiaa.org

EDITOR, AIAA BULLETIN
Christine Williams
christinew@aiaa.org

CONTRIBUTING WRITERS
Keith Button, Jonathan Coopersmith, Moriba Jah, Aaron Karp, Jon Kelvey, Paul Marks, Jonathan O'Callaghan, Robert van der Linden, Debra Werner, Frank H. Winter

Daniel Hastings AIAA PRESIDENT
Clay Mowry PUBLISHER
Rodger Williams DEPUTY PUBLISHER

ADVERTISING
advertising@aiaa.org

ART DIRECTION AND DESIGN
THOR Design Studio | thor.design

MANUFACTURING AND DISTRIBUTION
Association Vision | associationvision.com

LETTERS
letters@aerospaceamerica.org

CORRESPONDENCE
Ben Iannotta, beni@aiaa.org

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AIAA
SHAPING THE FUTURE OF AEROSPACE

IN THIS ISSUE

Keith Button

Keith 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. PAGE 20

Mike Gruss

Mike freelances from Northern Virginia. Previously, he was editor-in-chief of Sightline Media Group, where he led publications including Defense News and Military Times, and was the military reporter at SpaceNews. PAGE 14

Moriba Jah

Moriba is a space environmentalist, professor at the University of Texas at Austin and chief scientist at Privateer. He helped navigate spacecraft at NASA's Jet Propulsion Lab and researched space situational awareness issues at the U.S. Air Force Research Laboratory. PAGE 64

Jonathan O'Callaghan

Jonathan is a London-based space and science journalist covering commercial spaceflight, space exploration and astrophysics. A regular contributor to Scientific American and New Scientist, his work has also appeared in Forbes, The New York Times and Wired. PAGE 26

DEPARTMENTS

AD INDEX

Finishing strong

From now through early 2031, NASA will spend nearly twice the cost of the Webb telescope on its contribution to the International Space Station. If the final chapter of the station has indeed begun, it needs to be a good one, rich with research and scientific breakthroughs. Otherwise, history might not judge the vast expenditures on ISS very kindly.

Non-science-related justifications have often been made, given the lack of a blockbuster breakthrough in medicine or another field: The station is helping to ignite economic activity in space. It's teaching us how to live and work there too. There are geopolitical benefits to international partners working together up there.

These probably won't be enough to justify the almost incalculable expenditures to build and operate ISS over two and half decades. I found estimates ranging up to $200 billion when all partner contributions are tallied. Sadly, on the geopolitical front, having Americans and Russians working together in space has had absolutely no moderating effect on Russia since the fall of the Soviet Union.

So, that leaves it largely to science and technology to recoup the investment. Gauging the benefits of ISS compared to its costs is a complicated proposition. I wouldn't dare attempt it here. What seems safe to say is that major breakthroughs in medicine and other areas are still needed to push the cost-benefit equation into "no brainer" territory.

Six years could be enough time to do it. For example, LambdaVision, a Connecticut biotechnology company, sent its latest artificial retina experiment to ISS in January as the next step in its effort to cure age-related macular degeneration and retinitis pigmentosa. In the area of space manufacturing, researchers on ISS this year manufactured 12 kilometers of optical fiber made from ZBLAN glass, a material that's clearer than silica but that Earth's gravity prevents from being made in large, uniform quantities. These are just a couple promising technologies that could pay off in the years ahead.

Of course, perhaps it's not realistic to demand "blockbuster" breakthroughs from ISS research. After all, Alzheimer's disease, most cancers, Parkinson's disease and many others remain incurable after decades and hundreds of millions of dollars of research on Earth. Perhaps many small, important discoveries are how NASA will justify this last $18 billion expenditure.

Put simply, if I were pre-writing an obituary for ISS, I would save a few paragraphs. The story is not over. ★

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

▲ A crew member aboard the space shuttle Endeavour took this photo as the orbiter approached the International Space Station to dock in 2010.

NASA

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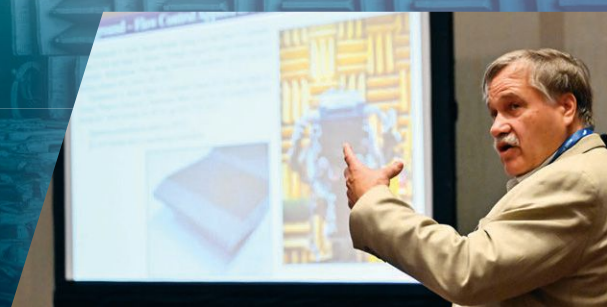

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Shaping the Future of Aerospace Together

Your greatness is measured by your horizons. – Michelangelo

Today, we embark on a journey to ensure a vibrant future for AIAA. I am thrilled to lead the Institute at this exciting time for the aerospace community as we push the boundaries of air and space. Together, we are charting a path to innovate and expand the Institute, ensuring its relevance for the next 100 years. The horizons we pursue are truly great.

I began my career in the U.S. Department of Commerce's Office of Aerospace three decades ago. Back then I told anyone who would listen that I had the best job in the U.S. government, helping the aerospace sector to thrive. Now, after leading a trade association, working as an executive in the satellite launch/human spaceflight industry, and serving on several nonprofit boards, I feel as if I've been training to take on the AIAA CEO role my entire career.

Looking back on the Institute's birth, we owe the success of our first 100 years to remarkable technical leaders and innovators. We stand on the shoulders of giants like Robert H. Goddard, who demonstrated liquid-fueled rocket technology, and Orville and Wilbur Wright, who broke the hold of Earth's gravity by sustaining controlled flight of an engine-powered aircraft.

Today's Institute is propelled into the future by remarkable advances in aeronautics and astronautics produced by our very members. Modern aviation capabilities and space exploration missions are possible due to AIAA members' purpose-driven technical pursuits.

I am truly grateful to Dan Dumbacher for his commitment to our community during his tenure at the yoke of AIAA. He led the Institute to address the needs of today's aerospace professionals, invest in future generations, and increase our relevance to the broader community. He also helped us tap into our resilience, as we weathered the impacts of the pandemic and continued our financial recovery. Please join me in thanking Dan for all he has done.

The AIAA Board of Trustees and CEO Search Committee that brought me to the Institute recognize that AIAA must evolve to stay relevant over the career path of today's aerospace professional. Technology allows us to be more efficient and productive. But it also means our members have less time to focus on AIAA volunteer activities like committees. While our 30,000-member-strong Institute is a mighty asset, we need to focus our efforts to provide meaningful programming, publishing, networking, and continuing education throughout the professional career arc if we are to remain the world's premier aerospace technical society.

My task is to harness our members' collective energy. We will honor the Institute's proud heritage by refining our member services to better meet the needs of the aerospace professionals, engineers, scientists, researchers, educators, and students of today and tomorrow. Our focus will be clear.

- **Engaging the next generation.** We will involve more young professionals and students in deeper ways. They will be the leaders who chart our community's bright future.
- **Expanding our international reach.** We will build bridges across the globe to strengthen our connections everywhere, growing the international contributions to the AIAA community.
- **Reimagining member services.** We will continue our digital transformation, making the vast amounts of expertise and content in our archives accessible, searchable, and even more valuable. We will revitalize our events, making them more engaging, interactive, and relevant. We will expand our lifelong learning opportunities through our continuing education courses that help members enhance their skillsets.

As I embark on this journey with you, it is my honor to represent our entire community – from aeronautics to aerospace R&D to space. The strength of AIAA has been built upon the strong technical connections our members make across the three AIAA Domains, working in all facets of government, industry, academia, and defense.

I am hitting the ground running. This fall I will be meeting members in our local sections and universities, as well as visiting Corporate Members and Corporate Partners. My goal is to connect with the AIAA community in person. We'll also have a fantastic opportunity in January 2025 when our community gathers in Orlando for one of our signature annual events, AIAA SciTech Forum. I hope to see you there to introduce myself and listen to your thoughts on how to better serve the membership over the next century.

It's a privilege to help shape the future of aerospace, leading the Institute and empowering members to achieve the next breakthroughs that will enable us to fly farther, faster, smarter, and safer in the Earth's atmosphere and beyond the Kármán Line. I look forward to all we'll do together. ★

Clay Mowry
Chief Executive Officer, AIAA

AERO PUZZLER

Email us at aeropuzzler@aerospaceamerica.org

The second Saturn V rocket lifted off from NASA's Kennedy Space Center in Florida in April 1968, sending the unoccupied Apollo 6 capsule to orbit.
NASA

Pogo sticks and rockets

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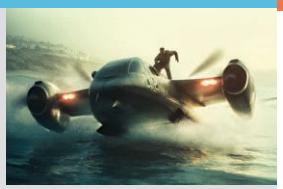
FROM THE SEPTEMBER ISSUE



A SHOCKING ENDING:

We asked you to choose between two endings for an action film scene in which water is about to reach the battery pack of an air taxi that's been ditched into the ocean with a hero and villain aboard. None of the responses chose the correct ending, so we asked Matt Alonis, an aerospace engineering fellow at TE Connectivity, to provide an answer:

"The answer is B — Our hero jumps into the ocean and starts swimming away furiously. The screen goes black and we cut to a yacht, where the hero requests a Fireball old fashioned and toasts the villain: 'Better to go out with a bang.'

"In a standard eVTOL design, the batteries and high voltage cables would likely be in the wings, which are higher than the passenger compartment. Thus, there would not be a significant risk of touching unprotected power cables to complete the circuit. Electrical energy follows Ohm's Law (I = V/R) and consequently, the path of least resistance, so being in contact with the water doesn't guarantee the villain would be shocked even if the battery is submerged in the ocean, as the short distance between battery terminals is significantly closer than the distance to the passengers, resulting in a very high resistive path to the passengers, thus negligible current reaching them.

"The greatest risk in the scene is a battery fire or explosion. Without a battery management system, there is high likelihood that the eVTOL battery would overheat and catch fire. The hero should swim away from the battery pack and hope his adversary is a slow swimmer."

Extravehicular activities, then and now

BY CAT HOFACKER | catherineh@aiaa.org

When billionaire Jared Isaacman and SpaceX engineer Sarah Gillis took turns poking their upper bodies out of their Crew Dragon capsule, the feat was less daring than the first spacewalks six decades ago.

In March 1965, in the midst of the Cold War space race, Soviet cosmonaut Alexei Leonov climbed through the airlock of his Voskhod-2 capsule and floated in free fall, tethered to his spacecraft by only a skinny umbilical. Three months later, when NASA astronaut Ed White ventured out of the Gemini IV capsule, NASA added a twist: He initially maneuvered by firing a handheld "zip gun" full of pressurized oxygen, stretching the umbilical to nearly its full 8-meter length.

By contrast, Isaacman performed what those in the spaceflight business call a "stand-up EVA." He emerged through the hatch opening normally reserved for docking to the International Space Station, while a camera on the hatch captured the scene for a live audience on X. He paused for a few moments to take in the view over New Zealand, then gripped one of the "skywalker" rails at the hatch opening. He slowly rotated his free arm back and forth, then switched to the other arm and also raised his legs. It all took about 10 minutes, and then Isaacman traded places with Gillis, who ran through a nearly identical set of exercises. Neither of them exited Dragon entirely, hence the distinction of a "stand-up" EVA.

Isaacman, in a post-mission tweet, described the maneuvers as "basic in comparison" to spacewalks done by professional astronauts. The purpose was to make Isaacman and Gillis the first private citizens to conduct an EVA, as well as test the mobility of the suits. It's all part of SpaceX's long-term plan to send millions of people to the moon and Mars. Without a Soviet Union to beat, SpaceX and Isaacman — who paid an undisclosed sum for the mission — had more leeway to dictate the schedule and objectives for Polaris Dawn.

For sure, it was "prudent" not to have the crew float outside the capsule, says veteran spacewalker Tom Jones, a former NASA astronaut. It was the first SpaceX-run EVA, and the first time the suits shielded humans against the harsh environment of space. Jones, who is not affiliated with SpaceX and Polaris Dawn, expects this will be the first in a series of increasingly ambitious EVAs that will be conducted to demonstrate SpaceX's suit and procedures.

He also expects the mission to have impacts beyond SpaceX: "They're rebuilding Gemini, but that's the first step in a process where commercial companies will one day be maintaining private space stations and eventually doing lunar EVAs."

Based on his own spacewalks from shuttle orbiters, Jones believes such tasks will require SpaceX to at some point develop a second, bulkier EVA suit, similar to the ones that astronauts don today to make repairs to ISS. Those suits have fiberglass and aluminum upper torsos "that you can attach hard things to, like cameras and power tools," he says, and eliminate the oxygen umbilical in favor of a life support backpack so astronauts can "travel farther without having the restraint from the umbilical." ★

◀ NASA astronaut Ed White completed the first U.S. spacewalk in June 1965, three months after Soviet cosmonaut Alexei Leonov conducted his. NASA

▲ A camera on the nose hatch of the Crew Dragon Resilience took this photo of Jared Isaacman testing the mobility of his SpaceX suit during his September stand-up extravehicular activity. SpaceX

PHOTO ILLUSTRATION

GOAL: A SMOOTHER AIR TAXI RIDE

BY PAUL BRINKMANN | paulb@aiaa.org

▲ Crisalion Mobility believes its method of adjusting the position of its aircraft's rotor assemblies via passive joints will result in a less bumpy ride for passengers through all phases of flight.

Crisalion Mobility

Among the many emerging airframe designs in the fledgling electric air taxi industry, it's unusual to come across a claim of fundamental uniqueness.

Crisalion Mobility, an 8-year-old company located in Madrid, is attempting to beat other multirotor designs on range while beating tiltrotor designs on smoothness of the ride by isolating the airframe from unwanted forces produced by its rotors.

The company propelled a two-seat demonstrator with this patented FlyFree propulsion structure during a series of remotely piloted flights. The airframe was connected to the rotor assemblies with passive joints, meaning they didn't have actuators like those that would shift the position of propellers on a tiltrotor. These joints flexed in a manner similar to shock absorbers. Control of the aircraft was derived from groups of four rotors, with each group mounted on a frame. The rotors' speed of rotation was adjusted to flex the passive joint and position the rotor groups to either make the aircraft climb, descend or fly horizontally.

Having flown the small demonstrator, the company is now building a six-seat prototype to test the FlyFree technology for its planned fleet of Integrity air taxis. Two booms perpendicular to the main wing will have a rotor group at each end, called a UPM, or unit propulsion motor. The passive joints that connect the UPM assemblies to the booms must absorb unwanted force from the rotors to produce a smooth ride for those in the passenger cabin. Each UPM will shift its orientation independently of the others because of the flexible passive joints that support each UPM.

Crisalion expects to fly this production prototype by 2026. The goal is to have Integrity in commercial service by 2030 after certification by the European Union Aviation Safety Agency.

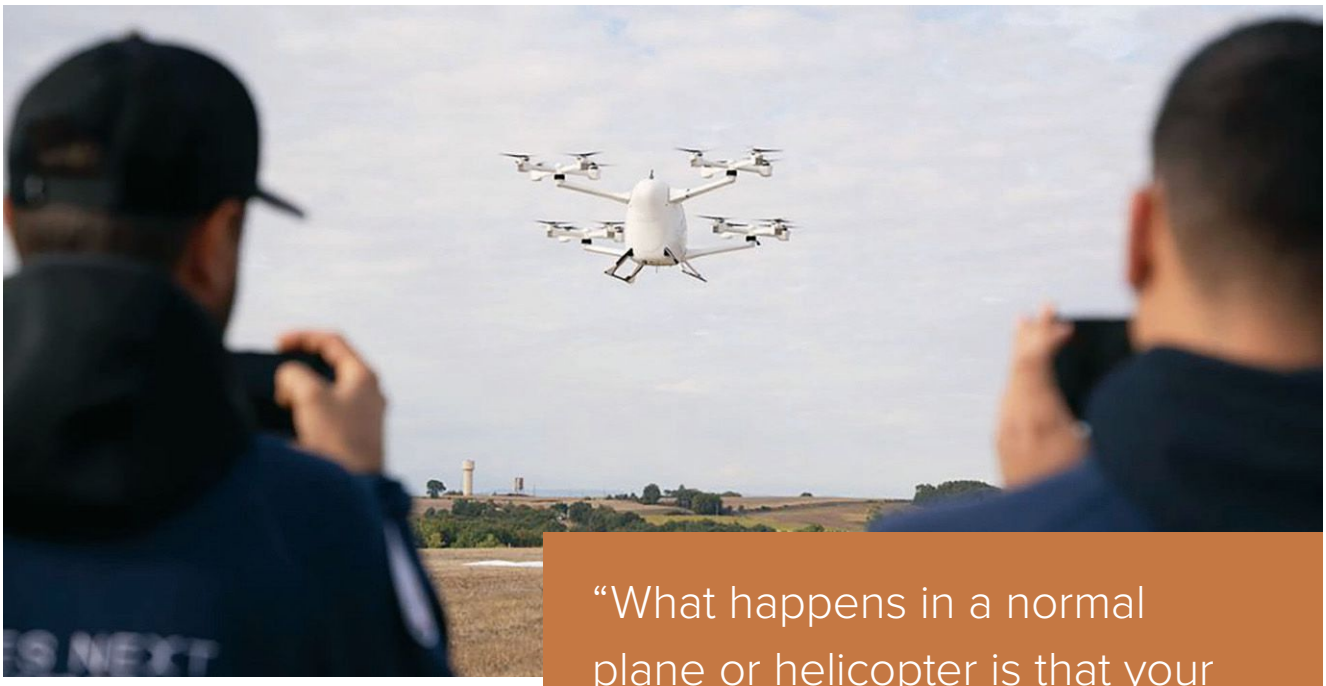
The aircraft achieves "exceptional safety, stability and agility in all phases of flight, even in adverse weather conditions," the company claims.

FlyFree was developed by Tecnalia, a nonprofit research and development center based in Donostia, Spain. Crisalion, then called UMILES Next, bought the rights to the technology and patented it in 2019. Crisalion has received funding from the Spanish Ministry of Science, Innovation and Universities. Additional investors include two wealthy Spanish families.

Oscar Rapp, Crisalion's chief operating officer, tells me the problem with most electric air taxis is that vibrations are passed to the airframe and to the passenger cabin by the rigid connections between the airframe and the propulsion units. This results in a bumpy ride for passengers.

While several companies are developing tilt-propeller air taxis, Rapp pointed out that the only tiltrotor design in operation today is the V-22 Osprey, which is certified for military use. He noted that the Osprey has repeatedly been grounded after accidents, most recently in 2023 after a crash off the coast of Japan that killed eight U.S. Air Force airmen.

"The tiltrotor or tilt-propeller design, we don't like it too much. Its complexity causes problems for certification," Rapp said. "What Crisalion has instead is a passive joint, a less complex structure, so that we are able to control the aircraft in a



▲ Crisalion has demonstrated its FlyFree propulsion configuration with its remotely piloted demonstrator. Plans call for beginning flight tests in 2026 with a production prototype of the six-seat design.

Crisalion Mobility

much simpler way. We are minimizing the coupling between the motors, the propellers and the cabin."

He continued: "And this is important, because when you have somebody inside, you will be able to correct for wind gusts or turbulence, just by moving your power plants" — the UPMs — "and minimizing the movement of your cabin."

Rapp said each UPM can adjust immediately to counter or control for turbulence in the atmosphere. "What happens in a normal plane or helicopter is that your engine is moving together with the cabin. So when you have turbulence, the whole aircraft is going to shake up and down," he said.

But the FlyFree structure, due to its passive joints, will respond to turbulence without transmitting it to the cabin, he said.

"So we think that we are really solving a problem from the point of view of passengers and potential customers — they will have a much more pleasant experience because they are not going to be moving up and down, shaking inside."

Researchers from Tecnalia published several papers describing FlyFree. One of them states that the structure enables "independent control of the six degrees of freedom of the airframe without having fixed propellers at inefficient configurations or making use of dedicated rotor-tilting actuators."

The production model of Integrity will be 3.5 meters high with a 15-meter wingspan and have a range of 130 kilometers at a speed of 180 kph, according to Crisalion.

U.S. observers of the industry that I spoke to said they were intrigued by the FlyFree concept but wanted to know more about it.

> "What happens in a normal plane or helicopter is that your engine is moving together with the cabin. So when you have turbulence, the whole aircraft is going to shake up and down."
>
> **— Oscar Rapp, Crisalion Mobility**

Mike Hirschberg, director of strategy for the Vertical Flight Society, the Virginia-based nonprofit technical society, said he doesn't know what to make of the boom structure on Integrity, and he's hoping Crisalion will present at an upcoming meeting of the group.

Daniel Smith, a helicopter pilot and assistant professor of aviation at the University of Nebraska at Kearney, reviewed papers about FlyFree at my request. He said he was intrigued and would like to know more about Integrity.

Smith said the structure would eliminate the need for actuators, but he thought some kind of motor control would still be required for the joints connecting the rotors to the airframe.

"This is definitely an interesting concept. I am not sure that it will increase stability, nor am I sure of the efficiency and durability of this design," he said. "But we haven't seen many advances in rotorcraft technology, so this would be an exciting technological improvement." ★

Hypersonics sage

Development of hypersonic weapons and defenses in the United States was limited to basic research a decade ago. Then, during the Trump administration, the Pentagon's Michael Griffin warned in a 2018 Senate hearing about China's hypersonics prowess. Russia had rattled its hypersonic saber a month before — and a year later, China did too. U.S. hypersonics research boomed into a multibillion-dollar annual enterprise, a level the Biden administration has maintained and even slightly increased. It was Mark Lewis, a former Air Force chief scientist with a Ph.D. from MIT, who guided much of the research from 2019 to 2021 as the Pentagon's director of research and engineering for modernization. Lewis is now head of the Purdue Applied Research Institute, the Purdue University-affiliated organization that aims to be an incubator for transitioning research into real-world innovations in national security and other fields. I spoke to Lewis over the phone to learn just how worried the U.S. should be and what can be done to defend against these weapons. — *Mike Gruss*

MARK LEWIS

POSITIONS: Since May 2023, president and chief executive officer, Purdue Applied Research Institute. 2021-2023, executive director of the National Defense Industrial Association's Emerging Technologies Institute. 2020-2021, acting deputy undersecretary of defense for research and engineering. 2019-2021, director of research and engineering for modernization at the U.S. Department of Defense. Since 2016, AIAA Honorary Fellow. 2012-2019, director of the Science and Technology Policy Institute at the Institute for Defense Analyses. 2010-2011, AIAA president. 2004-2008, chief scientist of the U.S. Air Force. Since 1988, variety of teaching and research roles at the University of Maryland, most recently as an affiliated research scientist in the Applied Research Lab for Intelligence and Security.

NOTABLE: Longest tenure of any Air Force chief scientist. Sounded the alarm in 2016 about hypersonics in a National Academies report that said "the value of extreme speed coupled with maneuverability and altitude constitutes a potential threat to U.S. capabilities that should not be discounted or ignored." The report did, however, suggest that such weapons might "never reach operational maturity."

AGE: 62

RESIDES: Potomac, Maryland

EDUCATION: Bachelor of Science in earth and planetary science (1984), Master of Science (1985) and Doctor of Science (1988) in aeronautics and astronautics, all from MIT.

Q: In May 2023, Russia reportedly launched a hypersonic Kinzhal missile into Ukraine. It's a weapon Vladmir Putin's been talking about for years. Why is this significant?

A: The most important thing we learned from that is the Russians build really crappy weapons. So the Russian weapons are really bad, and a lot of it is legacy technology from the Cold War era. They're barely hypersonic. I won't go into details, but they've made some really bad engineering decisions.

Q: Should we even think of the Kinzhal as a hypersonic weapon?

A: It's clearly a hypersonic weapon, traveling hypersonic speeds in the upper Mach range. They modified an old missile that was a ground-launched missile and modified it for air launch. It wasn't a particularly innovative idea. It wasn't any sort of major breakthrough, and it's got some features that I can't go into that make it particularly easy to stop. So it doesn't really concern me, and I don't think it's a particularly big threat. Except there's one aspect of it that I think we need to take notice of: There was strategic messaging involved in the Russians' use of that hypersonic weapon. If you stand back and say, "Why did they use a hypersonic weapon in Ukraine?" It frankly makes no sense from a tactical standpoint. I mean, they weren't going against fleeting targets. They weren't going against a particularly difficult integrated air defense system. They weren't going after something time sensitive or anything like that. So what were they doing? It's pretty clear what the Russians were signaling was, "We've got these weapons, and we are willing to use them." And that is a bit of a sobering message, because it shows how hypersonic weapons can shape the future landscape of war. It's not a hypothetical.

Q: So what's the right takeaway?

A: Takeaway No. 1 is that the genie is out of a bottle; the toothpaste is out of the tube. They're deployed, and they're being used. No. 2, there is a wide range of hypersonic weapons, and not all hypersonics weapons are the same. They don't fly the same missions. They're not going to be used in the same way, and we have to be very, very careful about applying lessons learned from one particular type of hypersonic weapon to other types of hypersonic weapons. And we have to be careful applying lessons learned from one country's investments to our own investments.

Q: What makes a hypersonic glider so much more difficult to defend versus a traditional ballistic missile?

A: The big difference is that hypersonic weapons spend a significant amount of time in the atmosphere, as opposed to ballistic weapons that are going up and coming down, where there will be less time in the atmosphere. And by virtue of being in the atmosphere, those hypersonic weapons can now use aerodynamic forces to maneuver, which is a key element of their performance. When we talk about hypersonics today, we're really using that as a shorthand for hypersonic maneuvering. And let me explain that: So a ballistic warhead coming in is probably at hypersonic speeds, but it's not maneuvering or not maneuvering much. When we talk about hypersonic weapons today, we're talking about things that are moving very quickly but also maneuvering, and it's that combination of speed and maneuverability that becomes critical to their effectiveness.

Q: We've heard for years that they're harder to track from space. Why is that?

A: If I'm standing on the ground, I can see something up high more easily than if it's lower down, and I have to deal with the horizon. So detecting these things from the ground is more difficult. You say, "OK, what about from space?" Detecting it from space is also more difficult. And the reason is, if I am imaging an object

"When we talk about hypersonic weapons today, we're talking about things that are moving very quickly but also maneuvering, and it's that combination of speed and maneuverability that becomes critical to their effectiveness."

The U.S. military has tested a handful of hypersonic missile prototypes in recent years. The Army and Navy in June ground-launched a rocket motor that carried a prototype of the Common Hypersonic Glide Body.

U.S. Navy

that goes to very high altitude, I may be imaging it generally against the black background of space. If it's at a low altitude and if I'm seeing it from orbit, I'm generally looking at it down against the background of Earth — and Earth is warm, so certain sensors will have a harder time detecting the object against the warm background of Earth than they would against the black background of space. So either from the ground or from space, there's a bigger challenge detecting a hypersonic maneuvering weapon than there is a standard ballistic weapon. Now, having said that, we know how to do this, and the HBTSS is the first major step.

Lewis is referring to the Hypersonic and Ballistic Tracking Space Sensor satellites, a joint project between the Space Development Agency and the Missile Defense Agency. The first two prototypes built under the program, one built by L3Harris and the other by Northrop Grumman, were launched in February. In June, officials said they recorded their first tracking of an experimental hypersonic vehicle, one built by Kratos and launched from Wallops Island in Virginia. — MG

It's extremely well designed, extremely well engineered to do this critical mission, but it's a mission that existing sensors have a challenge completing.

Q. From a missile warning and tracking perspective, how do you compensate for that speed and maneuverability? What's the technical solution?

A: There are a couple pieces to it. One is, of course, the sensitivity of your detectors, the resolution of your detectors. But then there is absolutely a machine learning element to this. One of the reasons that hypersonics can make for such an effective weapon system is it gets inside the classic OODA loop.

That's short for observe, orient, decide and act, an acronym that captures the decision-making behind firing a weapon or forcing an enemy to react. The term is attributed to U.S. Air Force Col. John Boyd, a Korean War-era fighter pilot and military theorist who died in 1997. — MG

▲ Then-Pentagon technology chief Mike Griffin warned Congress in 2018 that U.S. aircraft carrier groups in the Pacific were vulnerable to Chinese hypersonic missiles. This vulnerability persists today, Lewis says.

U.S. Navy

A hypersonic weapon gives you very little time — first to figure out even what it is, and then figure out what its intentions are or even what the target is. It requires very, very quick processing, so the ability to couple machine learning and ultimately artificial intelligence techniques with exquisite sensors I think is going to be the key to help solve this problem.

Q: The missile warning and tracking of hypersonic weapons is largely done from space. Are you seeing progress there?

A: When I was in the Pentagon, we would often say, "If you can't see it, you can't stop it." So step No. 1 is seeing it. The department has the HBTSS. You're seeing some really good developments there. So that's good progress being made.

Q: Has there been a moment in recent years where you realized, "Hey, we're taking the steps we need"?

A: It was less a technical issue and more of a programmatic issue. Were we willing to put the resources against solving this problem? Especially when the stand-up of the Space Development Agency and everything that they brought to the table, that was when I thought, "Yeah, OK, we as a nation, certainly as a Department of Defense, are taking this problem seriously."

▲ As Lewis sees it, Ukraine's 2023 takedown of a Russian Kinzhal missile, one of which is shown here underneath a Mikoyan MiG-31K interceptor, doesn't negate the threat he sees from more sophisticated hypersonic missiles.

Office of the President of the Russian Federation/Kremlin.ru

Q: What do people get wrong about hypersonic weapons?

A: There's the old adage, "the best defense is a strong offense," but I think that's absolutely true for hypersonics. We have to be investing in our own offensive capabilities — first to deter but also to respond quickly to hypersonic threats. If someone is lobbing hypersonic weapons at us, we need to be able to hit them on a timescale that's comparable to the timescale at which they're shooting at us. And that gets lost in this conversation. I'll tell you a funny little anecdote. The National Academies has this process whereby there's a thorough, thorough review, and they opened the review up to people who haven't been involved in writing the report. We had this one reviewer in particular who took great, great offense at our report because he said we had mission creep; we were only supposed to focus on the defensive side, and instead, we had sections on the offensive side. But in fact, they go very closely together. The offensive side informs how we do our defensive capabilities. Our defensive side informs how we shape our offensive capabilities, and that's something that I would like to emphasize.

Q: What's one thing that you're watching for to see if there's progress?

A: Obviously the most important thing is actually deploying systems. So we've got the Army system, the LRHW, that's close to deployment.

LRHW is the Army's Long-Range Hypersonic Weapon, sometimes known as Dark Eagle. The Army has described it as a truck-launched hypersonic glide body missile "that can travel well over 3,800 miles per hour. They can reach the top of the Earth's atmosphere and remain just beyond the range of air and missile defense systems until they are ready to strike." — MG

"The Air Force could actually be the first service to deploy a hypersonic weapon. They've got this capability that works, and it would be great to see it delivered to the hands of the warfighter."

And you know, tip of the hat for the Army for pressing on that system. The other one I'm really looking forward to is the Air Force system, in particular the ARRW.

ARRW, pronounced arrow, is the AGM-183 Air-Launched Rapid Response Weapon. This glide vehicle would be released from a B-52 Stratofortress to travel as fast as Mach 8. The Air Force's fiscal 2025 budget request did not include any research funding for ARRW, and Pentagon leaders in February declined to answer questions from a U.S. House committee about the program's future. — MG

ARRW had an initial flight test that wasn't successful, which is fine. We keep preaching the doctrine that we need to be allowed to fail, so we needed to allow them to fail. And they recovered, and then they had a very successful series of flight tests, so much so that the most recent flight test exceeded expectations. ARRW could go to deployment. We could turn it on tomorrow and start rolling ARRW weapons off the assembly line. And so I think we're going to be looking to see where the Air Force goes with that. The Air Force could actually be the first service to deploy a hypersonic weapon. They've got this capability that works, and it would be great to see it delivered to the hands of the warfighter.

Q: Hypersonic weapons can feel abstract. How do you describe them in tangible ways?

A: If you have the ability to stop some of these, then wouldn't you want to exercise it if you think about how devastating a hypersonic attack could be? Let's take a China-invading-Taiwan scenario. So we know the Chinese have made a big point about the fact that they have built hypersonic weapons, that they display them. It's not a secret. And some of those weapons are clearly designed to take out aircraft carriers. Well, think about what it would mean for us to lose an aircraft carrier to a hypersonic attack. The cost of an aircraft carrier rolling out of dry dock right now is coming in at about $14 billion. You add the planes onto that, you're talking about maybe another $10 billion. And then you've got 5,000 souls on board. So imagine you lost an aircraft carrier: You lost a $25 billion asset with thousands and thousands of American lives on board. If I could stop that from happening, if I could defend against it, if I've got a reasonable chance of doing so, why wouldn't I? It's incumbent upon us to do so. ★

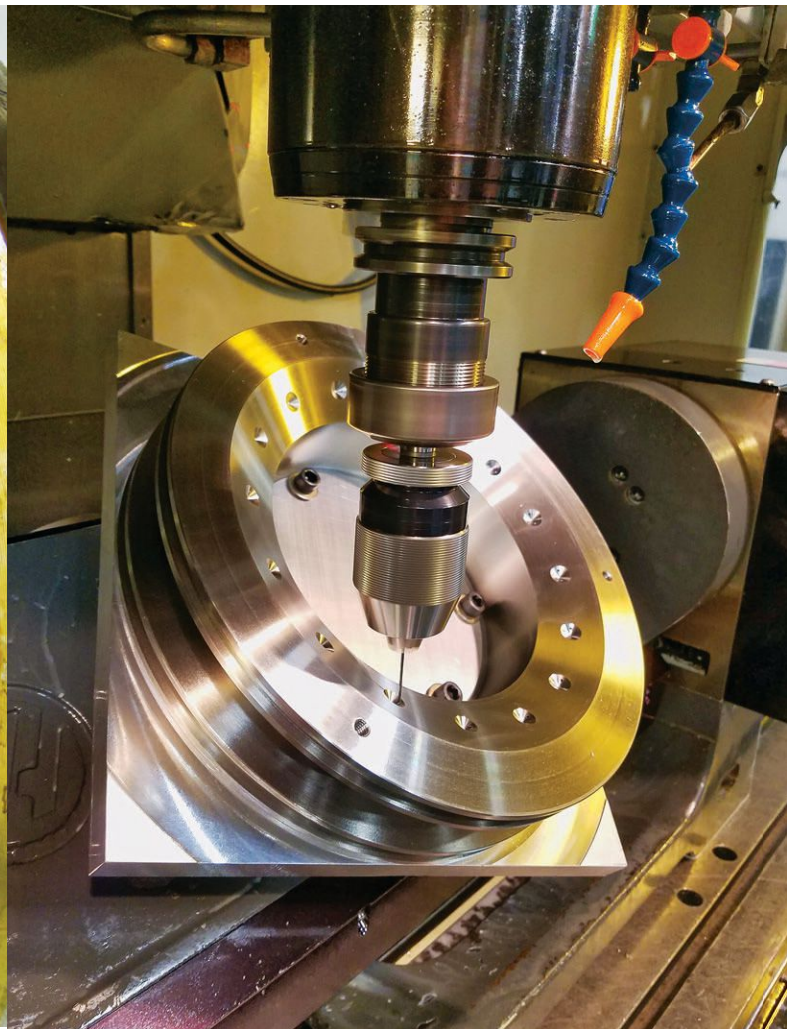
Exquadrum of California is preparing for the inaugural flight test of its Liquid Augmented Solid Rocket motor. Here, an earlier prototype undergoes a hot fire test at the Southern California Logistics Airport in Victorville.

Exquadrum

Making a new motor for hypersonics

Hypersonic weapons and experimental versions share something in common: They must be boosted up to high speeds so that tests can begin or hypersonic weapons can be released. Keith Button spoke to aerospace engineers who think they have a better motor for these jobs.

BY KEITH BUTTON | buttonkeith@gmail.com



▲ In Exquadrum's Liquid Augmented Solid Rocket motor design, the thrust is be adjusted by changing how much liquid monopropellant is injected into the combustion chamber (left).

Exquadrum

Kevin Mahaffy was among those who attended a classified session six years ago at DARPA headquarters near the Pentagon to learn more about the competition for the agency's Operational Fires program. DARPA's goal was to empower the Pentagon to equip troops with ground-launched rockets that could loft hypersonic glide vehicles at the enemy. Mahaffy, co-founder of the small rocket company Exquadrum, came away "reeling" about the technical possibilities and says he spent the plane ride home from Washington, D.C., to California "cycling through every rocket propulsion idea that I have ever had, trying to find a solution."

By the time the plane landed, he had scribbled notes on a cocktail napkin about an idea that he thought might work.

Exquadrum had a heritage of making solid rocket motors, each consisting of a cylinder of rubbery polymer embedded with powdered oxidizer and metals and enclosed in a case with a nozzle on the end. The solid propellant, in most designs, would burn from a hollow center outward. Normally, the entire motor would be considered the combustion chamber, Mahaffy says, but previously the company had come up with an alternative design in which the solid fuel would be cast inside a pressure vessel made of either metal or composite that would serve as the combustion chamber. A liquid monopropellant, meaning one with the oxidizer already incorporated into it, would be injected into the chamber to burn with the solid fuel. The monopropellant would augment the thrust by an amount determined by its rate of flow into the chamber. It was a strategy to overcome a downside of solid rocket motors, which is that they cannot be throttled in flight to adjust their velocity.

Exquadrum had yet to build, test or name the design. OpFires looked like a chance to get that done.

This is the story of how Exquadrum managed to win OpFires funding and how it conceived of additional hypersonics applications for the technology.

Mahaffy and Eric Schmidt started Exquadrum in 2002 after getting to know each other through 10 years as researchers at the Air Force Research Laboratory site at Edwards Air Force Base in California. After the classified DARPA session, they and their

engineers considered the requirements and the idea that Mahaffy jotted down on the napkin.

The requirements were daunting in many ways, not the least of which was that DARPA wanted a missile that could be fired from a truck or a tracked vehicle. In the boost-glide application, the warhead would be accelerated to hypersonic velocity and then separate and glide to the target.

The mobile requirement ruled out a fuel that needed to be matched with liquid oxygen as the oxidizer. "Let's say you deploy this thing and these guys are in the woods for weeks or months until they get a launch signal," Schmidt says. "But with all this liquid oxygen that you've got to carry around with you, that didn't make sense."

Nitrous oxide, another liquid oxidizer, also wasn't an option, mainly because of its lack of energy density compared to other propellants and its low specific impulse, a measurement of fuel efficiency.

Solids might have seemed like an obvious choice, given that missiles and nearly all hypersonic boosters in this emerging class of weapons are accelerated that way. Solid propellant remains stable and ready to fire over long periods, for 30 years in some cases. They also provide a higher energy density than any liquid or hybrid propellants.

But another DARPA requirement seemed to rule out that option: The winning design would have to be capable of unleashing small amounts of propulsion energy to hit close-in targets or large amounts of energy to hit targets at a greater distance.

To meet the DARPA range requirements, the rocket motor would need to be throttleable. It was, says Schmidt, "a very hard problem to solve."

Mahaffy's "aha" moment on the plane stemmed from the company's 2017-2021 work on a liquid monopropellant for Neptune, a Missile Defense Agency program. Adding monopropellant to a solid propellant would deliver the velocities and range needed for the hypersonic missiles to hit near-in and distant targets.

One of the first tasks as they prepared their proposal was to conduct a study of fuel efficiency. This showed that the concept should indeed provide better fuel efficiency than solid-only rocket motors. They then turned Mahaffy's cocktail napkin notes into a plan for a motor that would consist of a nozzle, a cylinder of solid fuel contained in a titanium combustion chamber and a tank for the monopropellant, the identity of which is classified. The monopropellant would be fed through tubes into the chamber, where the heat of the combustion of the solid fuel would cause a chemical reaction that releases the oxygen and fuel components of the monopropellant, resulting in it burning too. They called the conceptual motor LASR, short for Liquid Augmented Solid Rocket.

At this point, they made an unusual decision. "While we were writing the proposal, we said: 'Well, if we're going to write a proposal on this concept, let's test it and see if it works,'" Schmidt says.

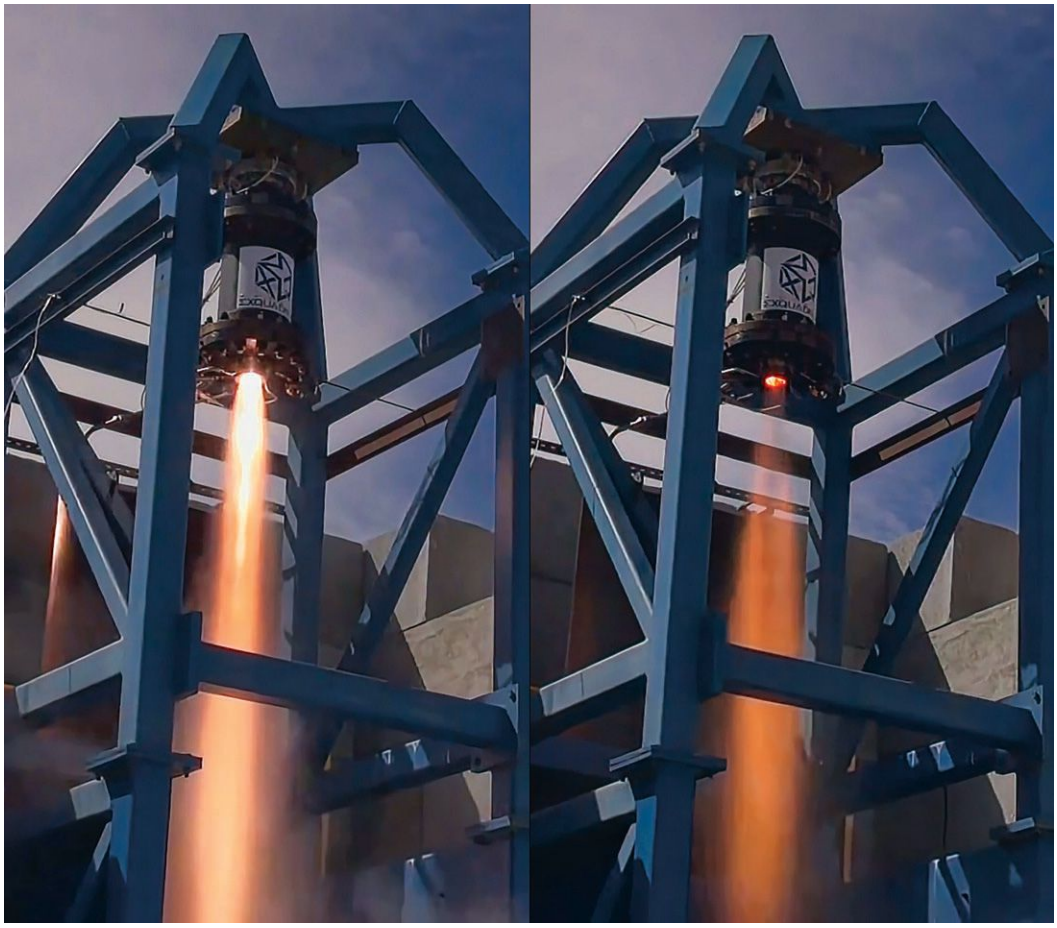
At their facility in Victorville, California, they attached a soda-can-sized test motor to their outdoor test bench, a meter-high steel structure. They ignited the motor and opened a valve to allow a stream of monopropellant to flow from a small tank through tubing into the combustion chamber. The result was a sharp rise in the chamber pressure and thrust. They

Exquadrum was one of three companies awarded DARPA funding to design and conduct hot fires of a motor for Operational Fires, a notional ground-launched booster for hypersonic glide weapons. OpFires was concluded in 2022 after flight testing with a prototype missile, built by Lockheed Martin, that was launched from a logistics truck by a Northrop Grumman rocket motor.

DARPA

FACT

EXQUADRUM can be loosely translated from Latin to mean "outside the box."



Exquadram has conducted some 200 hot fires with various prototypes of its Liquid Augmented Solid Rocket motor design for DARPA. In this side-by-side of two tests at the company's Victorville, California, site, the less opaque plume on the right is the result of injecting a higher flow of liquid monopropellant.

Exquadrum

ran a succession of tests, and the motors burned for anywhere from 1.5 to 3 seconds.

As confident as they were about throttleability, they still had to test the idea, says Elias Wilson, Exquadrum's chief technology officer. "Can you really throttle it the way you want to, or do you saturate it in such a way that performance was down?"

Research and development is often "a game of failure" that requires many, many iterations, Schmidt says. But this time, "son of a gun, it worked like a champ the first time. That doesn't often happen."

Their proposal was among those selected, and Exquadrum received a 12-month contract and later a seven-month follow-on contract, worth a combined $15.1 million. The team spent the next 12 months refining the idea and testing it to measure the chemical, kinetic and thermal characteristics.

"We were able to cage and develop that concept very, very quickly," Schmidt says.

In this refinement testing, they measured combustion rate, thrust force and other characteristics to compare various solids of different chemical formulations. They settled on a formulation that is classified, per DARPA requirements. In later iterations, they employed a solid containing an ammonium perchlorate oxidizer and powdered aluminum fuel, like the solid rocket propellant for the space shuttle's solid rocket motors. For the liquid monopropellant, they knew from decades of industry studies that it had a high level of energy density but also a history of combusting slowly.

"We were worried that we would have issues getting it to combust," Wilson says. But they found that the high temperature from solid fuel combustion provided the "thermal hammer" needed to chemically decompose the liquid monopropellant's molecules for combustion.

They also spent a lot of their time working on the monopropellant injection system to pinpoint the best ratio of monopropellant to solid fuel to achieve the

FACT

EXQUADRUM'S LIQUID AUGMENTED SOLID ROCKET, LASR, would be powered by a liquid and a solid, but the company does not consider it a hybrid design. That's because both the liquid and solid propellants can combust independently of each other, whereas in a hybrid the liquid and solid react chemically with each other to combust.

best combustion fuel efficiency, Wilson says: "How much monopropellant can I put in? Can I put in five or six or 20 times the amount of monopropellant?"

They measured the specific amounts of solid and liquid consumed in the scaled-down motor on the bench, as well as thrust and chamber pressure, and used those figures to calculate the performance.

They also needed to figure whether the concept would work at larger sizes. Within six months, they had proven through ground tests that a 53-centimeter-diameter motor burned as planned and for up to 30 seconds. These tests were done on a vertical, adjustable metal frame surrounded on three sides by concrete blocks, stacked LEGO style.

By month 12, they had proven their concept with an 81-centimeter-diameter motor — the full-size goal for the DARPA project. It ran for some 90 seconds, Mahaffy says. They further refined the motor over the final seven months of the contract, culminating in a ground test of a flight-ready, full-size motor. In all, they conducted some 200 hot fire tests for DARPA.

When OpFires ended in 2022, they continued developing the technology under separate programs for the Missile Defense Agency and NASA. They were pleased to learn that the monopropellant could continue combusting after the solid fuel had burned up because of the heat in the empty chamber, Wilson says.

"That was a turning point in the design," he says. They could start the rocket motor with the solid combustion, add the monopropellant to throttle the motor up and down on top of the solid combustion, and continue to combust the monopropellant after the solid had burned up, which provided the ability to continue to throttle or turn off the motor. That opened the possibility of throttling to reach specific hypersonic velocities or to turn off propulsion at the later stage of a flight, which isn't possible with a solid-only rocket motor.

Now, under a $2.4 million Small Business Innovation Research contract with the Missile Defense Agency, Exquadrum has started planning a 2025 flight test of the LASR motor. They haven't decided where and when specifically they will seek to launch this sounding rocket. So far, the company has enough funding for one flight, and the hope is to raise funding from other customers for subsequent test flights.

The ultimate goal is to demonstrate a missile, meaning a rocket with guidance, and then manufacture and sell motors for tests of hypersonic materials and components. Exquadrum hopes to help the U.S. Defense Department meet its goal of 50 hypersonic tests per year to compete with China and Russia, Mahaffy says.

Exquadrum plans to market the motor as a cheaper and more precise alternative to a solid-fueled or liquid rocket. Technologists typically need to test components, engines or materials at specific Mach numbers. It just would not be affordable or practical to design, build and conduct the multiple static testing firings of a motor design that are required to qualify the design to meet a particular experiment's required Mach number, Mahaffy says.

"Typically, you'll do at least three tests to qualify a system," he says.

Currently, hypersonic testers have a catalog of about a dozen different qualified solid rocket motors, and they "Frankenstein" them together, stacked in the order at which they will combust, to approximate the desired thrust profile they want for each test, Wilson says.

Researchers may want their test flights to reach specific altitudes as well, which is easier to achieve with a throttled test flight, Schmidt says. "With the solid system, you may or may not hit that just because of the variability of the solid burn out."

David Van Wie, head of air and missile defense programs at Johns Hopkins Applied Physics Laboratory in Maryland, says if the rocket motor is affordable, "this capability could provide a useful test capability for satisfying some of the test needs for hypersonic system development."

Depending on the testing needs, "a rocket that is throttleable provides flexibility, which could translate into more flexible test approaches," says Van Wie, who is not associated with Exquadrum or its research.

Exquadrum says its liquid monopropellant is one-tenth the price of solid rocket fuel, which makes its rocket motor's overall costs much lower than traditional solid-rocket test beds, Schmidt says.

"Ultimately driving cost down and either maintaining or enhancing capability — that's what we need if we're to move forward." ★

FACT

DARPA SUPPORTED EXQUADRUM in its early years by selecting the company in 2003 along with several others, including SpaceX, to study the development of small launch vehicles that could be launched rapidly by a military crew to put more eyes or ears in orbit over a battlespace. The DARPA/Air Force Falcon program is best known for seeding the small launch vehicle industry and for helping SpaceX get started, despite the failure of its Falcon 1 rocket on its first launch attempt.

The end of an era

If all goes as NASA plans, the deorbiting of the International Space Station in early 2031 will be its final chapter, but also the start of a new one in which one or more companies will operate their own stations independently from NASA. But not everyone believes the station should be deorbited then, if ever. Jonathan O'Callaghan examined the differing views and proposed alternatives.

JONATHAN O'CALLAGHAN | jonathan.d.ocallaghan@gmail.com

▲ To make the U.S. Deorbit Vehicle, SpaceX plans to install an enlarged trunk section to one of its existing Cargo Dragon capsules. During the deorbiting, the bulk of the thrust will come from the 30 thrusters on the trunk, with another 16 thrusters on the capsule providing attitude control. Delivery is scheduled for 2028.

SpaceX

Gary Calnan traveled to the White House in 2022 with a proposal to melt parts of the International Space Station down into rocket fuel. His firm, CisLunar Industries of Colorado, was developing technology to recycle and reuse machinery in orbit, and the National Space Council and the Office of Science, Technology and Policy were interested to hear more.

The company had previously published a white paper with several other companies — including Astroscale, a Japan-based debris removal company — describing how radiators, solar panels and batteries could be reused and how other parts of the station could be turned into an orbital salvage yard. For example, CisLunar was developing technology in partnership with the Australian company Neumann Space that could melt metal structures in orbit into rods of aluminum that could serve as fuel for electric propulsion, a concept that the U.S. Space Force awarded Cislunar a $1.7 million contract last year to explore.

That's just one idea for what could be done with ISS instead of steering it into the atmosphere to break apart and largely burn up over the Pacific Ocean in early 2031.

While NASA has in the past slipped disposal dates for ISS to the right, the 2031 date has sparked former astronauts and technologists, including AIAA members, to discuss the wisdom of the plan among themselves — and in some cases publicly. That's because in June, NASA awarded an $843 million contract to SpaceX to create the U.S. Deorbit Vehicle, a larger version of the Cargo Dragon.

The selection of the USDV "makes it more real," says former NASA official Daniel Dumbacher, who last month completed nearly six years as executive director and then CEO of AIAA.

An additional trunk section would be added to a Dragon and packed with fuel and 30 Draco engines. These thrusters arrayed around the base of the trunk would fire with 10,000 Newtons of thrust — about four times the thrust of a normal Dragon — to slow the 420-metric-ton station and steer it into the atmosphere toward a region of the Pacific Ocean yet to be chosen. To NASA, that scenario is vastly preferred over one in which atmospheric drag gradually pulls ISS lower and lower until the station begins to tumble uncontrollably — increasing the odds of any surviving components raining down on populated areas.

Among those with thoughts on the matter is former astronaut Tom Jones, who was a member of the space shuttle crew that delivered ISS' Destiny module to orbit in 2001 and conducted three spacewalks to help install it. "I would not like to see it dumped in the

The future station operators

A handful of companies are vying to take over the role of microgravity research platform after ISS is deorbited. New services are also envisioned, including manufacturing and orbital tourism.

Station	Operator(s)	Initial configuration	Planned orbit	Maximum crew size	Targeted operational date	Funding
Axiom Station	**Axiom Space** *Houston*	Four rigid modules, the first of which would to be launched in 2026 to dock with ISS. After the remaining modules arrive, they would separate from ISS and become a free-flying station.	400 km after detaching from ISS	8	2028	$140 million NASA contract to attach at least one module to ISS; $480 million in private investment as of August 2023
Haven-1	**Vast Space** *California*	One habitation module, to be launched inside the payload fairing of a SpaceX Falcon 9. Haven-1 is to be a precoursor to larger stations that would be launched by Starships.	425 km	4	2025	Undisclosed amount from founder, billionaire Jed McCaleb
Orbital Reef	**Blue Origin and Sierra Space** *Washington/Colorado*	Five rigid modules provided by Blue Origin, and at least four of Sierra Space's inflatable LIFE modules.	400 km	10	2029	$172 million NASA contract and an undisclosed amount of private investment
Starlab	**Starlab Space** *Joint venture of Airbus and Voyager Space of Colorado*	One inflatable module, built by Airbus, to be launched by a SpaceX Starship.	400 km	4	2028	$217.5 million NASA contract, undisclosed amount of private investment

ocean," says Jones. "I would spend the same money on boosting it to a high orbit," one where it would remain for "decades if not centuries" and be used as a future resource, such as for its aluminum. He reiterated this suggestion in a June keynote at the Outer Space Heritage Summit, hosted by AIAA and the Smithsonian's National Air and Space Museum.

Despite such qualms about the fate of the $150 billion station, NASA has shown no signs of rethinking matters. In a deorbit summary published in June, the agency said it had considered alternatives for the station but found none were viable. "NASA has concluded that deorbiting the International Space Station using a U.S.-developed deorbit vehicle, with a final target in a remote part of the ocean, is the best option for station's end of life," the agency wrote.

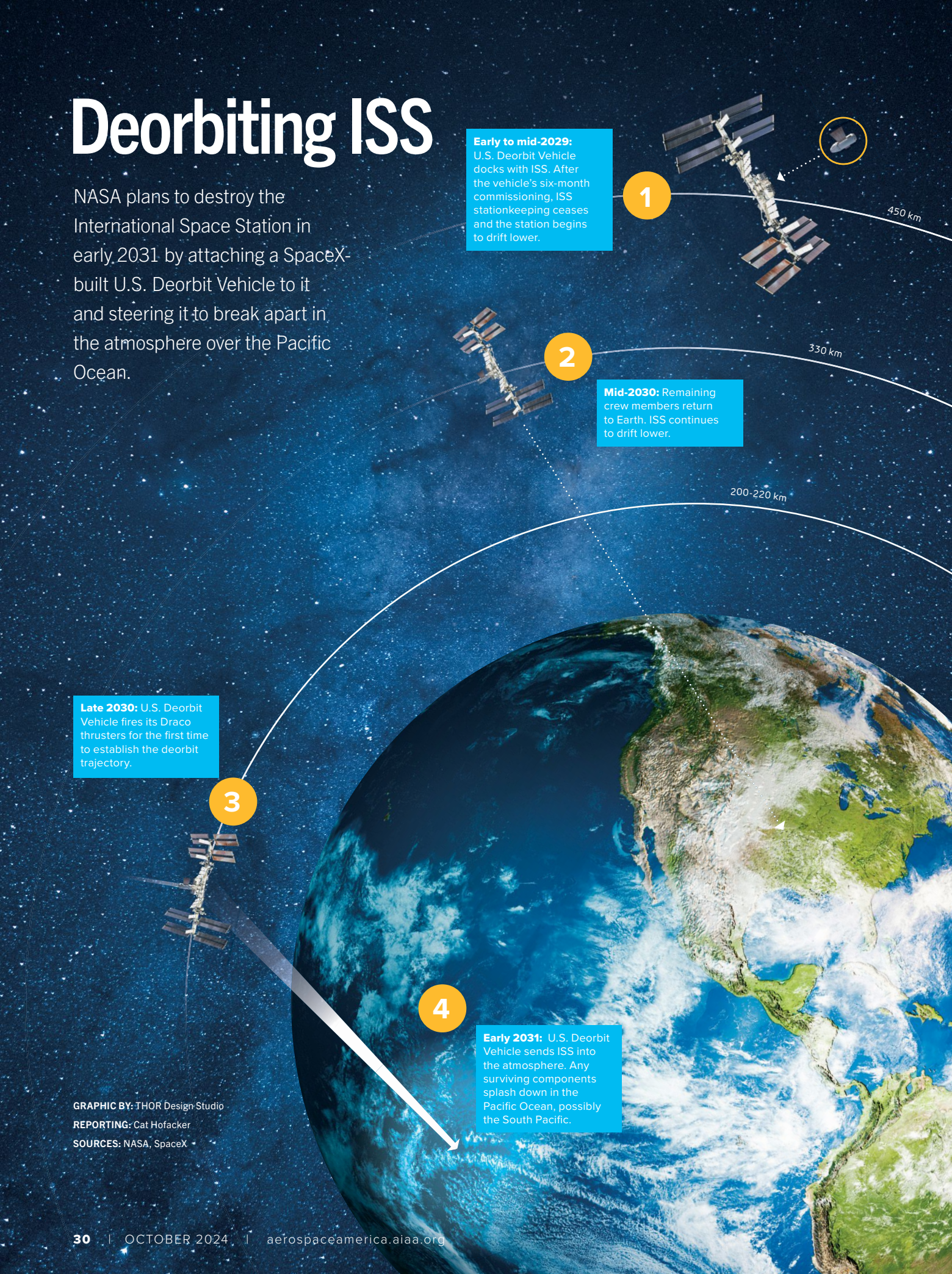
That decision, according to NASA, was driven in large part by the age of the hardware that arrived in a series of assembly missions between 1998 and 2011. "The primary structure of the station, such as the crewed modules and the truss structures, cannot be repaired or replaced practically," the agency wrote in the summary, noting there was an "original 30-year structural life estimate" for these components, which is now being reached.

Andy Thomas, who holds a Ph.D. in fluid mechanics and is a former NASA shuttle astronaut who flew

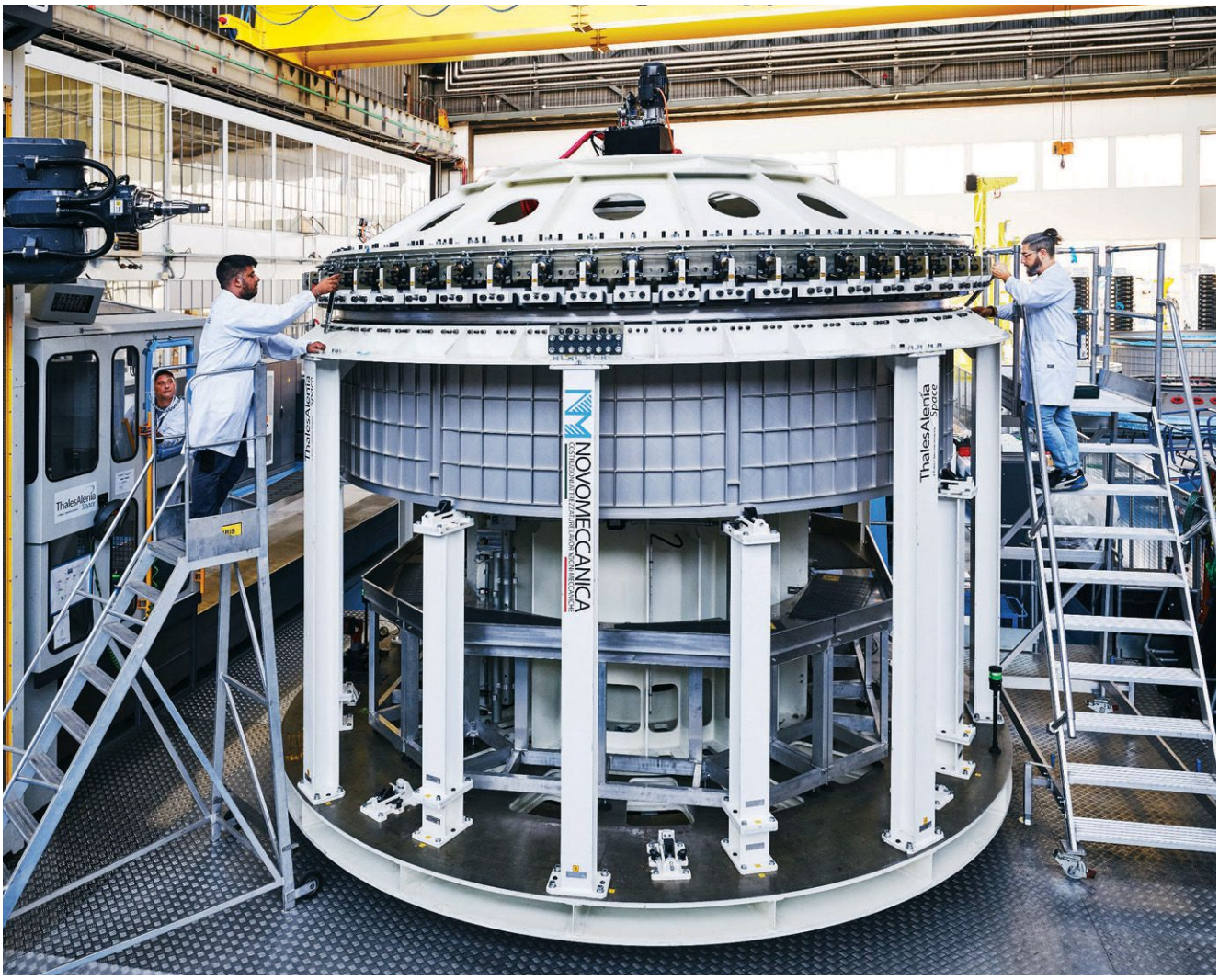
> **"To say we spent $150 billion over the last 25 years and we're going to dump it in the ocean is very sad, a final conclusion to what has been a pretty remarkable engineering achievement."**
>
> — Andy Thomas, former NASA astronaut

Deorbiting ISS

NASA plans to destroy the International Space Station in early 2031 by attaching a SpaceX-built U.S. Deorbit Vehicle to it and steering it to break apart in the atmosphere over the Pacific Ocean.



GRAPHIC BY: THOR Design Studio
REPORTING: Cat Hofacker
SOURCES: NASA, SpaceX



▲ Axiom Space of Houston plans to operate its initial space station modules while docked to the International Space Station. Plans call for the Hab One module, shown here being constructed by Thales Alenia Space in France, to be launched in 2026 to dock with the Node 2 forward port.

Axiom Space

ISS assembly missions in 2001 and 2005, agrees that age is an issue that would need to be addressed if station weren't deorbited. "There would be engineering limitations on some of the ISS systems and hardware," he says. "Critical systems are reaching end of life. I suspect the biggest challenge would be maintaining the overall structural integrity of the station for many more years."

Some are sanguine about deorbiting the station, not only because of the age of the components, but also because doing so would free up roughly $3 billion a year for other human spaceflight projects, such as NASA's return to the moon.

"It hurts me to say it needs to come down," says Wendy Whitman Cobb, a professor at the U.S. Air Force School of Advanced Air and Space Studies in Alabama. She notes similarities with the end of Russia's Mir space station in 2001, when a Progress vehicle pushed the station's orbit into Earth's atmosphere. Russia was eager to continue Mir, but NASA "saw that it was taking Russia's attention and funding" away from ISS, says Cobb.

"Probably we're seeing echoes of that here," she says. "Space is a harsh environment. I think there's a lot of sentimentality, but at the end of the day, safety is going to trump sentimentality."

And so, as Thomas says, "The clock is certainly running."

Others have suggested boosting ISS upward into a graveyard orbit, where its orbit would take centuries to degrade and the station could be left uncrewed. Thomas investigated this possibility for NASA in 2014, examining whether solar electric propulsion could slowly but continuously boost the station higher.

"You could do it either with a single large unit or multiple smaller units," he says. "I would favor the latter, as it gives you some redundancy in the event of engine failure. But there is no doubt that it would be an engineering challenge."

Brent Sherwood, a former senior vice president of space systems at Blue Origin and now the Space Domain lead for AIAA, favors the idea of a graveyard orbit.

"A 200-year orbit buys lots of time for multiple

Sierra Space in June conducted a burst test with a full-scale test article of its LIFE habitat, short for Large Integrated Flexible Environment. Plans call for launching and then inflating a handful of these to serve as crew quarters and research laboratories for Orbital Reef, the space station that Sierra and Blue Origin plan to erect in low-Earth orbit later this decade.

Sierra Space

generations of advanced spaceflight to decide if they want to deorbit it, boost it higher or salvage it," he says. "[Deorbit] just seems hasty and premature. This ought to be a more transparent, hard conversation. Maybe the outcome is the same, but maybe it's not."

However, placing ISS in a parking orbit would still require considerable and continued legwork by NASA and the 14 other ISS partners. It also opens up the possibility of ISS becoming a significant debris risk, says Jonathan McDowell, a Harvard-Smithsonian Center astrophysicist in Massachusetts who monitors worldwide astronautical activity.

"If it gets into a tumbling mode, it could break up," he says.

In the June deorbit summary, NASA said ISS operations "require a full-time crew to operate," so it could not simply leave the station in a higher orbit uncrewed. It did note that raising the orbit to 800 kilometers or higher would give the station an orbital lifetime of at least 700 years. But reaching this altitude would be difficult and "require the development of new propulsive and tanker vehicles that do not currently exist." SpaceX's Starship could do the job, the agency said, but "there are prohibitive engineering challenges with docking such a large vehicle to the space station and being able to use its thrusters while remaining within space station structural margins."

After ISS, NASA's hope is that private companies will operate one or more stations in low-Earth orbit. One aspiring operator, Axiom Space of Houston, plans to attach up to four modules to ISS beginning in 2026, partially funded by NASA, which would later be detached to form a free-flying space station. [See "The future station operators," page 29.] If plans hold, at least one of these stations would be operational before 2031. But should they be delayed, ISS Progam Manager Dana Weigel said in a July press conference about the deorbit plans that NASA may be willing to "extend ISS a little bit to avoid a gap in low-Earth orbit."

Though she did not reference it, the U.S. had to rely on Russian Soyuz capsules to ferry astronauts to and from ISS during the nine-year gap between retirement of the space shuttles and the first Commercial Crew flight.

"We'd really like an overlap between station and the next platform," Weigel said.

Even in that scenario, it's unlikely that Axiom or other private companies would consider taking over the entire ISS if such an opportunity arose, says Courtney Stadd, a former NASA chief of staff. He says he has a "hard time trying to figure out where the private part of that partnership would see a generation of revenue" in a reasonable period.

"Maybe over time you get a sufficient number of space travelers, but how many years until you reach

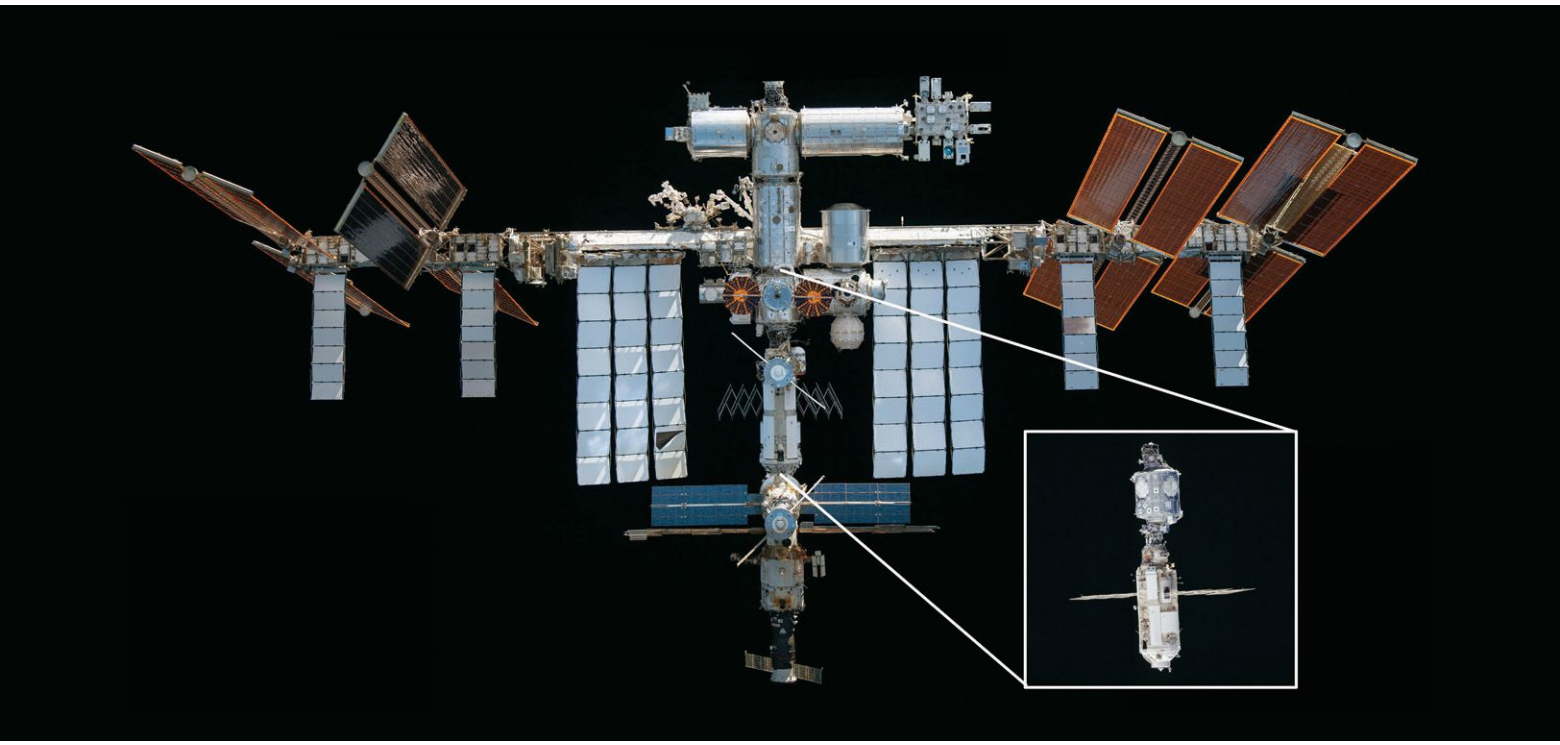
Why not Starship or Progress?

If you're wondering whether a Starship with the addition of a docking apparatus could be a viable option for deorbiting ISS, I was curious too. After all, by 2031, the Starship design should be well proven, with multiple vehicles having made multiple landings on the moon under NASA's Artemis program.

I asked Sarah Walker, director of Dragon mission management at SpaceX, during an audio press conference in July about a possible role for Starship. "Starship has too much thrust," Walker said. "We wanted to propose a vehicle that would best meet the needs of the mission that they asked for."

That role, to be played by the modified Cargo Dragon, also represents a shift in planning for NASA. Originally, three Russian Progress vehicles were to play the central role, with a yet-to-be-selected U.S. Deorbit Vehicle available for redundancy, according to NASA's "International Space Station Transition Report" released in January 2022. At some point in the ensuing two years, and for reasons NASA declined to explain to me, the roles were reversed. Now, it's the Progress vehicles that will be the backups.

In the July press conference, Dana Weigel, NASA's ISS program manager, said that the Progress vehicles would "still play a critical role" as redundancy for the USDV. "We're looking at contingency options in the event of multiple failures on the USDV," she said.



▲ At least two crew members have occupied the International Space Station since November 2000, two years after five NASA astronauts and one cosmonaut joined together the first two modules on orbit. Those modules, Zarya (top) and Unity, are pictured here along with ISS as it appeared in 2021.

NASA

that critical mass?" he says. "I think the venture capital and investment people that I interact with would say there's no business case to be made."

Before Mir was deorbited, such a transition to the private sector was attempted by a privately funded initiative called MirCorp. Based out of the Netherlands, MirCorp hoped to take over operations of Mir from Russia, but the effort eventually failed due to a lack of funding.

"Privatizing a government laboratory in orbit is a very hard thing to do," says Sherwood.

If ISS cannot be saved in its entirety, some have suggested saving smaller parts of it. Former astronaut Frank de Winne, the ISS coordinator for the European Space Agency, said the presence of the Axiom modules could help in that regard.

"If there are things we can reuse from ISS and transfer to the Axiom modules, certainly we are ready to look into that," he says, but he noted that ESA had "not started concrete discussions" with Axiom on the topic. Axiom declined to comment on the possibility.

As for turning parts of ISS into rocket fuel, I could not learn whether the Cislunar white paper reached the NASA officials who are in charge of the station's fate.

"We did not get any feedback," says Ron Lopez, president and managing director of the U.S. arm of Astroscale, the Japanese-based debris removal company involved in the white paper.

In lieu of a viable alternative, that leaves the seemingly inescapable option of dropping ISS over the ocean.

"It's a sad but probably inevitable milestone," says Thomas, the former astronaut. "To say we spent $100 billion over the last 25 years and we're going to dump it in the ocean is very sad, a final conclusion to what has been a pretty remarkable engineering achievement."

But the clamor to save ISS may increase.

"I wouldn't be surprised if there was a public outcry," says Mai'a Cross, director of the Center for International Affairs and World Cultures at Northeastern University in Massachusetts, perhaps even to the point that government steps in.

"Congress can direct NASA to not deorbit," says Michelle Hanlon, executive director of the Center for Air and Space Law at the University of Mississippi's School of Law. That would require funding, but that could be repurposed from elsewhere, such as SpaceX's USDV contract.

Bob Brumley, senior managing director at the technology development firm Marble Arch Partners in Virginia, suggests another alternative: taking the money NASA has earmarked for its planned lunar space station, Gateway.

"I'd take the billion dollars a year for Gateway and use that money to save ISS," he says.

In that July press conference, I asked Ken Bowersox, head of NASA's Space Operations Mission Directorate, if the fate of ISS was 100% certain.

"I've never seen anything that's 100% in space," he said. "It wouldn't be surprising at all to me if, in a couple of years, folks came in and took a look again at the work that's been done to try and decide what we would do at ISS end of life." But, he added, "I honestly think they'll end up in the same spot." ★

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Interest grows in hybrid-electric flight

BY PAUL BRINKMANN | paulb@aiaa.org

Agility Prime, the U.S. Air Force's small electric aircraft program, has adjusted its research focus toward hybrid-electric aircraft and autonomous flight in the belief that vehicles with these attributes will be most likely to make it across the figurative valley of death between research flights and acquisition of operational aircraft.

Under the 4-year-old program, companies developing electric air taxis mainly for civilian services have been paid to send experimental versions of their wares to various flight ranges, where Air Force pilots or contractors fly them. The goal is to "prime" commercial markets to produce such aircraft or related equipment for the military.

The leader of Agility Prime, Acting Branch Chief Jacob Wilson, updated a crowd on the program's progress at the National Advanced Air Mobility Industry Forum that I attended in September in Springfield, Ohio, where Agility Prime conducts test flights at Springfield-Beckley Municipal Airport. The program is part of AFWERX, the Air Force Research Laboratory's innovation arm with a site at Wright-Patterson in Dayton, Ohio, and four other locations around the country.

Wilson identified hybrid-electric powertrains and autonomy as "key enablers" for military applications. Hybrid-electric aircraft contain a combustion engine that, depending on the design, either charges the battery during flight or generates electricity that is delivered to motors that turn propellers. They offer greater range than purely electric designs.

I asked Wilson to elaborate during a follow-up video call. He told me that based on his conversations with pilots and commanders from the Air Force and other branches, the services have become more interested than ever in "transformative vertical lift," a term that includes concepts for battery-powered aircraft, hybrid-electric and those that would be powered by hydrogen fuel cells. Of those: "We expect that there might be a quicker transition path for hybrid-electric" into military service, he said.

He is wary of the so-called valley of death, the figurative chasm that sometimes traps promising defense technologies because no potential customer has identified a real-world need or requirement that can be met with it.

"It is our perception that there may be emerging requirements [for hybrid-electric] that we don't have to push so hard for," Wilson said.

This emphasis doesn't mean Agility Prime is done with purely battery or hydrogen-powered concepts, just that he believes those technologies may take longer to study before they can be integrated into military fleets.

Wilson said Agility Prime reports regularly to several Air Force commanders and to other branches of the military about the program's findings. It also receives updates on guidance from those commanders about what they want or need in emerging aircraft technology."It has been an evolving conversation, I would say, since I came on the program in 2022," he said. "We have completed a lot more analysis than we

▲ Virginia aircraft developer Electra is among the companies that have received Agility Prime funding to fly prototypes of their hybrid-electric designs. The company in September announced that it had completed several ultra-short-takeoff-and-landing demonstration flights at Marine Corps Air Facility Quantico and at Army-Air Force Joint Base Langley-Eustis in Virginia.

Electra

▲ U.S. military services may prefer hybrid-electric designs because of their greater range than purely electric aircraft, but testing also continues with fully electric prototypes like this one from Joby Aviation of California.

Joby Aviation

initially had in the early years — specifically catered toward some use cases."

Regarding the promise of electrification, whether in pure or hybrid form, "I would say internal sentiment [within the services] is a lot more positive than it was in 2022." Sentiments are also shifting because companies including Joby Aviation and Archer Aviation, whose purely electric prototypes have been flown under Agility Prime contracts, are advancing toward receiving FAA type certificates by 2025, he added.

A military branch can self-certify an aircraft, meaning it doesn't have to wait for FAA to issue a type certificate, but Wilson said they would rather not duplicate any work being done by the companies to prove airworthiness to FAA.

Regarding battery-only aircraft, their range might be limited to about 240 kilometers. That means they might be limited to transporting cargo relatively short distances between facilities, carrying equipment or maintenance personnel from one location to another within a base or range, or to ferrying VIPs around urban areas like Washington, D.C. There may also be a niche in special operations for quiet, low-flying transport of personnel, but "there isn't much I can say about that," Wilson said.

In the civilian world, he said, this limited range would be fine for urban air taxis, but longer range is generally preferable for the military because in many cases the services must deliver supplies, equipment and personnel from safer locations to field outposts. That's why a hybrid-electric aircraft may be preferred. A gas engine can extend range or boost payload capacity. For example, Virginia company Electra, which has a contract with Agility Prime, said its hybrid-electric, short-takeoff-and-landing Goldfinch demonstrator has a range of 800 km. Electra announced in September that the Goldfinch had taken off and landed in distances as short as 46 meters in test flights conducted under the company's Agility Prime contract. The intent was to demonstrate that the aircraft could ferry supplies to troops "in contested environments where traditional airstrips may be unavailable or compromised."

Other companies developing hybrid-electric propulsion or aircraft under Agility Prime contracts are Ampaire of Long Beach, California; H3X of Louisville, Colorado; VerdeGo Aero of Daytona Beach, Florida; and LiquidPiston of Bloomfield, Connecticut.

With battery-electric only, "we're still bridging the gap" between demonstrating what the aircraft are generally capable of and the range and/or payload needs of the operators, Wilson said.

Regardless of the use case, fully electric or hybrid-electric aircraft would be cheaper to operate than conventional aircraft because they would require no fuel or less fuel and would have less downtime for maintenance, he said. If such aircraft are also autonomous, that would result in more savings and frees a pilot to do something more important, he added.

Overall, Agility Prime has become more selective about signing contracts with companies they've never worked with. "I'd say the bar is higher than it may have been in, say, 2021 because we're familiar with the space, we're familiar with the technologies," Wilson said. "A clean sheet aircraft, for example, is going to get a lot more scrutiny now." ★

THE VIEW FROM 50,000 FEET

AVIATION'S BIGGEST CHALLENGES

The global aviation sector is at a pivotal moment. Just as the world is facing enormous challenges — climate change, workforce demographic shifts, geopolitical instability, disruptive technological advances and more — so is our industry. Success for the future will require diverse, future-facing strategic systems thinking that connects stakeholders and challenges across the ecosystem we are all part of. It also requires articulating how we can help solve, rather than make worse, those global challenges. The panel I moderated in July at the AIAA Aviation Forum, "The View From 50,000 Feet," teased out some of the issues. Here is a compressed version of our two-hour discussion. *— Russell Boyce, AIAA Aeronautics Domain Lead*

Russell Boyce: Thank you everybody, welcome to the panel. Together, we're going to tease out the following scenario: Many of you will remember "The Jetsons." What we're going to address in the next hour and a half or so is "'The Jetsons' meets the 21st century." Bob, for that scenario, what pieces of technology do we need to bring it about?

Bob Whittington, Amaon Prime Air: At Amazon, we've developed a very good computer vision system to help the drone make sure it stays safe as it operates in a crowded environment. Let's say you don't want to come into somebody's backyard with a package when somebody's there. You have to train your system to know what a person looks like or what animals look like. You wind up taking thousands or tens of thousands of photographs, and you have thousands of hours of labor to label all those photographs to teach the system what a person is, or what a dog is, what an airplane is, what another unpiloted vehicle looks like. So, if we're going to personal transportation, the disruptor is going to be doing the automation in a way that doesn't require all those labor hours. So, large language models, the LLMs, are not there yet. We need to figure out how to train our systems in a way that's economical, and then apply that to take pilots out of the airplanes. That takes a lot of computing power and a lot of technology that we don't have yet.

Nick Lappos, Lockheed Martin: Today, Federal Express transports 20.5 million packages each day in the week before Christmas. I don't think those packages "see" each other, but Federal Express knows where each is within a few meters during the entire journey. If you think about the air traffic system in the future, it could be like a drone show today. I've seen 3,000 drones make beautiful pictures of ducks and cats, and they never bump into each other because they're networked together. We have to change the whole concept of the air traffic system away from detect and avoid.

Keoki Jackson, MITRE Corp.: The question is, "How do we get there from where we are today?" We also need to consider the application of automation or new framing of networks. The CrowdStrike update in July that shut down a lot of the aviation sector was one example. Take, also, the NOTAM system going down in January 2023. This somewhat ancillary system essentially shut down big chunks of the airspace for a couple of days. You also have to think about the infrastructure. Take the 2021 Colonial Pipeline ransomware attack that essentially shut down a lot of the fuel, including aviation fuel, to the East Coast. Then, think about some of the network effects and systems like ADS-B that are reliant on GPS. How do we think about re-architecting and redesigning these systems so there's redundancy, but they can also re-heal in case of disruption?

Whittington: Nick, I appreciate your vision and where you want to be. If I wait for you to go implement that vision, I'll be out of business. So, we need a system that integrates within our current system. I'm planning on delivering 500 million packages per year by 2029.

Lappos: I absolutely agree that if you disrupt the system for a future that might or might not be, you end up with chaos. However, if every air vehicle has detect and avoid built in, the economic threshold increases. If you had a network system, the network connection and instructions might be 5% of the cost, and therefore your vehicles get smaller, cheaper and easier to use —

Whittington: Agreed.

Lappos: No one wants to stop what you are describing. On the other hand, if you were to design the future system based on the limitations of today, you'll end up with those limitations carried through for the next 200 years. We have to be careful that the transportation systems for the future are designed for the capabilities of the future.

Oscar Garcia, InterFlight Global Corp.: My concern is that technology development is outpacing the policy and regulations frameworks. So AIAA as a standards-developed organization has a lot of solutions for that.

Boyce: Michael, what are the key pieces of science needed for this future world, this future scenario?

Michael Winter, RTX: If we think about the vehicles that we fly today, you're carrying several orders of magnitude in energy storage when you leave the ground. As a society, we are really not good at storing energy. We've been relying on these hydrocarbons, which provide 44-45 megajoules per kilogram. That's why we're starting to see for space, as an example, the reintroduction of nuclear to go longer distances. I'll also mention hydrogen storage. Hydrogen at approximately 120 megajoules per kilogram is three times the energy density of jet fuel, but it's four times the volume, so you need to store it as a cryogenic liquid. There's some interesting work that was done about three decades ago that looked at capillary condensation, essentially using carbon nanotubes to condense hydrogen to a liquid state at room temperature. It was demonstrated in the laboratory, and nobody was able to repeat it until about 10 years ago, and

THE MODERATOR

Russell Boyce, *AIAA Aeronautics Domain Lead*

Guides the AIAA community in its leadership on aviation-related matters. Runs his own consultancy, Mission Assurance; visiting faculty at both INSEAD: The Business School for the World and Arizona State University's Thunderbird School of Global Management. AIAA Fellow.

THE PANEL

Oscar S. Garcia, *founding partner, chair and CEO, InterFlight Global Corp.*

Leads the Florida and Luxembourg advisory, consultancy, investments and brokerage firm that completes economic development projects for a variety of customers. A former airline pilot, he chairs the Policy, Regulations, Operations, Standards and Safety Subcommittee of AIAA's High-Speed Task Force.

Keoki Jackson, *senior vice president and general manager of the National Security Sector at the MITRE Corp.*

Oversees national security programs conducted for the U.S. Defense Department, Justice Department and intelligence community. Previously chief scientist and chief engineer at Lockheed Martin. AIAA Fellow.

Vivek Lall, *Chief Executive, General Atomics Global Corp.*

Heads the technology company whose affiliated companies include General Atomics Aeronautical Systems, maker of the Predator and Reaper drones. A former adviser to the U.S. Transportation Department, he's held executive roles at Raytheon, Boeing and Lockheed Martin.

Nick Lappos, *senior fellow of Rotary and Mission Systems, Lockheed Martin*

Provides technical expertise for product development; oversaw development of the Sikorsky S-92 that won the 2002 Collier Trophy. A former helicopter pilot who flew combat missions in Vietnam; holds three speed records. AIAA Associate Fellow and co-chair of AIAA Certification Task Force.

Linda Cadwell Stancin, *vice president of the Air Vehicles Engineering division, Lockheed Martin Aeronautics*

Oversees aircraft development from planning to execution of flight simulations and tests. Previously vice president of research and technology for Lockheed Martin, she's also had roles at Spirit Aerosystems and Boeing.

Bob Whittington, *vice president of technology and engineering, Amazon Prime Air*

Leads technology development for Amazon's drone delivery division. Spent 34 years at Boeing, where he was chief engineer for the 767, 777 and 787 Dreamliner airliners and the P8-A Poseidon maritime patrol and reconnaissance craft.

Michael Winter, *chief science officer, RTX*

Accelerates RTX's technology development and accumulation of engineering knowledge. Spent 35 years at United Technologies Corp., where his various roles included Pratt and Whitney principal fellow. AIAA Fellow.

that too was not routinely repeatable. So there's some science there in terms of the properties of hydrogen that we really don't understand.

Linda Cadwell Stancin, Lockheed Martin: Mike, how do you see nuclear fission playing in the future for commercial transportation?

Winter: Any new technology that we introduce will be as safe or safer than anything flying previously. The basis of safety for commercial certification is one part in 10 to the ninth — one in a billion. Is that going to be tolerable in fissionable materials that could end up on somebody's property or in an urban setting? I believe that will likely remain a challenge.

Vivek Lall, General Atomics Global Corp.: In space, there are new developments in nuclear thermal propulsion as well as nuclear electric propulsion, and I do feel fission power on the surface of the moon and reactors for that, those lines will blur eventually into aviation.

Boyce: Nick, what are the gaps in certifying, regulating and managing a future transportation system?

Lappos: We must find a societal answer to the questions about emissions. Society may decide that fossil fuels work very well in some areas, and as long as it only represents, say, 5% or 10% of the total emissions of the society, it may be acceptable. I think we have to govern ourselves with that in mind, because gasoline is five times the energy density of dynamite. It's going to be hard to break that habit unless we recognize ways to get around it. The No. 1 barrier is that many of the innovative companies that are trying their hands at air vehicles today have no idea what the FAA certification system is like. In our final report, the AIAA Certification Task Force noted that AIAA could serve as an information-clearing house. So people in Silicon Valley can deal with some of us who have been in this tough world for a long time to help shape their submittals and get them much more likely to be certified quickly. The other barrier is how FAA has not considered the business requirements of the future advanced air mobility machines. The current rules would exclude probably about one-third of the urban environments. We think the idea of the future advanced air system would be allowing time variable airspace denial. So when a 747 is on the ILS, nobody goes near them. But when they're not using the ILS, then the package express flits around and delivers packages in otherwise forbidden airspace.

Boyce: Instead of the FAA perspective, what about the venture capitalist's perspective?

Garcia: FAA's role in certification is to administer — not to disrupt, not to promote, not to create. So it's up to us as an industry to bring to FAA not only the technology we want, but the means of compliance of that technology going forward. It's up to us in industry to create the consensus, voluntary industry standards that we deliver to FAA as a means of compliance for the technologies, whether it's automation, whether it's propulsion. We have to shift the paradigm to where we do not wait for FAA to give us the solution to scaling and commercializing technology. And that is where AIAA can shine, in terms of the consensus standards, capabilities. The billions of dollars we need to enable technologies like high-speed flight or advanced air mobility will not come until we show decision-makers that we have not only technology solutions but compliance-ready solutions.

Winter: I'll expand on that. Today, the certification chapters for the electrical system onboard an aircraft and for the propulsion system are separately defined. We and others are actively working on demonstrator programs for a regional turboprop, which is a 50/50 hybrid, and we're working in partnership with Airbus and others on a single-aisle that is a mild hybrid of about 5%. There are no certification chapters for when the propulsion system is reliant and interdependent on an 800-volt bus. So the key is back to what Oscar said: Show the alternate means of compliance.

Boyce: A question from the audience: What should we be doing to make transportation — air and multimodal — more resilient to climate change?

Lappos: The idea that the emissions of the vehicles are an important measure of the vehicle's performance is absolutely essential. And I must also say this: We always balance the future vehicle, like the battery-powered air vehicle, against today's machine, but today's machine is not tithed with the expense of the effluent that it throws into the atmosphere. We buy a gallon of fuel and we spend a given amount for it, and then we burn it, and no one looks back and says, "You just caused this much damage, and that has to be recovered." It's my belief that one of the ways that society will end up creating a proper economic balance for the future is to create the expense for the fuel's damage at the pump.

Jackson: Also, just think about the impacts of extreme heat events. We've seen cases where certain aircraft types have been grounded in certain regions because they're outside of their operating regime. Now, there are technological solutions to all that, but we should anticipate that these kinds of challenges will become even more prevalent over time.

Lall: There are a lot of gains from sustainable aviation fuel or electric or hydrogen. Oftentimes, you do get cleaner energy at a particular point design, but you have to look at the lifecycle — whether it's batteries or other things — to assess the total impact to the environment.

Boyce: Oscar, what's the No. 1 issue that developers of the technology and the airspace management systems should be firmly fixed on to achieve viability?

Garcia: The capital decision-makers look at technology evolution through the readiness levels. Look at market demand, and when those two start meeting each other, immediately look at three vectors. First, policy. Is this going to be scalable? Can it proliferate into the societal market evolution? Next, the regulator. Who is going to administer and take responsibility for the certification of that technology? Finally, can the technology evolve?. If you look at those in terms of sustainability, safety and service to the community, there

> "DISRUPTION CAN BE UNCOMFORTABLE, OR IT CAN PROVIDE PHENOMENAL OPPORTUNITY."
>
> — Michael Winter, RTX

are oftentimes misalignment. So, a top priority would be to wrap those regulation vectors around the super vector that I call the voluntary consensus standards— the norms of behavior, best practices vector. That gives investors and capital decision-makers the assurance that the policy, regulation and the technology could be aligned to scale up for market use and return on investment.

Lappos: On the technical vector, AIAA serves as a very good clearing house for technology, because unlike the applicants who come to you with their very best pig in a polka dot dress, AIAA is a group of technicians and scientists who can comment in a way that does not have political or monetary implications. The only organization I see that does that as well is NASA.

Whittington: For certification, we have to talk about safety. In piloted aviation with passengers on board, we talk about one in a billion as our design criteria. When somebody dies, there's a much greater reaction than, for instance, the 50,000 people in the U.S. who die every year driving cars. Part of our certification challenge in the AAM world is there are no agreed-to standards. That means every time there's an accident, there's a potential to over rotate and shut down the entire industry because we haven't agreed on what safety means. There's increasing pressure to have zero be the only OK answer, and everybody who's been in this industry knows you can't get to zero unless you just park them.

Boyce: Is there an ethics conversation that's needed?

Whittington: There is that conversation, but nobody in a political environment can stand to have the conversation. It'd be great if AIAA could sort of take that on, or MITRE's in a pretty good position.

Lappos: Absolutely agree. One of the problems is that the AAM world of the future will have an order of magnitude more vehicles than today. If you hold today's practical standards — about 10 to the seventh for today's air transport system — and then you put 100,000 vehicles flying in the United States, you end up having a reportable headline in every city every day. It probably will bring the system to a halt unless there's some understanding of the reality of the numbers, and I have no answers.

Boyce: Linda, what is the opportunity for enhancing national and international security and stability?

Cadwell Stancin: There's a definite intersection between security for commercial travel and security for defense. I'll also raise an equality aspect. On security, it's quite critical for aircraft to be able to make decisions in real time. You can imagine the data processing, the amount of sensors, artificial intelligence, live agents applied to that. That's important in a defense setting, but I also believe that's going to be important in a commercial aspect. So how do we balance the two? I feel as a mom that we have to move so much faster toward security and sustainability. I worry about a volume of commercial flight that's two, three, four times greater without addressing sustainability. We are working very rapidly in computational fluid dynamics. For example, with NASA's Quesst, the X-59, we filled in the science blanks of supersonic flight, and then we started working speed, multifidelity physics, modeling, scaling the fidelity of our analysis in gridding, moving analysis from weeks to do analysis to hours. That allows us to iterate very quickly. In the area of sustainability, we now have additive manufacturing. Computational materials engineering has advanced dramatically from ab initio calculations to molecular reactions all the way to full scale, so we can design in the properties we absolutely need and dramatically reduce production waste. We also should be putting a lot more muscle into bioengineering. We can use biomaterials in our production support almost immediately and then move on to incorporating them into interiors, for example. And why do I equate that to equality? If we don't address these things as we plan our work, it's just going to be the super rich that get to fly supersonic or be space tourists. We have to build in design for cost up front.

Boyce: Vivek, what must the incumbents of today do to ensure they don't face their Kodak moment and become obsolete in the future?

Vivek Lall: We live in a world that's a globalized community. No one country has a lock on the best ideas, and no one country has a lock on the implementation of those ideas. If you're going to stay ahead of the game, not only do you need to have leapfrog technologies, but you need to do them at the right cost point. The other aspect is that the maintenance, repair and overhaul of products is the long tail where much of the investment goes. So understanding how that piece fits into the product or offering is very important. At a technology level, these days, AI is the buzz word. Well, we all knew AI existed 40 years ago, but what's new today is the implementation. It's now possible due to fast processors, the sim technologies. So timing all this into the future is going to be very critical.

Winter: Anytime you have changes in a market, it's an opportunity to displace the incumbents. I'll use the example of sustainability. How many countries can make a nuclear weapon? Somewhere between 19 and 21. How many can make a modern jet engine? Two and a half, maybe three. So that's a technology that is likely to undergo change in the next decade or two. Two of the companies that can make that modern jet engine are based in the United States, and they contribute positively to the largest category in the balance of trade for the U.S. Other countries understand this, and they want

what we enjoy. We all need to work together collaboratively through appropriate means to further those technologies and to invest through public-private partnerships.

Lappos: The reason so few countries can develop a practical jet engine is that it takes you about 30 years to develop the thermodynamicists and materials engineers. That's no longer true as we get better digitization of our systems. I'll offer an example: The prize for building a man-powered helicopter that could fly at 10 feet for 1 minute and maintain control was not won by any of the U.S. teams comprised of aerospace engineers. It was won by a Canadian group with no rotorcraft design experience. They actually looked up the code and bought some commercial software for the rotors. If we're not careful, the idea that there are large barriers to entry for people in major complex fields will no longer be true. There'll be a democratization of the design of these systems, which, in the end, will help humanity overall.

Boyce: Keoki, what would need to be the standout attribute of our future workforce?

Jackson: I'm going to take it as a given that we already have people in this room who love our technology, our science, research and development, engineering. I think the attributes we need beyond that lie in three particular areas. One is adaptability. At MITRE today, we're shifting toward hiring folks who can adapt to what the needs of a different mission, risk environment or challenge will be — Renaissance people that can bring the combination of great technical depth but also are curious, who have breadth, who are interested in the connections. We're hiring people that can connect ideas, and that is critically important. All the challenges you heard about today, they're not just technical connections. They're policy and environmental considerations. The third attribute is a growth mindset — the idea that we're not living in a fixed world, but a world of abundance and the opportunity to do almost an infinite variety of things. What kind of leaders do we need? Maybe the simple answer is leaders that can enable those folks that I just talked about. I would also say, "What do people care about as they're coming into the workforce?" Meaningful work, and that, interestingly, has to do with the colleagues and the co-workers that they're with. Why do people leave? They don't find opportunities for advancement, to continue to grow both professionally and in their personal experience. So the challenge is focusing on organizational health. I'll just end with this description of leadership from Max De Pree, who worked for the Herman Miller furniture company. What does that have to do with aerospace? I would argue that the integration of human-centered design and technology insertion that verges on art is what we do every day. He said, "The measure of leadership is not the quality of the head but the tone of the body."

Lall: That was outstanding, Keoki. I think ethics and integrity are going to be so important going into the future. It's important today; it was important in our history. But into the future, as we look at these future aviation, transportation systems, certifications, et cetera, one leadership attribute — and leadership at every level, whether you're talking technical or managerial — will be ethics and integrity, and that attribute cannot be foot stomped enough.

Cadwell Stancin: I'm concerned about diversity. If you look at the universities and aero degrees, we're still very, very, very low with women and people of color. I'm wondering if we can do something different, both in the universities and AIAA, where we start looking at multidisciplinary education. We talked this whole time about computing, software, propulsion, even about bioengineering. We should be hiring and we should be growing skills, and we should be cross-training degrees with multidisciplinary degrees enabled across all the engineering and science disciplines in order to meet this mission.

Lappos: To expand on Linda's point: I think if you were to look at the system that we have today that produces engineers, that starts with young women and young men who have a proclivity for math, science and the love of materials and things, and then we end up producing a graduate engineer. The space between those two milestones could not be less efficient if we tried. Also, to take a young man or young woman and move them to a city a thousand miles away and expend four years of their lives to become an engineer, I bet 80% of the expense and the bother is not in engineering, because our system is designed around Oxford University in the year 1550. What are we doing today with regard to Zoom and other things to help democratize education? I can only tell you the failure our society is that there are young women in Iowa who know how to repair a tractor, and they'll never think of going to engineering school. They don't have the money because our society cleaves itself with regard to economics. So those on the lower side of the economic scale may have no idea of how to get to college and then just turn it off.

Boyce: Here is the highest-voted question from the audience related to workforce: When you look to the future of aviation, what other industries would it benefit us to work with or learn from?

Garcia: Today, only about 20% of the 8 billion people on Earth have set foot in an airplane. When 90% have flown on an airplane, we'll have to quadruple, quintuple, our fleet. The automobile industry knows how to scale up. I'd keep an eye on that.

Lall: The universities are a very important tool that we have to interact with a lot more, not just domestically but in the international domain. Although a lot is being done, I think a lot more investment needs to go into the universities and R&D collaborations with industry.

Jackson: I'll throw a maybe nonobvious one out there. If we're really going to seize the seeds of disruption here and disrupt ourselves, it does require a very different mindset, whether in industry or in government. We've got some folks who have lived in the venture capital world here, with you would invest in things where maybe one in 10 is going to work out. Those are the kinds of things that we're going to need to do if we're going to tackle these challenges, whether it's sustainable fuels or getting safety incidents down by orders of magnitude.

Boyce: I want to give each panelist each 30 seconds for final thoughts. We'll start from Oscar and work our way back to Keoki.

Garcia: This event that blends aviation with space for the first time gives us an opportunity to cross-pollinate, to tackle some of the most challenging issues that we've discussed. So think about seamlessly blending the aviation and space frameworks and constructs. I think we can get a lot of low hanging fruit there.

Lall: We started with "The Jetsons," but we need to think about what is "The Jetsons" of today? Very critical will be the diversity piece that Linda talked about, because that's a building block, and the other is international collaborations.

Winter: Disruption can be uncomfortable or it could provide phenomenal opportunity, and it's up to us and everybody here at this conference to be the leaders of the future and realize our bright future.

Whittington: I think the aerospace industry is monochromatic. Generally speaking, we came from the same backgrounds, we look the same, we talk the same. That sets us up for disruption, because it keeps you from thinking outside the box. The up-and-coming companies that have huge pocketbooks and no sense of history are happy to go spend a lot of money to go leapfrog and bypass some of the history. So we really need to do a better job of creating a more diverse atmosphere.

Lappos: Right now, AIAA is organized in terms of technical challenges and technical leaps, but maybe it's not technology that we're talking about, but people. There's the question of how we harness ourselves to move forward, the idea that there is a whole capability to raise a crop of people that can help us in the future. How do we do that? And maybe AIAA can be organized to do that.

Watch the full discussion

Cadwell Stancin: Ethics. We face opportunities, huge, enormous opportunities, and we face huge risks in a very challenging climate. I want all of us in our companies, our universities to build in and strengthen ethics in engineering and scientific design. When you think about what's going on with artificial intelligence and pulling open-source software, it becomes absolutely imperative to really examine ethics in the products that we build.

Jackson: We're in the business, I would say, of making the miraculous mundane. I want to fly on that that hypersonic aircraft, and if we're going to make that happen, we are going to have to work collaboratively in spite of some of our instincts, and we're going to have to think from the outset in terms of resilience and robustness and safety. Those are the things that are going to allow us to accelerate that future that we've all been talking about today. So thank you to Russell, thank you to this entire panel. It really has been marvelous. ★

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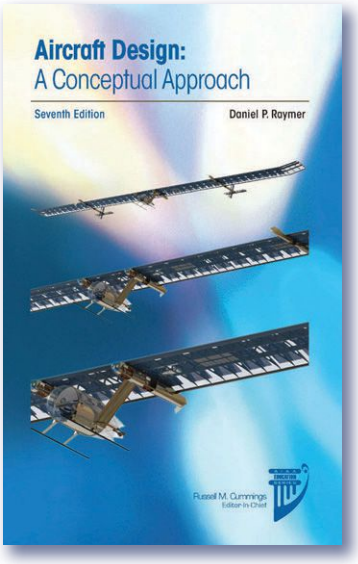

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All AIAA staff can be reached by email. Use the formula first name last initial@aiaa.org. Example: christinew@aiaa.org.

Other Important Numbers: Aerospace America / Catherine Hofacker, ext. 7587 • AIAA Bulletin / Christine Williams, ext. 7575 • AIAA Foundation / Alex D'Imperio, ext. 7536 • Book Sales / 800.682.AIAA or 703.661.1595, Dept. 415 • Communications / Rebecca Gray, 804.397.5270 • Continuing Education / Jason Cole, ext. 7596 • Corporate Programs / Merrie Scott, ext. 7530 • Editorial, Books and Journals / David Arthur, ext. 7572 • Exhibits and Sponsorship / Paul doCarmo , ext. 7576 • Honors and Awards / Patricia Carr, ext. 7523 • Integration and Outreach Committees / Angie Lander, ext. 7577 • Journal Subscriptions, Member / 800.639.AIAA • Journal Subscriptions, Institutional / Online Archive Subscriptions / David Arthur, ext. 7572 • K–12 Programs / Jake Williams, ext. 7568 • Media Relations / Rebecca Gray, 804.397.5270 • Public Policy / Ryan Cooperman, ext. 7541 • Section Activities / Lindsay Mitchell, ext. 7502 • Standards, International / Nick Tongson, ext. 7515 • Technical Committees / Angie Lander, ext. 7577 • University and Young Professional Programs / Michael Lagana, ext. 7503

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

Calendar

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2024			
1 Oct	Yvonne C. Brill Lecture in Aerospace Engineering	Washington, DC	
1–2 Oct	Fundamentals of Space Domain Awareness Course	ONLINE (learning.aiaa.org)	
8 Oct–7 Nov	Advanced Hydrogen Aerospace Technologies and Design Course	ONLINE (learning.aiaa.org)	
14–18 Oct*	75th International Astronautical Congress	Milan, Italy (iac2024.org)	
16 Oct–25 Nov	Spacecraft Design, Development, and Operations Course	ONLINE (learning.aiaa.org)	
19–20 Oct	SmallSat Education Conference	Cape Canaveral, FL	
22 Oct–7 Nov	Launch Vehicle Coupled Loads Analysis Course	ONLINE (learning.aiaa.org)	
22 Oct–14 Nov	Hypersonic Propulsion Concepts: Design, Control, Operation, and Testing Course	ONLINE (learning.aiaa.org)	
28–31 Oct	Space Domain Cybersecurity Course	ONLINE (learning.aiaa.org)	
28 Oct–20 Nov	Fundamentals and Applications of Thermal Vacuum Testing Course	ONLINE (learning.aiaa.org)	
2 Nov	Young Astronauts Day	Cleveland, OH	
5–21 Nov	Spacecraft Avionics Systems Design and Applications Course	ONLINE (learning.aiaa.org)	
6–7 Nov	Fundamentals of Space Domain Awareness Course (European Offering)	ONLINE (learning.aiaa.org)	
11–20 Nov	Technical Writing Essentials for Engineers Course	ONLINE (learning.aiaa.org)	
13–22 Nov	Aircraft Maintenance Management Course	ONLINE (learning.aiaa.org)	
14–15 Nov*	High Speed Aerospace Transportation Workshop	Midland, TX (hsat.highspeedflight.com)	
18–21 Nov	Applied Model-Based Systems (MBSE) Course	ONLINE (learning.aiaa.org)	
22 Nov	AIAA Young Professionals, Students, and Educators (YPSE) Conference	Laurel, MD	
25–26 Nov	Region VII Student Conference	Melbourne, Australia & Online	4 Aug 24
9–12 Dec	Practical Design Methods for Aircraft and Rotorcraft Flight Control for UAV, AAM, and Civil/ Military Using CONDUIT Course	ONLINE (learning.aiaa.org)	
2025			
6–10 Jan	AIAA SciTech Forum	Orlando, FL	23 May 24
6–10 Jan	26th AIAA International Space Planes and Hypersonic Systems and Technologies Conference	Orlando, FL	23 May 24

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

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2025			
8 Jan	2025 AIAA Associate Fellows Induction Ceremony and Dinner	Orlando, FL	
19–23 Jan*	2025 AAS/AIAA Space Flight Mechanics Meeting	Kaua'i, HI (www.space-flight.org)	13 Sep 24
4 Feb	Fundamentals of Python for Engineering Programming and Machine Learning Course	ONLINE (learning.aiaa.org)	
11 Feb	Business Development for Aerospace Professionals Course	ONLINE (learning.aiaa.org)	
26–27 Feb	ASCENDxTexas	Houston, TX	
1–8 Mar*	IEEE Aerospace Conference	Big Sky, MT (www.ieee.org)	1 Jul 24
20–21 Mar	AIAA Region I Student Conference	Montréal, Quebec, Canada	10 Jan 25
22–23 Mar	AIAA Region VI Student Conference	Irvine, CA	2 Feb 25
28–29 Mar	AIAA Region IV Student Conference	Dallas, TX	31 Jan 25
3–4 Apr	AIAA Region II Student Conference	Greensboro, NC	3 Feb 25
3–4 Apr	AIAA Region V Student Conference	Minneapolis, MN	31 Jan 25
4–5 Apr	AIAA Region III Student Conference	Cincinnati, OH	8 Feb25
10–13 Apr	29th Design/Build/Fly Competition	Tucson, AZ (aiaa.org/dbf)	
15–17 Apr	AIAA DEFENSE Forum	Laurel, MD	15 Aug 24
29 Apr	2025 AIAA Fellows Induction Ceremony and Dinner	Washington, DC	
30 Apr	2025 AIAA Awards Gala	Washington, DC	
21–25 Jul	AIAA AVIATION Forum	Las Vegas, NV	21 Nov 24
22–24 Jul	ASCEND Powered by AIAA	Las Vegas, NV	21 Nov 24
29 Sep–3 Oct*	75th International Astronautical Congress	Sydney, Australia (iac2025.org)	

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

AIAA Continuing Education offerings

FALL AIAA FOUNDATION NEWS FOR K-12 EDUCATORS

2025 AIAA Trailblazing STEM Educator Award Applications Open

The Trailblazing STEM Educator Award, sponsored by AIAA and Challenger Center, celebrates three K-12 educators who go above and beyond to inspire the next generation of explorers and innovators in science, technology, engineering, and mathematics.

The award winners receive $5,000 for the educator, $5,000 for the educator's school or organization, a trip to Washington, DC, to be honored at the AIAA Awards Gala, and free access to Challenger Center's STEM education programs. Details at **aiaa.org/trailblazingstemeducatoraward**. Applications Close: 1 December 2024.

AIAA Roger W. Kahn Scholarship

AIAA will award four $10,000 scholarships to current high school seniors who plan to study aerospace engineering at a college or university in fall 2025. AIAA will also provide an all-expense paid trip to Washington, DC, to attend the AIAA Awards Gala, where we recognize top aerospace professionals and contributors to the aerospace community. Each student also will be provided with a mentor from AIAA's professional members to help guide the students to achieve a career in aerospace.

Details of the eligibility and requirements can be found at **aiaa.org/kahnscholarship**. Applications Close: 31 December 2024.

AIAA Announces 2025 Design/Build/Fly Mission and Draft Rules

Teams are invited to participate in the 29th annual Design/Build/Fly (DBF) competition, 10–13 April 2025, in Tucson, AZ. The objective for the mission is a balanced design possessing good demonstrated flight handling qualities, and practical and affordable manufacturing requirements while providing a high vehicle performance. This year the teams also are required to show both release AND autonomous guidance of a vehicle to a grid on the ground to maximize mission points.

The 2025 rules can be found at **aiaa.org/dbf**. Team rosters and proposals can be submitted starting 15 October. Submissions must be received by **31 October**.

2025 AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award

CALL FOR NOMINATIONS

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

This award honors individuals who have made significant improvements in the relationships between airports and/or heliports and the surrounding environment, specifically by creating best-in-class practices that can be replicated elsewhere.

DEADLINE: 1 November 2024

CONTACT: AIAA Honors and Awards Program at awards@aiaa.org

For more information, please visit

aiaa.org/SpeasAward

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

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Presentation of the award will be made at the AAAE/ACC Planning, Design, and Construction Symposium scheduled for March 2025 in San Antonio, TX.

MAKING AN IMPACT

AIAA Announces Winners of Prestigious Zarem Graduate Student Award for Distinguished Achievement in Astronautics

AIAA is pleased to announce the winners of the 2024 Zarem Graduate Student Award for Distinguished Achievement: **Mohammed Abir Mahdi** and **Shafi Romeo**, Oklahoma State University, won the **astronautics award** for their paper, "Convolutional Neural Network and Homogenization based Hybrid Approach for Lattice Structures." Mahdi and Romeo will present their paper at the 75th International Astronautical Congress (IAC) in Milan, Italy, 14–18 October 2024.

The winners will receive their awards at the 2025 AIAA SciTech Forum, Orlando, Florida, 6–10 January 2025. This award was established by AIAA Honorary Fellow Abe Zarem, founder and managing director of Frontier Associates, to annually recognize graduate students in aeronautics and astronautics who have demonstrated outstanding scholarship in their field.

Mohammed Abir Mahdi, Oklahoma State University, Astronautics Award (Co-Recipient)

Mahdi is currently pursuing his Ph.D. in Purdue University's School of Mechanical Engineering. He recently completed his master's in mechanical and aerospace engineering from Oklahoma State University. Mahdi's research focuses on composite manufacturing and the design of lattice structures. He holds a bachelor's in Naval Architecture and Marine Engineering from the Bangladesh University of Engineering and Technology. Prior to his graduate studies, Mahdi worked as a Lecturer at MAS Marine Academy in Bangladesh, gaining expertise in naval structure design and analysis. He is passionate about teaching and inspiring students in the field of science and technology.

"Receiving this award makes the nights, days, and sacrifices for this novel work feel truly worthwhile," said Mahdi.

Shafi Romeo, Oklahoma State University, Astronautics Award (Co-Recipient)

Romeo is pursuing his Ph.D. in Mechanical Engineering at Oklahoma State University. His research interest lies in developing, analyzing, and applying physics-constrained deep learning models to tackle intricate scientific challenges within fluid dynamics. Currently, his focus is on the innovative realm of Physics-Guided Multifidelity Learning for characterizing the dynamic stability of atmospheric reentry vehicles.

"Receiving the Abe M. Zarem Graduate Award is a tremendous honor for me. This award recognizes my hard work and boosts my confidence and enthusiasm for future endeavors," said Romeo.

Faculty Advisor

Wei Zhao is currently an Assistant Professor in the Department of Mechanical and Aerospace Engineering at Oklahoma State University. He earned his Ph.D. in Aerospace Engineering from Virginia Tech. Zhao's research focuses on lightweight aerospace structures and materials created using advanced robotic automated fiber placement and 3D printing technologies. He is an AIAA Senior Member and a member of the AIAA Structures Technical Committee.

"As an advisor, witnessing the growth and development of my graduate students is extremely rewarding. From hands-on teaching to seeing them gradually conduct their work independently, this process not only advances our field but also helps shape the next generation of innovators and leaders. Their successes and discoveries drive the progression of aerospace engineering, particularly in next-generation fuel-efficient airplane design, and their unique perspectives and creativity continually inspire me. Advising graduate students is not just about sharing knowledge; it's about fostering a collaborative environment where both the mentor and mentee learn and grow together, ultimately pushing the boundaries of what we can achieve," Zhao said.

For more information on the Abe M. Zarem Graduate Awards for Distinguished Achievement, please contact Michael Lagana, at michaell@aiaa.org or 703.264 .7503.

AIAA New Standards Projects Approved and Call for Experts

The AIAA Standards Steering Committee (SSC) recently approved a new project, AIAA S-159, *Best Practices, Functional Requirements, and Norms for In-space Servicing, Assembly, and Manufacturing (ISAM) Power and Data Interfaces.* This document provides best practices, functional requirements, and norms associated with the power and data interfaces between a Servicing Spacecraft and a Client Space Object. The intent is to provide guidance to developers and operators of both the Servicing Spacecraft and the Client Space Object.

The AIAA SSC also approved a revision project, AIAA S-102.0.1A, *Capability-Based Mission Assurance Program – General Requirements* (revision of ANSI/AIAA S-102.0.1-2019). This document provides the basis for cost-effectively planning and applying SR&QA analyses to products. The resource requirements, planning, and empirical and analytical processes are established.

If you wish to participate as an expert on the committee or if you have questions, please contact Nick Tongson (nickt@aiaa.org).

Diversity Corner

Holly Pascal

NAME: Holly Pascal, AIAA Young Professional Member

NOTABLE CONTRIBUTIONS: Holly Pascal believes that the convergence of empowerment and innovation can lead to solving many of humanity's most complex challenges. She envisions a world where more individuals are empowered with the tools and knowledge to drive transformative change, not just in their lives but in the lives of others. This philosophy inspired her to write **The College to Dream Job Blueprint** and found The Women's Aerospace Network (WAN), the largest women's aerospace community in America, which connects, amplifies, and inspires a universal passion for aerospace. Pascal holds a Bachelor's in Computer Engineering, a Master's in Artificial Intelligence, and is a graduate of Wharton's Executive Program in Leadership and Management.

POTENTIAL SOCIETAL IMPACT OF CONTRIBUTIONS: As a NASA Headquarters Systems Engineer, she is dedicated to advancing humanity and improving lives through aerospace advancements. Pascal strives to leave a legacy of a positive impact on the world.

*In collaboration with the AIAA Diversity and Inclusion Working Group, the AIAA Society and Aerospace Technology Outreach Committee is highlighting prominent members of the wider aerospace community in the Diversity Corner.

A Recap of the 2024 SAT OC Activities

By Amir S. Gohardani, SAT OC Chair

From left to right: Janet Grondin (Stellar Solutions, Inc.), Shelli Brunswick (SB Global LLC), Amir S. Gohardani (Springs of Dreams Corporation), Melanie Stricklan (Space Foundation), and Aine Nakai (Space Systems Command, U.S. Space Force).

The AIAA Society and Aerospace Technology Outreach Committee (SAT OC) has actively advanced many activities this year. In May, the committee gathered to discuss several topics including committee representation at 2024 ASCEND held in Las Vegas, 30 July–1 August. During the ASCEND event, I was delighted to meet up with many SAT OC members and event participants. I represented SAT OC by serving as a member of the 2024 Diverse Dozen, where alongside my fellow cohort members, I provided thought leadership about space safety, security, and sustainability. As the ASCEND Deputy Technical Program Chair for Space and Sustainability, I also co-chaired two sessions – Space Activity I & II – which addressed some of the most impactful space-related topics. I am grateful to my co-chairs, John Carsten and Paula do Vale Pereira, for their valuable leadership and contributions on the sessions. One of the thought-provoking ASCEND sessions I experienced was Talent Strategies to Fuel the Aerospace Pipeline, which comprised discussions about the the U.S. aerospace workforce. Moderated by Janet Grondin, this panel of experts provided their perspectives on aerospace talent strategies, and I was proud to be a part of it.

To increase these type of SAT OC activities, the committee would like to fill multiple open positions that include: 1) membership lead for SAT OC members, 2) collaboration lead for other AIAA domains/organizations, 3) chairpersons for chairing conference sessions, 4) SAT OC webmaster, and 5) reviewers of conference abstracts. To serve in any of these positions, interested individuals need to initially be SAT OC members and then express their interest by sending an email to amirsgohardani.aiaa@gmail.com.

AIAA Launches New Mary W. Jackson Undergraduate Scholarship

AIAA has launched a new undergraduate scholarship honoring the late NASA mathematician and aerospace engineer Mary W. Jackson, which will first be awarded in summer 2025. The $10,000 Mary W. Jackson Scholarship was created to provide even greater access to opportunity for the best students studying the aerospace sciences and will be available to students studying at institutions in the United States or its territories. Applications will be open until **31 January 2025**. Students from underrepresented backgrounds are encouraged to apply.

"Honoring pioneering NASA scientist and aerospace engineer Mary W. Jackson through a scholarship is not just a tribute to her pioneering spirit, but a commitment to empowering the next generation of aerospace engineers. By investing in today's students, we're ensuring that her legacy inspires innovation and excellence in aerospace for years to come."
— Laura McGill, AIAA Foundation Chair

STEM Outreach for Poquoson Library Kids and Teens Programs

By Karen Berger, Hampton Roads Section


AIAA Hampton Roads Section (HRS) spent time in July at the Poquoson Library for outreach events with their Kids and Teens programs. In mid-July, HRS volunteers made spectroscopes with teen students (and their parents). The students learned about what a spectroscope is, how they are used and then got to use the ones they created to look at various light sources. This was a new activity for the section and was led by Josh Weisberger, with help from Karen Berger, Johnny Davami, Brian Mason, and Drew Turbeville.

In late July, HRS volunteers helped the elementary-age students build two different kinds of gliders. They built foam gliders, learning about control surfaces and lift and drag and then got to iterate on their designs to try to improve them. They built circular paper airplanes as an additional type of design. Some of the students even combined their designs to try to improve their vehicles. Throughout the activity, students went outside to test their designs. This activity was led by Karen Berger, with help from Brian Mason, Drew Turbeville, and Josh Weisberger. | **Photo credit: Karen Berger**



AIAA UTD Student Branch Kicks Off Fall Semester

AIAA University of Texas at Dallas (UTD) Student Branch Chair Jack Finnegan with the other student branch officers kicked off the fall semester with a great introduction to AIAA and mixer for 330 students to discuss all the different project opportunities at UTD's student branch. After an introduction to each of the different projects the student branch works on, from the Rocket Team, Finance, and Marketing to Design-Build-Fly (DBF) and the new rover section (Aerobotics), students were able to meet, discuss, and sign up with the different project teams. The UTD Student Branch will be hosting the AIAA Region IV Student Conference, 28–29 March 2025.

Northern Ohio Section Holds Distinguished Lecture

In September, the AIAA Northern Ohio Section had a great turnout for its Distinguished Lecture with David Avanesian from the Power and Propulsion Division at NASA Glenn Research Center. Avanesian returned to his alma mater, Cleveland State University's Washkewicz College of Engineering, to present "NASA's First All Electric Airplane: X-57 Lessons Learned." He examined the motivation and challenges behind the X-57's development and shared how the value of the airplane lies in advancing the U.S. ability to design, test, and certify electric power trains, which will enable new markets.

Obituaries

AIAA Associate Fellow Salim Died in March 2024

Abbas Salim, a retired Principal Engineer and Fellow at Lockheed Martin and a respected consultant in the aerospace industry, died on 29 March 2024. He was 79 years old.

Salim graduated with a BSEE degree from Raipur in India and an MSEE from Worcester Polytechnic Institute in Massachusetts. His almost-50-year career progressively spanned many corporations.

Salim started work with General Dynamics, before moving to Martin Marietta, where he worked on developing the world's largest terrestrial solar power park in Riyadh, SA. At Fairchild Space and Defense Systems, he contributed to the development of FS-100 lightweight power systems for satellites, and NASA's Earth Observatory System. At GE Aerospace and Lockheed Martin, as a senior staff engineer, he led power system development of a common satellite bus A2100, Space-Based Radar, Milstar, and LMT's proprietary HDI-based power switching and Actuation Module for NASA's New Millennium Program.

After his retirement, Salim continued to attend Space Power Conferences, hosted by AIAA in the United States and ESA in Europe, where he participated as an author, paper reviewer, organizer, and session chair in space power areas. He was also a regular attendee of the International Energy Conversion Engineering Conference (IECEC). Salim was a longtime member of the AIAA Aerospace Power Systems Technical Committee, where he continued to be a valued mentor to young engineers.

AIAA Associate Fellow Ingold Died in July 2024

Norman L. Ingold died on 21 July 2024. He was 90 years old.

Ingold studied at the University of Wisconsin, trained at the Army Language School in Monterey, CA, and served in the Korean War. Fluent in seven languages (English, Spanish, German, Norwegian, Japanese, Russian, and a little French), he studied geology, anthropology, physics (including both quantum mechanics and relativity), mathematics, linguistics, and chemistry). He earned his M.S. in Physics at American University. Ingold was undertaking a Physics Ph.D. at the University of Arizona when he received the offer from Holloman Air Force Base in 1965.

With over 50 years' practical expertise, one of the projects he worked on was increasing the accuracy of the guidance systems for the Lunar Excursion Module (LEM) from 200 miles to 3 miles. After 31 years, Ingold retired as the Chief Scientist for the Central Inertial and GPS Test Facility, the 746th Test Squadron at Holloman Air Force Base in 1996. He authored ten symposium papers and helped pioneer sled testing—sending a rocket on a sled down a track at beyond the speed of sound—including innovating reverse velocity sled tests. In 2009, he was asked back as a subject-matter expert and continued consulting for the remainder of his life. Ingold was a member of AIAA for over 50 years.

AIAA Associate Fellow Conway Died in August 2024

Bruce A. Conway died on 7 August 2024. He was 81 years old.

Conway graduated from Virginia Polytechnic Institute with a degree in Aerospace Engineering, from George Washington University with a Master of Science degree, from Harvard University School of Business with an advanced certificate in management development, and from Old Dominion University with a Ph.D.

Conway began his career at NASA in 1961 as a co-op student in the 16-ft wind tunnel and retired in January 1998 as a member of the Senior Executive Service in the Internal Operations Group. He worked in the Space Station Research Group, the Applied Materials and Physics Division, the Flight Dynamics and Control Division, the Flight Electronic Division and the Instrument Research Division (as Chief). As a young research engineer, Conway developed an experiment that flew on Skylab 3 called the Limb Motion Measurement System. Among his many awards and achievements was the selection for career development at NASA Headquarters.

Conway enjoyed a second career in education for 45 years with Embry-Riddle Aeronautical University in their Worldwide Campus. Hired as an adjunct professor in 1977 to teach algebra at the Langley AFB Education Center, he traveled the world teaching in ERAU education centers. His dream of having a School of Engineering established was finally realized in 2022 when he was named the founding Associate Dean. He retired in June 2023 as Professor Emeritus.

An AIAA Associate Fellow, Conway was involved as a member of the Sensor Systems and Information Fusion Technical Committee, as well as an Associate Editor for the *Journal of Guidance, Control, and Dynamics*.

AIAA Announces 2023–2024 Section Award Winners

AIAA has announced its 2023–2024 section award winners. The section awards honor particularly notable achievements made by members of AIAA's 57 sections around the world in a range of activities that help fulfill the Institute's mission. The local sections completed a total of 937 activities this year, each offering technical programs and activities tailored to local aerospace professionals, students, and educators. Section awards are given annually in eight categories based on the size of each section's membership. Each winning section receives a certificate and a cash award. The award period is 1 June 2023–31 May 2024.

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

VERY SMALL

First Place: Adelaide

Second Place: Delaware

Third Place: Melbourne

SMALL

First Place: Palm Beach

Second Place (tie): Central Coast of California

Second Place (tie): Northwest Florida

Third Place: Wichita

MEDIUM

First Place: Illinois

Second Place: Greater Philadelphia

Third Place: Antelope Valley

LARGE

First Place: North Texas

Second Place: Northern Ohio

Third Place: St. Louis

VERY LARGE

First Place: Los Angeles

Second Place: New England

Third Place: Hampton Roads

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

VERY SMALL

First Place: Point Lobos, Jae-Jun Kim (Naval Postgraduate School), website editor

Second Place: Adelaide, Patrick Neumann (Neumann Space), section chair

Third Place: Delaware, Zachary Gent (Northrop Grumman Defense Systems), membership officer

SMALL

First Place: Long Island, David Paris, section chair

Second Place: Central Coast of California, Matthew Tanner (United States Space Force), communications officer

Third Place: Northwest Florida, Micah Reese, secretary

MEDIUM

First Place: Illinois, Kenneth Brezinsky (University of Illinois at Chicago), secretary; Laura Villafañe Roca (University of Illinois at Urbana-Champaign), section chair

Second Place: Carolina, John Blanton (Classic Engineering LLC), section chair

Third Place: Phoenix, Aiden Bramer (Northrop Grumman Space Systems), section chair

LARGE

First Place: North Texas, James Sergeant, section chair

Second Place: Northern Ohio, Edmond Wong (NASA Glenn Research Center), communications officer

Third Place: San Gabriel Valley, Sahangi Dassanayake (California Institute of Technology), communications officer

VERY LARGE

First Place: Los Angeles, Kenneth Lui (Ken's Consulting), section chair; Ian Clavio (Northrop Grumman Aeronautics Systems), university education officer

Second Place: Hampton Roads (tie), Soumyo Dutta (NASA Langley Research Center), newsletter editor

Second Place: New England (tie), Aaryan Nagarkatti (Westboro HS Rocketry Association), social media officer; Shreyas Hegde (Pratt & Whitney), section chair

Third Place: Dayton-Cincinnati (tie), Oliver Leembruggen (Sumaria Systems), public policy officer

Third Place: Houston (tie), Joel Godinez (Harris County), website editor

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

VERY SMALL

First Place: Adelaide, Patrick Neumann (Neumann Space), section chair

Second Place: Delaware, Zachary Gent (Northrop Grumman Defense Systems), membership officer

Third Place: Melbourne, Bryan Aherne (consultant), membership officer; Jisoo Jeon (Boeing Aerostructures Australia); Julia Low (RMIT University), communications officer

SMALL

First Place: Wichita, Mary Drouin (Spirit AeroSystems Inc), membership officer

Second Place: Central Coast of California, Matthew Tanner (United States Space Force), membership officer

Third Place: Northwest Florida, Angela Diggs (Air Force Research Laboratory), vice chair; Humberto Ramos (University of Florida), technical officer; Judith Sherrill, education officer; Crystal Pasiliao (Airforce SEEK EAGLE Office), STEM K-12 officer; Sunny Narayanan (Florida State University), young professionals officer

MEDIUM

First Place: Illinois, Andrew Touvannas (Woodward Inc.), honors and awards officer; David Carroll (CU Aerospace LLC), treasurer

Second Place: Greater Philadelphia, Jonathan Moore (Lockheed Martin Space Systems), vice chair

Third Place: Tucson, Andrew Alexander, membership officer

LARGE

First Place: North Texas, James Sergeant, section chair

Second Place: Northern Ohio, Jonah Sachs-Wetstone (NASA Glenn Research Center), membership officer

Third Place: St. Louis, Alexander Friedman (The Boeing Company), membership officer

VERY LARGE

First Place: Hampton Roads, Richard Winski (NASA Langley Research Center), membership officer; Julia Cline (NASA Langley Research Center), membership officer

Second Place: Los Angeles, Sherry Stukes, membership officer

Third Place: New England, Charlie Wilson, advisor; Shreyas Hegde (Pratt & Whitney), section chair

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

VERY SMALL

First Place: Adelaide, Patrick Neumann (Neumann Space), section chair

Second Place: Delaware, Di Ena Davis, public policy officer

Third Place: Point Lobos, Giovanni Minelli (Naval Postgraduate School), section chair

SMALL

First Place: Palm Beach, Shawna Christenson (Aerospace and Innovation Academy); Kevin Simmons (BLUECUBE Aerospace), public policy officers

Second Place: Northwest Florida, Michael Kelton (U.S. Air Force), public policy officer

Third Place (tie): Long Island, George Kyriakou (BotFactory Inc.), public policy officer

Third Place (tie): Twin Cities, Cristin Finnigan (Northrop Grumman Space Systems), public policy officer

MEDIUM

First Place: Greater Philadelphia, Joi Spraggins (Legacy Bridges STEM Academy Inc.), diversity and inclusion officer

Second Place: Illinois, Mordechai Levin, public policy officer

LARGE

First Place: Northern Ohio, Michael Heil (ML Heil Consulting LLC), technical officer

Second Place: North Texas, James Sergeant, section chair

Third Place: San Diego, Mike Curtin, public policy officer

VERY LARGE

First Place: Hampton Roads, Steven Dunn (Jacobs Technology Inc), public policy officer

Second Place: Los Angeles, Daniel Scalese (University of Southern California), public policy officer

Third Place: Houston, Svetlana Hanson (Metecs), programs officer

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

VERY SMALL

First Place: Wisconsin, Todd Treichel (Sierra Space), section chair

Second Place: Adelaide, Rey Chin (University of Adelaide), university liaison officer

Third Place: Delaware, Nicholas Rogers (Northrop Grumman Defense Systems), STEM K-12 officer

SMALL

First Place: Palm Beach, Kevin Simmons (BLUECUBE Aerospace); Shawna Christenson (Aerospace and Innovation Academy), STEM K-12 officers

Second Place: Northwest Florida, Crystal Pasiliao (Air Force SEEK EAGLE Office), STEM K-12 officer

Third Place: Central Coast of California, Thomas Stevens (Space Launch Delta 30), STEM K-12 officer

MEDIUM

First Place: Illinois, Pamela Greyer (NASA Aeronautics Education Laboratory), STEM K-12 officer

Second Place: Greater Philadelphia, Christopher Reynolds (Lockheed Martin Space Systems), STEM K-12 officer

Third Place: Antelope Valley, Robert Jensen (Sierra Lobo Inc), STEM K-12 officer

LARGE

First Place: Cape Canaveral, Melissa Sleeper (Holy Trinity Episcopal Academy), STEM K-12 officer

Second Place: St. Louis, Jackie Blumer (Greenville Jr. High School), advisor

Third Place: Orange County, Binay Pandey, STEM K-12 officer

VERY LARGE

First Place: Los Angeles, Arpie Ovsepyan (Herbert Hoover High School), STEM K-12 officer; Ian Clavio (Northrop Grumman Aeronautics Systems), STEM K-12 officer

Second Place: Rocky Mountain, Trip Carter (Lockheed Martin Space Systems), education officer

Third Place: Hampton Roads, Karen Berger (NASA Langley Research Center), STEM K-12 officer; Amanda Chou (Air Force Office of Scientific Research), STEM K-12 officer

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

VERY SMALL

First Place: Adelaide, Rey Chin (University of Adelaide), university liaison officer; Michael Evans (University of South Australia), university liaison

Second Place: Melbourne, Kaustubh Dongre (Boeing), student branch liaison

Third Place (tie): Wisconsin, Todd Treichel (Sierra Space), section chair

Third Place (tie): Point Lobos, Giovanni Minelli (Navel Post Graduate School), chair

SMALL

First Place (tie): Palm Beach, Kevin Simmons (BLUECUBE Aerospace), STEM K-12 officer

First Place (tie) Northwest Florida, John Fay (Torch Technologies), education officer

Second Place: Wichita, Linda Kliment (Wichita State University), education officer

Third Place: Central Coast of California, Kyle Bezio (California Polytechnic State University), student branch liaison; Cassandra Herrera (California Polytechnic State University), student branch liaison

MEDIUM

First Place: Illinois, Laura Villafañe Roca (University of Illinois at Urbana-Champaign), section chair; Matthew Brotnow (University of Illinois at Urbana-Champaign), student branch chair

Second Place: Tucson, John Allen (University of Arizona), student branch liaison

Third Place: Greater Philadelphia, Jonathan Moore (Lockheed Martin Space Systems), vice chair

LARGE

First Place: North Texas, Jason Daugherty (University of Texas at Arlington), student branch president; Kevin Debord (University of Texas at Dallas), student branch president

Second Place: St. Louis, Mark Kammeyer (Boeing Test & Evaluation) education officer

Third Place: Northern Ohio, Aaron Hensley (NASA Glenn Research Center), university liaison officer

VERY LARGE

First Place: New England, Charlie Wilson, advisor; Shreyas Hegde (Pratt & Whitney), section chair; James Wetzel (Charles Stark Draper Laboratory Inc.), young professionals officer; Anoop Kiran, student branch liaison

Second Place: Rocky Mountain, Lynnane George (University of Colorado at Colorado Springs), outreach officer

Third Place: National Capital, Steven Brunetto (Booz Allen Hamilton), vice chair of operations

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

VERY SMALL

First Place: Delaware, Taylor Coleman, young professionals officer

Second Place: Adelaide, Daniel Kilonzo (University of Adelaide), vice chair

Third Place: Melbourne, Kaja Antlej (Deakin University), section chair

SMALL

First Place: Twin Cities, Kristen Gerzina (Northrop Grumman Defense Systems), section chair

Second Place: Palm Beach, Karl Roush (Georgia Institute of Technology), young professionals officer

Third Place: Northwest Florida, Sunny Narayanan (Florida State University), young professionals officer

MEDIUM

First Place: Greater Philadelphia, Jamil Grant (NDI Engineering), section chair

Second Place: Antelope Valley, Joseph Piotrowski (NASA Armstrong Flight Research Center), young professionals officer

Third Place: Tucson: John Allen, young professionals officer

LARGE

First Place: North Texas, James Sergeant, section chair

Second Place: San Diego, Laine D'Augustine (The MITRE Corporation), council member

Third Place: Northern Ohio, Halle Buescher (NASA Glenn Research Center), vice chair; Santino Bianco (NASA Glenn Research Center), professional development chair

VERY LARGE

First Place: Los Angeles, Luis Cuevas (Lockheed Martin Aeronautics), young professional officer

Second Place: New England, James Wetzel (Charles Stark Draper Laboratory), young professionals officer; Shreyas Hegde (Pratt & Whitney), section chair; Hiroaki Endo (Schenck USA Corporation Test Devices by Schenck), past chair and advisor

Third Place: Hampton Roads, Kyle Thompson (NASA Langley Research Center); Drew Turbeville (NASA Langley Research Center), young professional officers

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

VERY SMALL:

Melbourne, AIAA Melbourne Section Monthly Gatherings. In 2023, the AIAA Melbourne Section organized five hybrid meetings at RMIT University City Campus and online. Each gathering was dedicated to a different topic, presented by AIAA members or external speakers with vibrant Q&A sessions, and attendees both in person and online. The speakers came both from academia (professors and Ph.D. Candidates), industry (international corporations and SMEs), and NGOs. After every event, networking continued at a local restaurant. The following speakers presented at the events: Grace Mei Ing Loke, It Smells Different Up Here – Food Odor Perception and Virtual Reality for Space Applications; Graham Dorrington, RMIT University, Why Support the Return to the Moon?, and Joseph Kenrick, Lunar Outpost Oceania, the Australian Space Agency Trailblazer Lunar Rover Project and the ELO2 Consortium; Alan Sherwood, Senior Structural Analyst, Boeing Aerostructures Australia, The Strange Case of the Phantom Flaperon Flutter; Colin Campbell, General Manager, Applied Fasteners and Tooling (AFT), Our Journey Into Space; and Art Cotterell, University of Adelaide, From Space Debris to Space Resources: Contemporary Issues in Space Law.

Southern New Jersey, Southern New Jersey Professional Societies Awards Banquet. The Southern New Jersey Professional Societies Annual Awards Banquet is held in partnership with other professional societies, including the AIAA Southern New Jersey Section, IEEE, and NSBE to recognize the accomplishments of the talented aviation professionals in South Jersey. The 30 November 2023 awards ceremony included a keynote address by Bruce Webb of Airbus Helicopters. His speech on "Flying Blind" highlighted how humans may not perceive all the information available and how this contributes to aviation accidents and what can be done to mitigate this hazard. Award nominees were recognized, and awards were presented for Outstanding Engineer or Scientist, Outstanding Aviation Research, Outstanding Technical Leadership, Outstanding Contributions to Test or ATC, and Outstanding Young Professionals.

Wisconsin, Rocket Science for Future Engineers. The AIAA Wisconsin Section has leveraged the talent of its members to provide a variety of outreach opportunities for precollege-aged students, including hands-on demonstrations, visual aids, and real-life spaceflight examples. Bringing precollege-aged students face-to-face with space-related science, designed hardware, technology, and its potential benefits increases interest in aerospace and space-related fields, inspiring students to pursue a STEM degree at university, followed by an aerospace career. The goal of the Advanced Rocket Science for Future Aerospace Engineers special initiative was to reach an underserved demographic using tools from AIAA and NASA's directorate for STEM outreach. In spring 2024 the section served a total of 16 students consisting of 4 females, 12 males, and 50% of this group were African American.

Delaware, Joint Speaker Exchange with Mid-Atlantic Section. The AIAA Delaware and Mid-Atlantic sections hosted a speaker exchange, where each section sponsored a speaker to present a topic at a dinner meeting for members of both sections to join. It was hosted at a location central to both membership areas.

SMALL:

Palm Beach, SmallSat Education Conference. The SmallSat Education Conference, held at NASA Kennedy Space Center, is a dynamic event that brings together aerospace professionals and students to network, share knowledge, and collaborate on innovative projects. This conference serves as a pivotal platform for fostering connections between seasoned industry experts and the next generation of aerospace engineers and scientists. Participants at the conference engage in a variety of activities, including keynote speeches from leading aerospace professionals, technical workshops, and panel discussions. These sessions cover a wide range of topics related to small satellite (SmallSat) technology, offering insights into the latest advancements, challenges, and future trends in the field. Students have the unique opportunity to present their own SmallSat projects, receiving feedback and mentorship from experienced professionals. This interaction not only enhances their technical skills but also provides valuable industry exposure and career guidance. The SmallSat Education Conference is a cornerstone event that nurtures talent, encourages collaboration, and drives the future of aerospace technology.

Central Coast of California, 39th Annual Central Coast STEM Exposition. The 39th Annual Central Coast STEM Expo, held 3-4 May at Lompoc High School, supported 172 projects and over 200 students with the aid of over 60 judges and volunteers from across Vandenberg Space Force Base. Over $1,700 in cash and plaques sponsored by local professional organizations and companies were awarded to the top scoring students at the awards reception attended by over 300 students, parents, teachers, and administrators. On Saturday, 4 May, two local FIRST Robotics Competition (FRC) teams from Arroyo Grande and Santa Ynez High Schools demonstrated their current robots to attendees. Also present were members of Darth Vader's 501st Legion in full costume regalia for photo ops. A partnered team of contractors, professional organizations, school district representatives, and base personnel come together annually to make this event a success. It was a great successful team effort between the base and the Lompoc Unified School District!

Northern New Jersey, Careers in Aviation. On 29 January 2024, the AIAA Northern New Jersey Section participated in the Careers in Aviation event for high school students, sponsored by the Morris Hills Regional District Aviation Program. 200 students and parents attended the event, where approximately 19 organizations set up tables and displays to discuss various career opportunities within the aviation industry. The

AIAA Northern New Jersey Section had volunteers available to discuss aerospace, AIAA benefits, and what could students consider doing at the different phases of their education, and at least 50 students visited to engage in conversations. The section provided trinkets including Career in Aerospace brochures, student membership flyers, stress balls, pencils, stickers, and magnet clips. Volunteers also met up with a few professionals that they have previously engaged with at other events. The Morris Hills Regional District Aviation Program is in its infancy, and this was their first career event.

Sydney, Canberra Airport Open Day. Canberra Airport Open Day is a community event that brings about 35,000 people over a day, mostly families. This year they had an incredible number of teenagers and tweens coming and talking to our members, three of whom are university professors and one hypersonics Ph.D. student. The professors talked to the students and gave them quality advice on their studies and future, engaging their parents as well. The section counts it as an outstanding event on the grounds of K-12 STEM Engagement, young people reached with career and study advice, and membership outreach with educators.

MEDIUM:

Illinois, AIAA UIUC Freshman Conference. The AIAA UIUC Freshman Conference, serves multiple purposes as it welcomes new students to the exciting world of aerospace engineering (AE); the AIAA organization, its values, its purpose and its history; the University of Illinois Urbana-Champaign campus and resources; and the cohort of students that are part of the world of aerospace engineering. It is an essential event for student member recruiting. During this daylong event, students participate in talks by faculty and senior AE students, all members of AIAA, and are given lab tours and engage in hands-on activities, airplane competitions, CAD workshop, and tech project demos. Social events are also part of the schedule, which concludes with a movie night. This is a beautiful day, the first of four years, in which freshman students are given a sense of belonging to the community they chose to embrace, and AIAA is the host organization. The AIAA Illinois Section Chair, also UIUC faculty, is always one of the keynote speakers. In the last years, this event has evolved from a small student-led reception to an event receiving a large amount of time and attention from the section chair, assisting with logistics and ensuring the core values of AIAA are transmitted and the new cohort of students get the best possible presenters during the event.

Antelope Valley, E-Week History Symposium. During this AIAA Antelope Valley event, four speakers presented on relevant history topics: Robert Wetherall - F-16 XL Story; Brian Duddy - Origins of the F-16 Program; James Goodall - An Inside Look at the Blackbird, and Cam Martin - Skyrocketing to Mach Two. The networking aspect of this event is one of its best qualities, where everyone can meet new people and hang around with the speakers

during and after the event. This symposium was held at the local Antelope Valley Community College, who has a long-standing relationship with the section that synergies our events and supports their students.

LARGE

Northern Ohio, Young Astronauts Day. On 18 November 2023, the 29th Annual Young Astronaut Day (YAD) event was held at the Cleveland Public Library's Main Library in downtown Cleveland. Over 150 1st–8th grade students along with over 60 chaperones participated in the Northern Ohio Section's STEM event. NASA's Orion European Service Module (ESM) Integration Office Deputy Manager, Katie Oriti, gave an inspiring keynote address on the Artemis I mission and her personal experiences with the program, including serving as a Mission Evaluation Room (MER) Manager for the mission. She shared footage of the ESM flying around the moon, shots of Snoopy bouncing around in the crew cabin and a final video of the crew module skipping off the atmosphere and safely landing in the ocean. As she explained what it takes to fly the ESM, she used interactive demonstration to teach concepts such as atmosphere skipping, thrust, and gravity led orbits. During the afternoon, the students jumped right into the activity competition inspired by this year's theme, "Powering Through, Earth to Space." The students participated in two different grade categories: Pilots (1st–4th grade) and Mission Specialists (5th–8th grade). The pilot activities were: Remote Sensing, Landing on the Moon, and Safe Landing. The mission specialist activities were: Powered and Pumped, Lunar Rovers! Best Wheels!, and Lunar Prospector. The students also had the opportunity to learn about the Immaculate Heart of Mary (IHM) Middle School rocket team and their effort toward competing in the NASA Student Launch Initiative. The activities taught the students different science, engineering, and math concepts that relate to real-world applications in the aviation and space industries. YAD was a great success due to the tireless efforts of over 50 volunteers, including many regional engineers, students from local universities, the Akronauts, the Fighting Unicorns, and the IHM Rocket Team.

North Texas, Moon Day STEM Event at Frontiers of Flight Museum, Dallas, TX. The unique STEM Moon Day program seeks to promote and educate young people about aerospace and AIAA. The hangar museum displayed the Apollo 7 command module, a Southwest Airline 737, Vought heritage aircraft, and numerous other exhibits and activities. For Moon Day, the museum hosted STEM activities across the hangar floor and notable aerospace speakers in their auditorium. The section brought a real F-35 sim (courtesy of Lockheed Martin) to Moon Day that was staffed by volunteers and F-35 test pilots. Also featured was their own STEM invention, the Flight Test Range, where kids designed and built their own paper airplanes with the assistance of our members, flew them on the test range to measure time of flight and distance, then computed average flight speed and wrote the computations on their airplane that they took home with them. F-35 test pilots explained the F-35 flying qualities and systems to the kids flying the simulator with parents taking lots of pictures. While waiting in line for the sim, our members engaged the parents and kids in discussions about aerospace careers, education, and opportunities available to them. Boys and girls from different areas and backgrounds attended from all over North Texas and interacted directly with our AIAA volunteers. A strong effort was made to have young women and diverse representation at each station during the event to connect directly with the kids. Role models that look similar to the kids themselves are important to help them visualize an aerospace career. The Society of Flight Test Engineers (SFTE) & Society of Experimental Test Pilots (SETP) are co-sponsors/participants.

St. Louis, F/A-18 E1: From the Future of Naval Aviation to Nearly Forgotten Relic. This dinner meeting at the St. Louis National Museum of Transportation (NMoT) was a celebration of the historic achievements of the F/A-18 E/F flight test program, as well as the recent addition of the F/A-18 E1 flight test aircraft to museum. Attendees enjoyed the museum displays both inside the hall and outside on the museum grounds where the subject aircraft is sited. The 130 attendees heard a talk by Tim Bischoff, a 40-year Boeing veteran who worked directly on the E1 aircraft as a flight test engineer in the early days of the program. Bischoff described the F/A-18 E/F program genesis and his role in flight testing the E1 aircraft. He explained the significance of the contributions made by the E1 test program to the decades-long success of the overall program, described the fate of the jet once its airframe life was consumed, and narrated the persistent effort necessary to rescue the historic aircraft from destruction that resulted in its display at the NMoT. Many in the audience had personal involvement with the F/A-18 E/F project.

Cape Canaveral, SmallSat Education Conference. In its second year, this two-day event brings together educators, administrators, and students at all levels from K-12 to university for a series of technical presentations, hands-on workshops, exhibitors, an art contest, and more, all centered around the theme of CubeSats and related technologies that enable students and others to access space. The event was held in the Astronaut Memorial Foundation Center for Space Education on the grounds of the Kennedy Space Center Visitors Center. The keynote speaker was Jose Núñez, NASA Kennedy Space Center (KSC) University Partnerships & Small Satellite Capabilities Manager. Numerous exhibitors were present, including NASA's Launch Services Program. Seven workshops were held with topics such as "Introduction to Machine Learning" and "Creating a High Altitude Balloon Program." In conjunction with this event, a separate dinner meeting was held at the Cape Canaveral Space Force Station's Sands Space History Center featuring Northrop Grumman's Jonathan W. Arenberg, Chief Engineer for NASA's James Webb Space Telescope. Personnel from other sections also contributed to the organization of the event.

Orange County, 20th Annual SoCal Aerospace Systems and Technology (ASAT) Conference. The objective of the AIAA Southern California Aerospace Systems and Technology (SoCal ASAT) Conference is to bring together seasoned and new engineers, researchers, leaders, managers, academia and students, and provide a forum to exchange new ideas, review achievements, and chart a new course for aerospace in the local area. The AIAA Orange County (OC) Section highlighted their activities during the past year and honored a few section members in a year-in-review presentation during the included luncheon. Members and nonmembers attended, and a pitch was made for nonmembers to join AIAA during the OC Section presentation, as well as an appeal to members for participation on the council and/or section activities. This year's conference was co-sponsored by the San Gabriel Valley Section, the UCI Student Chapter, and Caltech. With attendance of 114 and 21 presentations in 6 sessions, along with a morning and afternoon keynote, it was hugely successful. Attendance ranged from high school (2 high school students made excellent presentations) and university students to retired professionals and everything in-between.

VERY LARGE:

Rocky Mountain, 11th Annual AIAA Rocky Mountain Section Annual Technical Symposium (ATS). On 21–22 September 2023, the AIAA Rocky Mountain Section Annual Technical

Symposium was held at Colorado State University (CSU). Thanks to the tremendous amount of resources provided by CSU, this was our biggest ATS with 530 participants. There were three keynotes, 14 panel discussions, 80+ speakers, and a student poster session, followed by an evening reception and silent auction to support the AIAA CSU Student Branch. Lt. Gen. John E. Shaw, Deputy Commander, U.S. Space Command, was our lunch keynote speaker, and Lockheed Martin's Director of Technology Acceleration, Colonel Bob Behnken, former NASA astronaut and one of the first SpaceX Crewed Dragon astronauts, was also a keynote. Our over 25 sponsors hosted students at a Meet the Employers event to learn about internships, full-time employment opportunities, organizational culture, fascinating company projects, and anything else you want to know. An award ceremony was also held.

Los Angeles, AIAA LA-LV University Student Branches Mini-Conference 2024. On 23 February, the AIAA LA-LV University Student Branches Mini-Conference 2024 was held. This conference included exciting activities and projects with the AIAA LA-LV universities/student branches, as well as other professionals to help, inspire, guide them, and network together. Students were able to learn more about their student branches and other students involved in aerospace. There was also a Q&A session with a panel of professionals to discuss local aerospace industries and school-life balance, work-life balance, transition to professional life, networking, finding a job, extracurriculars, summer experiences. Students also were encouraged to present papers or posters at this mini-conference.

Greater Huntsville, Rocket City QuizBowl. This year 24 teams consisting of 108 students competed for trophies and 1st, 2nd, 3rd, and 4th place cash prizes of $1000, $750, $500, and $250 at the Rocket City QuizBowl. Teams typically use the funds for travel and registration fees for national tournaments in Chicago and Atlanta, or to defray the cost of study materials. The event was hosted jointly by the AIAA Greater Huntsville Section (GHS) and the AIAA University of Alabama in Huntsville Student Branch. Tournament volunteers included members of AIAA GHS and the AIAA UAH Student Branch, as well as volunteers from local institutions and schools. In addition to bringing the students together with members of the Huntsville aerospace community, the tournament provided an opportunity to remind those planning to major in STEM fields related to aeronautics or astronautics to apply for AIAA GHS's Robert L. Sackheim Engineering, Science, & Math Scholarship and also take advantage of AIAA's free high school student membership.

New England, AIAA New England Honors & Awards Night. The AIAA New England Section organized an Honors & Awards ceremony in May 2024 to recognize our AIAA members' achievements and service to the aeronautics, astronautics, and aerospace industry. Held on 24 May, the Honors and Awards program recognized outstanding recipients in several categories, followed by dinner and a networking reception. In addition to recognizing distinguished AIAA members and their service, the event also provided young professionals and students with an opportunity to build professional knowledge related to fields, organizations, and roles and mingle with members of the professional community with the hope of attracting new members. The speakers included Mark Maybury, Lockheed Martin, and Steve Smith, Principal Director, Engineering, Draper.

CAREER OPPORTUNITIES

Faculty Positions in Hypersonics

Aerospace Engineering Department

EMBRY-RIDDLE Aeronautical University

The Aerospace Engineering Department in the College of Engineering at Embry-Riddle Aeronautical University (ERAU) – Daytona Beach invites applications for several tenure-track positions at all levels (i.e., Assistant, Associate, full Professor). Candidates must hold a terminal degree in engineering, with preference given to those candidates with research expertise in hypersonics and those who hold a Ph.D. in Aerospace Engineering. The State of Florida has made a ground-breaking $26 million investment to establish new hypersonics facilities at ERAU. The selected faculty candidate(s) in hypersonics will have the opportunity and expectation to contribute to the development and operation of these facilities. In addition, the department seeks candidates who will deliver student-centered teaching and provide mentoring to graduate and undergraduate students.

The Aerospace Engineering Department is the largest in the nation with an enrollment of about 2,500 full-time students. The department offers Bachelors, Masters, and Ph.D. degrees, including seventy students in the Ph.D. program. The undergraduate program is currently ranked #4 by U.S. News and World Report, while the graduate program is ranked #32, and our research expenditures have more than tripled over the last five years. Also, the University has invested in a new 50,000 square foot engineering building, the John Mica Engineering and Aerospace Innovation Complex (MicaPlex), housing several research laboratories (**https://erau.edu/research-park/micaplex/labs**), a state-of-the-art subsonic wind tunnel, and a new Flight Research Center facility, all as part of a Research Park with incubator space and growing industry engagement, creating an ecosystem to support innovation and entrepreneurship.

Embry-Riddle Aeronautical University is the world's largest, fully accredited university specializing in aviation and aerospace, with more than 70 Bachelors, Masters, and Ph.D. programs. The Daytona Beach Campus serves a diverse student body of approximately 8,300 students.

For more information about the positions and to apply, please visit **https://careers.erau.edu**, click on the Career Search tab, and search to find requisition R308552. Applicants must submit one single .PDF file that includes the following documents: cover letter, curriculum vitae, teaching interests and philosophy, research plan, a diversity statement, and the names and contact information for at least three professional references.

For full consideration, candidates are encouraged to apply before **October 31, 2024**. Positions will start August 2025. Screening of the applications will start upon receipt and will continue until the positions are filled. Questions about these positions may be directed to Dr. Richard Prazenica, Interim Department Chair, via email at **prazenir@erau.edu**.

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Assistant or Associate Professor

Aerospace Engineering Department

EMBRY-RIDDLE Aeronautical University

The Aerospace Engineering Department in the College of Engineering at Embry-Riddle Aeronautical University – Daytona Beach invites applications for several tenure-track and non-tenure positions at the Assistant or Associate Professor level. Candidates must hold a terminal degree in engineering, with preference given to those candidates who hold a Ph.D. in Aerospace Engineering. For non-tenure positions, a PhD degree could be replaced by an MS and substantial industry experience. Preferred areas of expertise include astronautics and space applications, aerodynamics, propulsion, structures, and materials. However, applicants in all areas of aerospace engineering will be considered. The department seeks candidates who can expand its research expertise in aerospace engineering, as well as deliver student-centered teaching and provide mentoring to undergraduate and graduate students.

The Aerospace Engineering Department is the largest in the nation with an enrollment of about 2,500 full-time students. The department offers Bachelors, Masters, and Ph.D. degrees, including seventy students in the Ph.D. program. The undergraduate program is currently ranked #4 by U.S. News and World Report, while the graduate program is ranked #32, and our research expenditures have more than tripled over the last five years. Also, the University has invested in a new 50,000 square foot engineering building, the John Mica Engineering and Aerospace Innovation Complex (MicaPlex), housing several research laboratories (**https://erau.edu/research-park/micaplex/labs**), a state-of-the-art subsonic wind tunnel, and a new Flight Research Center facility, all as part of a Research Park with incubator space and growing industry engagement, creating an ecosystem to support innovation and entrepreneurship.

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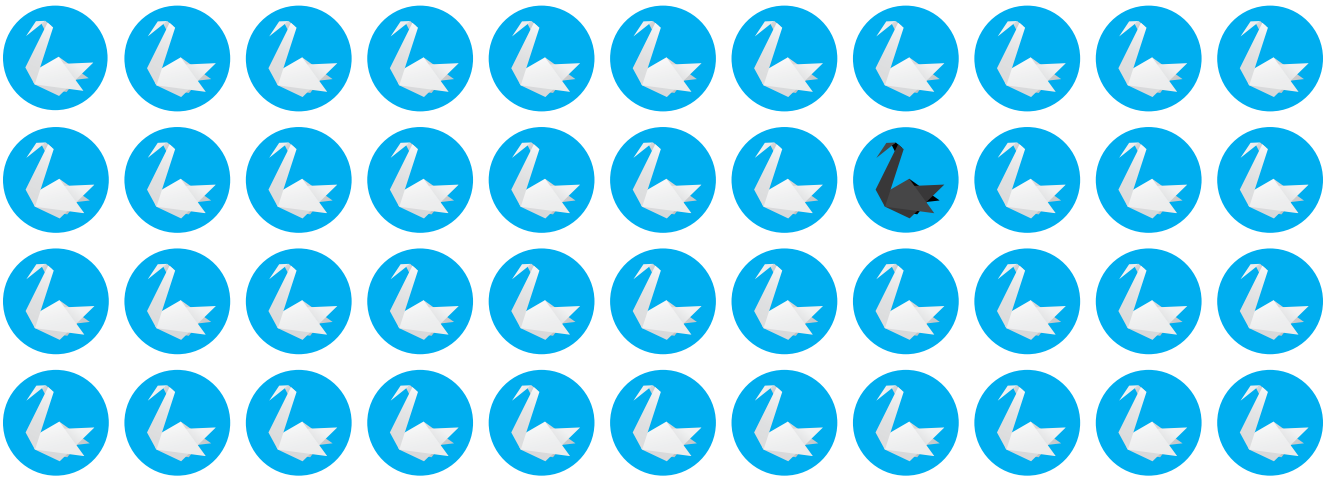

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up to the station aboard a Crew Dragon that at this writing was due to arrive in late September. None of that matters, because in an emergency such as a debris strike, there aren't enough umbilical plugs in the Dragon that's currently docked at the station for Butch and Suni to plug into. They would have to evacuate without suits. This will change when the next Dragon arrives with two fewer astronauts than planned for the station's Crew-9 rotation, creating slots for Butch and Suni to become part of Crew-9.

But suppose there had been enough plugs? The incompatibility of umbilicals would have presented unnecessary risk. NASA got by in this case, but that should not be the takeaway. The incompatibility of the umbilicals means that not all astronauts can ride on any vehicle of choice or need, if it came down to it. The situation faced by Butch and Suni is just a real example of how decisions can stack up to lead to Black Swan events, and there could be others.

This brings to the forefront a critical question: Why was the incompatibility between Starliner and Dragon not foreseen and planned for, or at least considered in the earliest stages of development? The simple answer is unsatisfying: It wasn't a requirement. But that's just another way to state the problem. In NASA's current contracts with its commercial providers, there was no stipulation that spacesuits had to be interchangeable between spacecraft. Nelson referenced the Challenger and Columbia tragedies as cautionary tales in which the culture didn't allow information to rise to the surface. Once again, the culture appears to not have allowed a risk to be voiced and resolved.

The assumption was likely made that a Starliner and Dragon would never be operational at the station at the same time, since the capsules were to alternate missions. It was hard to see a scenario in which an astronaut who came up on one would need to ride back in the other. This is precisely the kind of thinking that opens the door to a Black Swan event. It is not that these scenarios are truly unforeseeable — they were probably ignored because they seemed unlikely, until they happened. Improbable is not equivalent to impossible.

For example, there have been times when I'm in some remote part of the planet and I run into someone I know. When they say, "Gee, Moriba, what were the odds that we'd find each other here?" I reply with, "100%!" Probabilities, when used to model our ignorance, can be dangerous because they are subjective. We're trained to think about so-called three-sigma scenarios, in which we imagine what can be captured by 99% of probable occurrences, but there is still the 1%. Worth noting, too, is that this issue of incompatibility didn't show up randomly but rather systematically. We're quick to attribute uncertainty to randomness and, in the act, set ourselves up to be hit by an unknown but real systematic effects.

Consider the Titanic. Designed as an unsinkable ship, it wasn't the "random" iceberg itself that doomed most of the passengers but the systematic lack of enough lifeboats. This oversight probably came from a belief that the improbable wasn't worth preparing for. For NASA, the lesson seems similar: Be ready for the unexpected. The incompatibility between the spacecraft didn't need to be an issue; there were solutions available, such as standardizing the interface for spacesuits or creating a "power adapter." Yet, none of these appear to have been pursued.

NASA has made progress with its partnerships in commercial spaceflight, but the gaps exposed by the Starliner test highlight a deeper need for standardized protocols across all space systems. Just as travelers carry adapters to deal with different power outlets around the world, NASA should have ensured that astronauts could safely operate and survive on either spacecraft. In this case, the extra risk was dodged, but a simple, well-planned design feature — interoperable spacesuits — could prevent it from arising in future scenarios. If you're in a decision-making position, don't make the mistake of equating improbable to impossible, because your improbability may show up. And when it does, it'll be in the guise of a Black Swan. ★

LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1924

Oct. 1 Dutch pilots Thomassen van der Hoop, Hendrik van Weerden Poelman and Pieter van den Brocke begin their long-distance flight from Amsterdam to Batavia (now Jakarta, Indonesia). On Oct. 4, they make a forced landing in Bulgaria due to what appears to be engine overheating. They spend about a month waiting for a new engine for their Fokker F.VII monoplane and then resume their flight and arrive in Batavia on Nov. 24. In doing so, they win a 15,000-guilder prize from the Dutch East Indies Society Air Force. **Flight**, Nov. 27, 1924, p. 746. **Aircraft Year Book for 1924**, p. 114.

Oct. 2-4 The International Air Races are held in Dayton, Ohio. The major event, the Pulitzer Cup race, is won by Army Lt. H.H. Mills. He pilots his 1922 Verville-Sperry racer at an average speed of 216.55 mph (348.5 kph). **Aero Digest, Oct. 1924**, p. 227. **Aero Digest, November 1924**, pp. 269-272, 300.

Oct. 14-15 The record for a nonstop seaplane flight is broken by a Douglas S.D.-W scouting plane. Piloted by Navy Lts. Andrew Crinkley and R. D. Lyons, the aircraft remains in the air for 20 hours, 10 minutes and 10 seconds. That's nearly six hours longer than the previous record established by a CS-2 seaplane in July. **Aero Digest, December 1924**, p. 372. **Aircraft Yearbook for 1924**, p. 175.

1 **Oct. 15** The ZR-3 rigid airship arrives at Lakehurst, New Jersey, after crossing the Atlantic with a German crew under the command of Hugo Eckener. One of three German dirigibles constructed for the U.S. Navy under the terms of the Treaty of Versailles, the ZR-3 is later renamed the USS Los Angeles. **Flight**, Oct. 23, 1924, p. 689; NASA, **Aeronautics and Astronautics, 1915-1960**, p. 18.

Oct. 24 German pilot Karl Lesch sets distance and speed records at Sund, Denmark. His Rohrbach Flugboot Typ RO II all-metal seaplane travels 684.64 miles (1,101.82 km) and averages 94.736 mph (152.335 kph) on the 1,000-km flight. **Aircraft Year Book for 1924**, p. 175.

Oct. 25 The rigid airship USS Shenandoah, commanded by U.S. Navy Lt. Cmdr. Zachary Lansdowne, lands at the Naval Air Station in Lakehurst, New Jersey, completing a round-trip transcontinental cruise that began on Oct. 7. The 15,000-km trip included stops in Fort Worth, Texas, and San Diego, plus a stay of 11 days on the West Coast, including a flight to Camp Lewis at Tacoma, Washington. **U.S. Naval Aviation, 1910-1970**, p. 56.

Also during October French pilot Jean Callizo breaks the world's altitude record. The barograph of his Gourdou-Lesseure monoplane registers a height of 11,000 meters, but after calibration by the Conservatoire des Arts et Metiers, this is raised to 12,066 meters (39,587 feet). The previous record of 11,145 meters was set in 1923 by Joseph Sadi-Lecointe. **The Aeroplane**, Nov. 5, 1924, p. 432.

1949

Oct. 1 The U.S. Department of Defense activates the Long Range Proving Ground at Cape Canaveral, Florida, under the command of Air Force Maj. Gen. W. L. Richardson. Under an agreement among the British, Bahamian and U.S. governments, tracking stations are later set up on Grand Bahama, Eleuthera, Watling, Mayaguana and Turks Island. L. G. S. Payne, **Air Dates**, p. 407; NASA, **Aeronautics and Astronautics, 1915-1960**, p. 62.

2 **Oct. 14** Chase Aircraft Co. test pilots complete the first flight of the experimental XC-123 assault transport at West Trenton, New Jersey. The production version, the C-123 Provider built by Fairchild Aircraft, is later used extensively by the U.S. Air Force to transport supplies to remote base camps during the Vietnam War. A later variant included the addition of two General Electric J85 wing-mounted turbojets to improve takeoff and load capability. **Aircraft Yearbook for 1949**, p. 345.

Oct. 25 A de Havilland Comet, the world's first jet airliner, completes a round trip between London and Castel Benito, Tripoli. This is the design's first overseas demonstration flight, meant to measure fuel consumption under simulated airline operations. The Comet averages 725 kph during the 4,785-km flight. The trip to Tripoli takes 3 hours, 23 minutes; the return to London is 3 hours, 15 minutes. A.J. Jackson, **De Havilland Aircraft Since 1909**, p. 453.

Oct. 27 The U.S. Congress passes the Unitary Wind Tunnel Act, authorizing the construction of $136 million worth of new NACA facilities. This comprises $10 million in grants for wind tunnels at universities; $6 million for a wind tunnel at the David W. Taylor Model Basin in Carderock, Maryland; and $100 million to build the Air Force's Arnold Engineering Development Center in Tullahoma, Tennessee. **Aviation Week**, Oct. 10, 1949, p. 13; NASA, **Aeronautics and Astronautics, 1915-1960**, pp. 62-63.

3 **Oct. 28** Martin test pilot O. E. "Pat" Tibbs completes the first flight of the prototype Martin XB-51 trijet bomber, flying from the Martin plant in Middle River, Baltimore, to the Naval Air Test Center in Patuxent River, Maryland. The two-seat XB-51 has three General Electric J-47 engines, a T-tail and swept wings with variable angle-of-incidence for takeoff and landing. Although the design is passed over by the U.S. Air Force in favor of the B-57 Canberra, test flights continue until this XB-51 and the second prototype crash. **Aviation Week**, Oct. 3, 1949, pp. 12-13.

1974

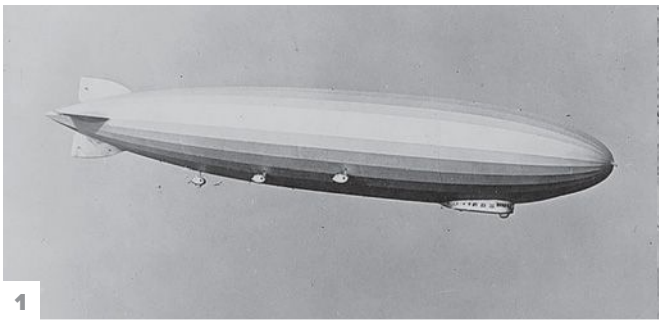
Oct. 1 Cosmonauts Pavel Popovich, Yuri Artyukhin, Gennady Sarafanov and Lev Dyomin receive the Order of Lenin, the Soviet Union's highest honor. Popovich and Artyukhin are honored for their July flight to low-Earth orbit, in which they became the first and only crew to dock with the Salut 3 space station. Sarafanov and Demin are recognized for their Soyuz 15 flight in August, during which they experimented in maneuvering and rendezvousing with Salyut 3. A spacecraft malfunction prevented them from docking with the station before landing under parachutes in Tselinograd, now the capital of Kazakhstan. NASA, **Aeronautics and Astronautics, 1974**, p. 181.

Oct. 1-7 Astronaut-physician F. Story Musgrave with Dennis Morrison of NASA's Bioscience Payloads Office spend a week in a mock-up of Spacelab, the orbital laboratory in development by the European Space Agency. The tests at NASA's Johnson Space Center in Texas are to evaluate operational procedures and experiments for flight crews and space shuttle ground support. Musgrave and Morrison also complete biomedical demonstrations representative of on-orbit medical experiments. **JSC Roundup**, Oct. 11, 1974, p. 1.

Oct. 5 The New York Times reports that scientists at the Arecibo Observatory in Puerto Rico have discovered a pulsar orbiting a companion celestial object in the constellation Aqila, a first for astronomy. Both the pulsar and the object weigh as much as the sun but are only a few kilometers in diameter. **New York Times**, Oct. 5, 1974, p. 50.

Oct. 10 Western Union Telegraph Co.'s second satellite, Westar 2, is launched by a Thor-Delta rocket. The satellite is later placed into a geosynchronous orbit as part of a communications network for voice, TV and data-transmitting services throughout the continental U.S., Alaska, Hawaii and Puerto Rico. **NASA Releases** 74-147 and 74-265.

Oct. 11 A modified Piper Seneca aircraft completes the first test flight of a new wing design for general aviation aircraft. Developed at NASA's Langley Research Center in Virginia, this GAW-1 wing is a derivative of the supercritical airfoil and shows potential for lift increases up to 30% over conventional designs. **NASA Release** 74-227.



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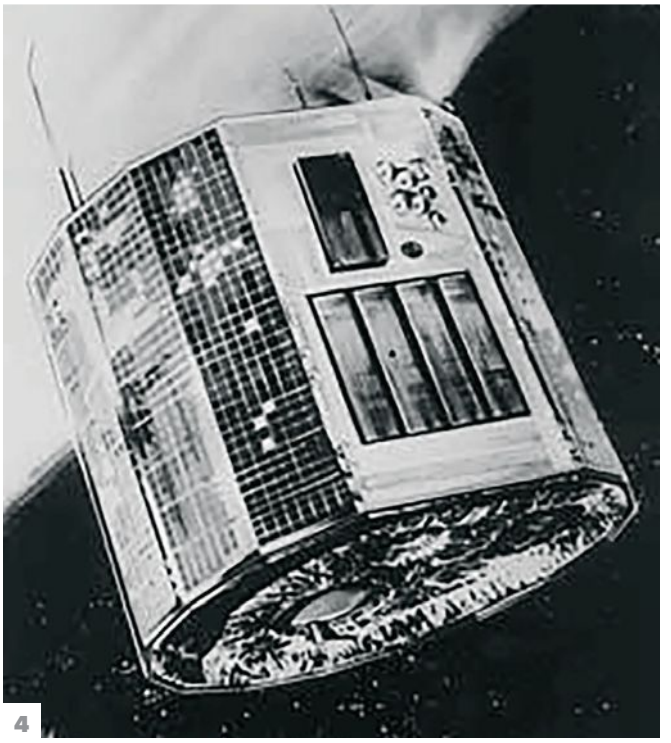

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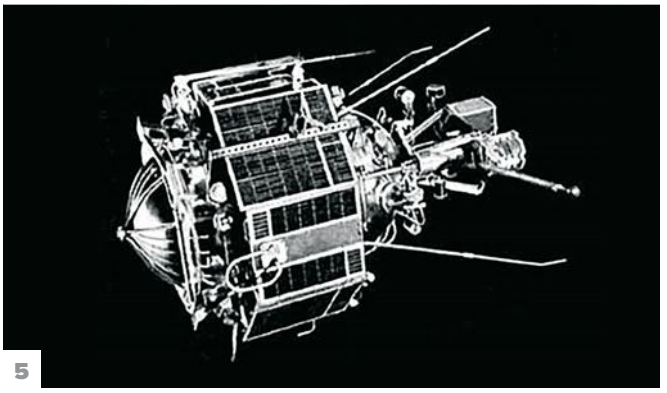

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4 **Oct. 15** The United Kingdom's Ariel 5 satellite is launched aboard a NASA Scout rocket from Italy's San Marco launch facility off the coast of Kenya. The 132-kilogram solar-powered, 16-sided satellite is to spot X-ray sources both within and beyond the Milky Way, and houses five experiments from the U.K. and one from NASA's Goddard Space Flight Center in Maryland. **NASA Release** 74-274.

Oct. 15 Jacques-Yves Cousteau's research vessel Calypso leaves Galveston, Texas, beginning a nine-month voyage of oceanographic and weather experiments for NASA in cooperation with Texas A&M University. Researchers are to measure the chemical content of seawater, temperature, depth factors, water colors and pollutants in different regions for correlation with weather and water appraisals collected by NASA's Ats-3 and Nimbus 5 satellites. **NASA Ames Research Center Release** 74-47.

Oct. 24 The Soviet Union launches its Molniya-1 28 communications satellite. Each of the Molniya series are placed in highly eccentric elliptical orbits that have long dwell times over high latitudes — well-suited for remote multichannel radio communications in polar regions. **Aviation Week**, Nov. 4, 1974, p. 13.

Oct. 27-Nov. 2 The 67th annual General Conference of the Féderation Aéronautique Internationale convenes in Sydney. NASA astronaut Charles Conrad Jr. is presented the FAI Gold Medal for his role in repairing the Skylab space station during the Skylab 2; astronaut Alan Bean receives the Yuri Gagarin Gold Medal for serving as the commander of Skylab 3; and both men also are awarded the De La Vaulx Medal for their successive spaceflight duration records. **National Aeronautic Association News**, December 1994. p. 1.

Oct. 28 The Soviet Union's third lunar sample retrieval, Luna 23, begins with the lander's launch from the Baikonur Cosmodrome. The craft touches down in the southern part of Mare Crisium on Nov. 6 and continues transmission for three days but is damaged and cannot collect any samples. Images taken by NASA's Lunar Reconnaissance Orbiter decades later indicate the lander tipped over on its side. **Aviation Week**, Nov. 4, 1974, p. 13 and later issues.

5 **Oct. 31** The Soviet Union launches Intercosmos 12 to study Earth's atmosphere and ionosphere and the flow of micrometeorites. The satellite carries equipment made by specialists from Bulgaria, Hungary, Czechoslovakia, East Germany and Romania, as well as the Soviet Union. NASA, **Aeronautics and Astronautics, 1974**, p. 195.

1999

Oct. 9 A Zenit rocket lifts off from Sea Launch's marine launch platform, placing a DIRECTV 1-R director broadcast TV satellite in geosynchronous orbit. This is the first operational launch for Sea Launch, a multinational consortium managed by Boeing, after a March demonstration flight with a test article. **Aviation Week**, Oct. 18, 1999, p. 33.

Oct. 12 The Boeing 717-200 enters service with AirTran Airways between Atlanta and Washington, D.C. A derivative of the McDonnell Douglas MD-80, the MD-95 — as the design was originally called — has two BMW/Rolls-Royce 715 turbofans. The aircraft was renamed the 717 after the merger of McDonnell Douglas and Boeing in 1997. Mike Badrocke and Bill Gunston, **Boeing Aircraft Cutaways**, p. 145.

A preventable Black Swan: incompatible tech in spaceflight

BY MORIBA JAH | moriba@utexas.edu

The space industry is no stranger to risk. Every test flight, every mission represents the culmination of thousands of hours of meticulous planning, engineering and collaboration. But as history has shown us, even the smallest oversight can have catastrophic consequences or pose a risk of such consequences. A mission can be marred by what I will loosely label a Black Swan event, a term that comes from a complicated theory but in my field has come to mean a rare occurrence with big consequences that was not impossible to predict.

There was a brush with one Black Swan event in the case of Boeing's Starliner crewed flight test to the International Space Station, and it doesn't have to do with balky thrusters or helium leaks (at least not directly). It has to do with spacesuits.

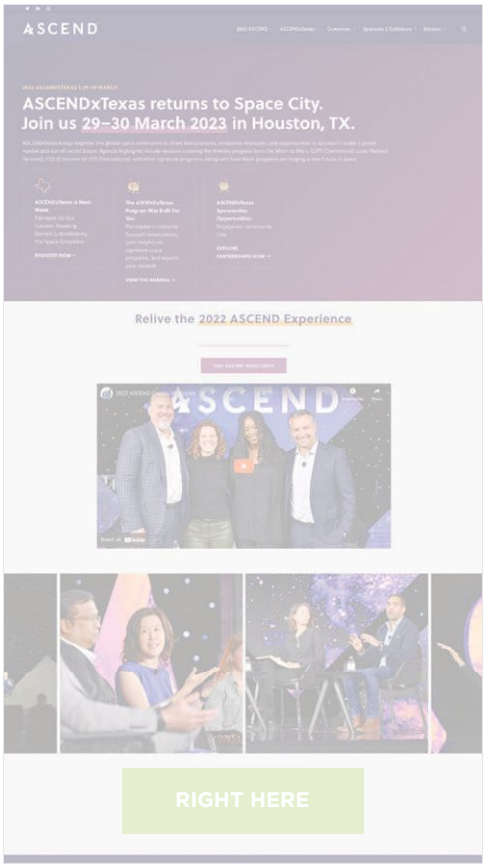
NASA Administrator Bill Nelson announced in August that astronauts Barry "Butch" Wilmore and Suni Williams would return aboard a SpaceX Crew Dragon in February rather than this year on Starliner, an extension necessitated by the limited number of seats and flights up and down from the space station. It was a wise, safety-first approach, even though during Starliner's unoccupied return Sept. 6, the thrusters worked without issue and the capsule made a picture-perfect, nighttime landing in the New Mexico desert as night-vision cameras rolled.

The scenario facing Butch and Suni — two extra crew members on an extended stay — demonstrated another potential risk. When astronauts head home, they wear spacesuits whose umbilicals provide a communications link and are plugged into an emergency supply of oxygen and power in case the capsule depressurizes. The issue? The Starliner and Crew Dragon spacesuits are mutually exclusive. Each Starliner spacesuit could only be plugged into Starliner, and it departed on Sept. 6.

This lack of compatibility highlights a potential Black Swan, although in this particular scenario, the incompatibility was rendered moot by other issues. Aboard the station was one extra Dragon suit that NASA said would fit Suni. A second suit for Butch was scheduled to be brought

CONTINUED ON PAGE 61

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.



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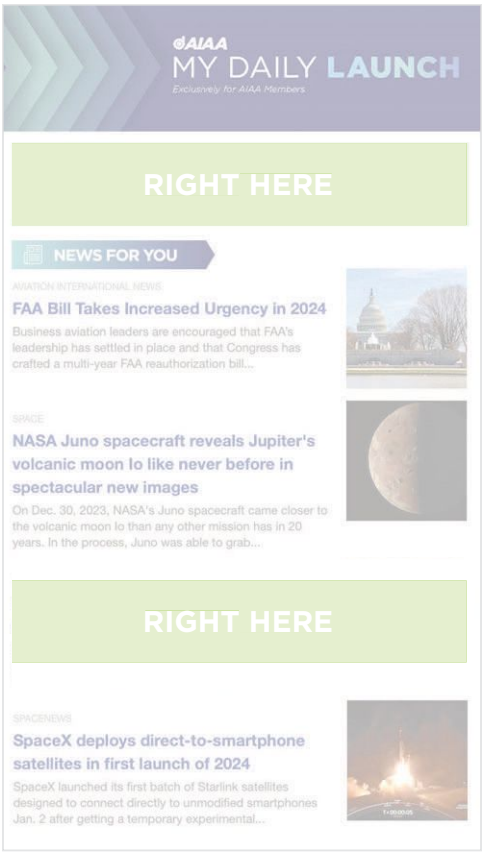

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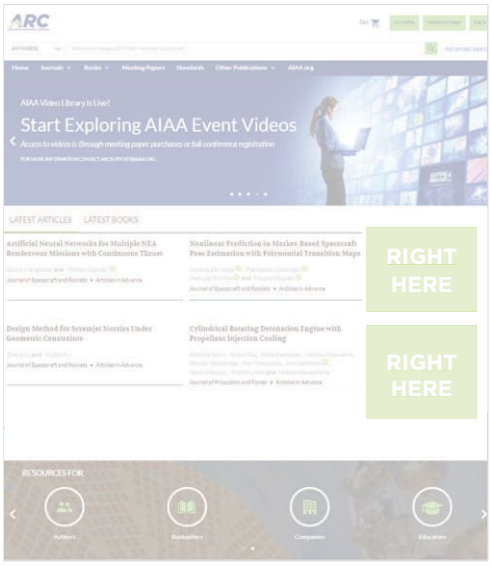

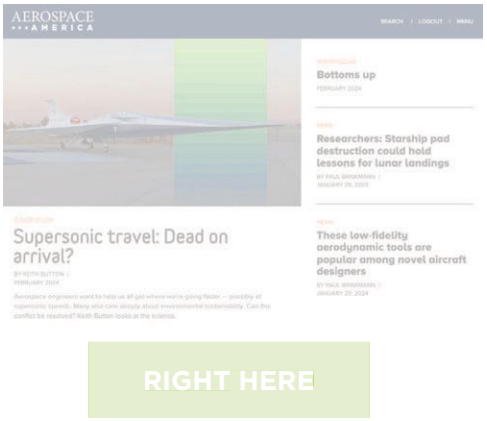

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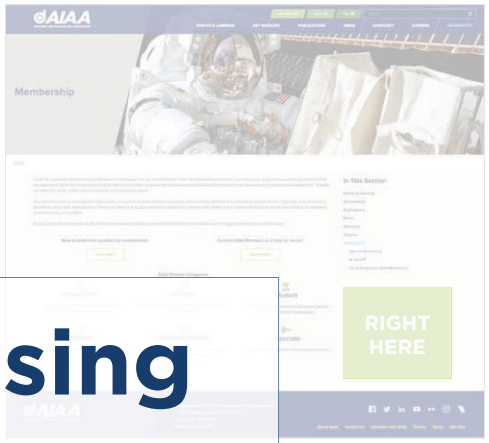

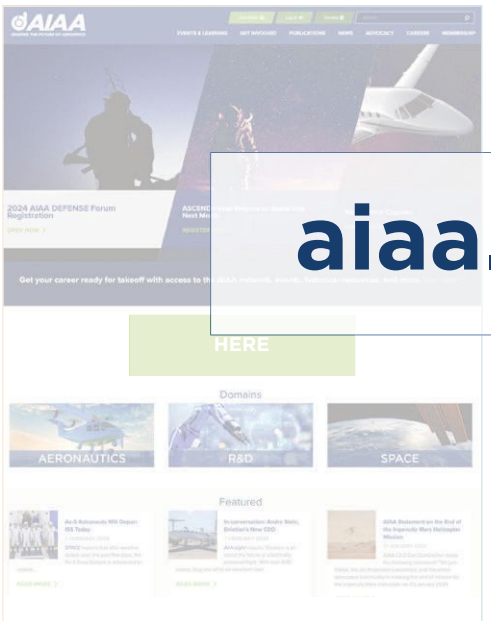

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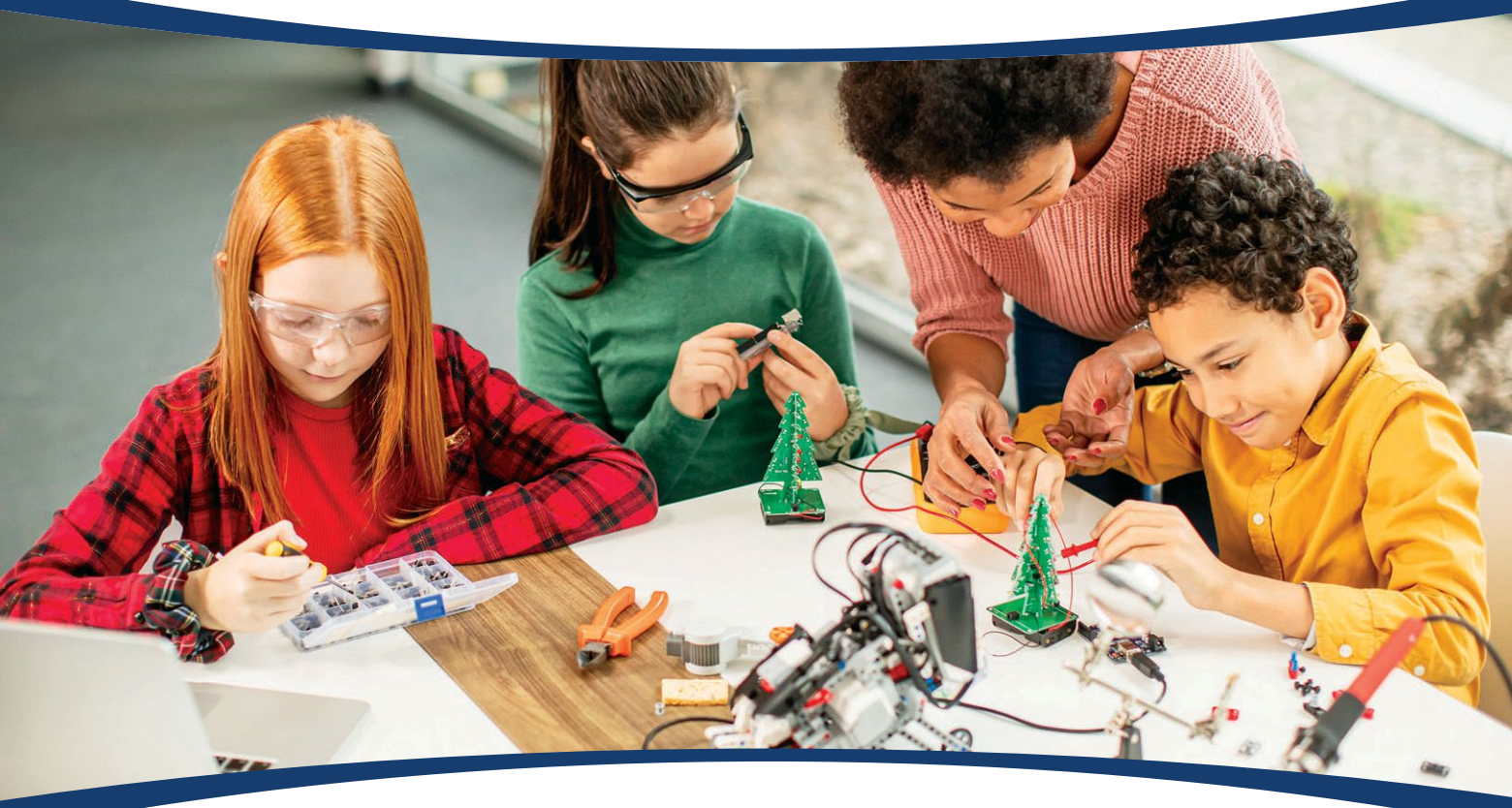

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