Q&A 10
de Crespigny on single-pilot operations

LUNAR EXPLORATION 8
Navigating autonomously

COMMENTARY 44
Is there such a thing as too safe?

AEROSPACE
★ ★ ★ AMERICA ★ ★ ★

Tailor-made

The U.S. and other nations lack enough air tankers to fight wildfires on a hotter, drier planet. Is it time for another clean-sheet design, just as the 1990s gave us the CL-415s? It's an idea that's percolating. PAGE 26

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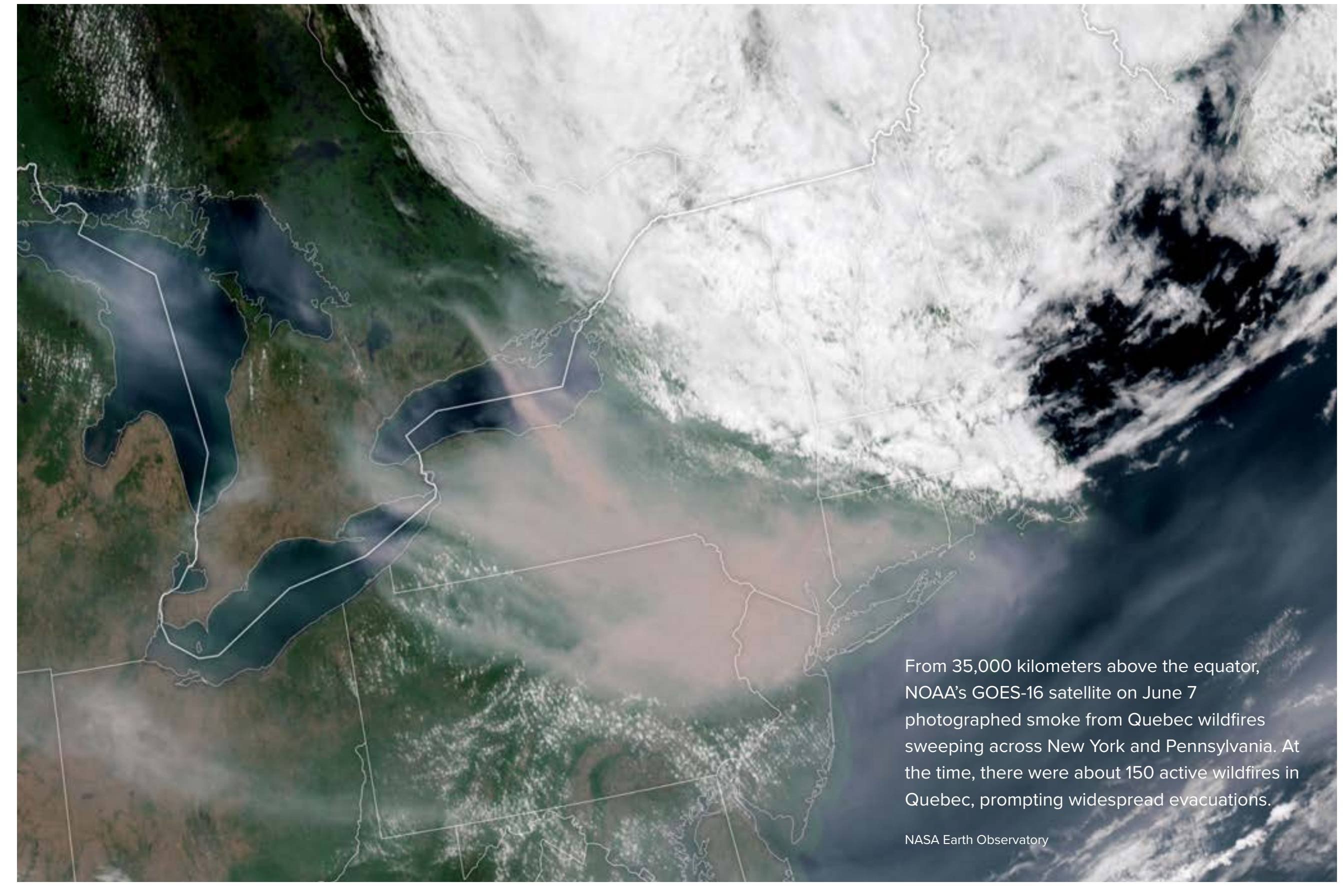
AIAA
SHAPING THE FUTURE OF AEROSPACE



From 35,000 kilometers above the equator, NOAA's GOES-16 satellite on June 7 photographed smoke from Quebec wildfires sweeping across New York and Pennsylvania. At the time, there were about 150 active wildfires in Quebec, prompting widespread evacuations.

NASA Earth Observatory

26
Tomorrow's air tankers

Operators of firefighting aircraft face a choice between refurbished civilian and military planes or clean-sheet designs to bolster their fleets.

By Keith Button

18
Near Space Network 2.0

NASA is poised to select multiple contractors to augment communications and data relay for the coming class of lunar missions.

By Jon Kelvey

34
Waiting for Starship

Technical and legal fallout from April's Starship launch are complicating Elon Musk's prediction that the company can resume flying the design quickly.

By Jonathan O'Callaghan

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IN THIS ISSUE

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PAGE 26

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PAGE 64

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PAGE 34

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PAGE 10

DEPARTMENTS

4 Editor's Notebook
5 For the Record
7 Flight Path
8 R&D
40 Case Study
48 AIAA Bulletin
60 Looking Back

6 AeroPuzzler
Golf balls have dimples, so why not airliner wings?

10 Q&A
Hero pilot de Crespigny on single-pilot ops

44 Opinion
Obsessing over air safety crimps innovation

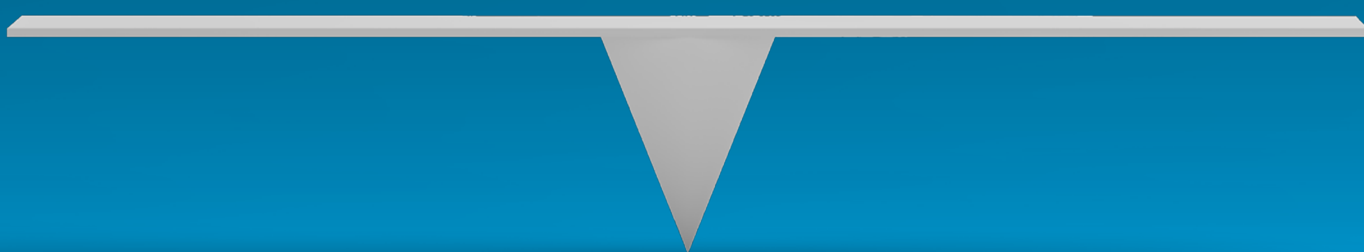
64 Jahniverse
Learning from indigenous communities

AD INDEX

Bastion 5
BWX Technologies .... Back cover
dSPACE 16

EDITOR'S NOTEBOOK

Balancing act: GOVERNMENT vs COMMERCIAL



Lately, most topics we explore in Aerospace America inevitably go to the fluid and sometimes tense relationships between governments and the companies that drive so much of the innovation in aerospace. Rational discussions are needed over the degree and kind of control that governments should exert in a host of areas, including the planned return of Americans to the moon and the growing desire to introduce radically different aircraft to the market. We view our reporting and opinion pages as an essential part of those discussions.

This issue's commentary article, "Safety versus innovation: It's time for a rebalancing," [p. 44] makes the provocative argument that standards for commercial air safety should be lowered to spark innovation. That sounds drastic, but what if doing so leads to aircraft that slash aviation's carbon footprint? Regardless of whether you agree with the author's premise, the argument is presented respectfully and with facts and logic.

Our Q&A with former Qantas pilot Richard de Crespigny [p. 10] offers a more cautious perspective. He and his flight crew managed to save their wounded A380 airliner back in 2010 despite severed wires and damaged computers. He is not a fan of ideas percolating in Europe to permit one pilot aboard large airliners and other crew streamlining steps. "Every critical aircraft system, including the pilots, are duplicated — if not triplicated. That's why we're safe," de Crespigny says.

Turning to space, NASA has placed SpaceX at the center of its plan to return American astronauts to the moon in the Artemis III mission, awarding it a $2.9 billion contract for that mission and $1.5 billion more for the proposed Artemis IV mission. As our story, "Fixing Starship," [p. 34] points out, NASA in 2019 said the Starship pad at the Cape Canaveral site leased from NASA would have a flame diverter, the protective steel apparatus that Elon Musk decided to launch Starship without in Boca Chica, Texas. Environmental groups contend that during the runup to that April test, FAA did not dig deeply enough into the possible environmental consequences of something going wrong. A group of them in May filed a lawsuit demanding a new and deeper environmental study. If that suit has legs, we may be witnessing the beginning of a resetting of FAA's relationship with SpaceX and NASA. It's now largely up to FAA to hold the line against unacceptable risk in the Starship program, given that NASA has so much riding on those rockets to help it achieve the moon landing. NASA has come across as highly protective of its Cape Canaveral site and less so about Boca Chica, given that it did not speak out, at least publicly, about the risks of not having a flame diverter.

On the topic of space communications, NASA also wants to give commercial providers a greater hand in augmenting the Near Space Network, the antennas and satellites that will connect operators and scientists to a growing number of spacecraft in cislunar space. Our story, "Live from the moon in HD," [p. 18] shows the tension between NASA's desire to have its needs met and its desire to leverage the commercial world's knack for going quickly. NASA wants to augment the NSN quickly, but it also insists that the contractors "meet the specific technical acceptability standards" set by the agency.

A better balance needs to be struck between these competing forces, but some tensions might always be inevitable and even desirable. ★

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

FOR THE RECORD

CORRECTION

Our May cover story, "Cosmic jolt," contained an incorrect description of the James Webb Space Telescope's orbit and its advantages. The orbit keeps the Earth, moon and sun behind the telescope, so their infrared energy can be blocked by Webb's sunshield. We also updated the story to specify that NIRCam's detector material is a semiconductor. The online version of the story has been updated.

LET US HEAR FROM YOU

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

The Fourth Industrial Revolution – Digital Transformation

As engineers in the aerospace industry, we are always pushing toward the next horizon, the next frontier, and the next innovation that will unlock value and benefits. Digital transformation is one of the most powerful approaches available today and AIAA believes we should accelerate our use of digital engineering tools across the community.

The Institute is building the foundation for digital transformation in aerospace. One building block is being led by the AIAA Digital Engineering Integration Committee (DEIC) through its series of papers that define terminology, quantify value, and establish references for everyone in the aerospace community.

The community is responding with high energy and interest. We've seen a strong response to the papers, with thousands of AIAA members and nonmembers downloading the papers as they have been released. (See box for download information.) This is a positive signal affirming our focus on digital engineering as part of the AIAA Domain Approach through the Aerospace R&D Domain, currently led by Scott Fouse.

The momentum is building around digital engineering as we witnessed during popular sessions held at both the 2023 AIAA SciTech Forum and the 2023 AIAA AVIATION Forum. During our opening keynote address at AIAA AVIATION Forum, we were privileged to hear from Istari CEO Will Roper (former Assistant Secretary of the Air Force for Acquisition, Technology and Logistics) on digital engineering. We see how his predictions for aviation's and aerospace's digital future can be manifested:

- The industry will have an infinite appetite and applications for aerospace performance data.
- We will use multiple, expanding, and competing approaches for developing and using "digital sources of truth."
- Digital processes will streamline, automate, and lead product development across the aerospace industry.
- Aerospace players will win, lose, and recover digitally.

Dr. Roper also emphasized how the aerospace community can learn from other industries such as Formula 1 racing. We can and must learn rapidly from whomever possible and apply the technologies and skills quickly. Other markets and industries are moving more quickly than aerospace with digital engineering. Aerospace must pick up the pace.

As a natural next step, we will conduct digital engineering sessions built for attendees from civil, commercial, and national security space sectors during 2023 ASCEND, 23–25 October, Caesars Forum, Las Vegas, Nevada. These sessions are part of the powerful program offered at this event, which will provide an opportunity to engage in meaningful dialogue and collaboration with each other, as well as attendees from adjacent industries, on topics that cut across all our projects, programs, and research. It is imperative that these critical discussions continue to evolve for our industry to enhance our competitiveness. Digital engineering is a key method by which we as an industry continue to "work at the speed of the marketplace" and more rapidly and efficiently bring our products to market for the benefit of all.

As the Institute continues supporting and leading our community to adopt digital engineering more broadly, we are grateful for the efforts of the members of the AIAA DEIC and the AIAA Public Policy Committee. They have collaborated with the Aerospace Industries Association (AIA) and the Americas Regional Steering Committee of the International Association for the Engineering Modelling, Analysis and Simulation Community (NAFEMS). We also appreciate the substantial contributions by the International Council on Systems Engineering (INCOSE) Model-Based Systems Engineering (MBSE) Patterns Working Group and the Digital Twin Consortium, a community of the Object Management Group (OMG).

Such collaboration and important partnerships are how AIAA brings forward the crucial value to our industry and society as a whole. ★

Dan Dumbacher
AIAA Executive Director

Papers Available for Download on the AIAA Website

Digital Thread: Definition, Value, and Reference Model
June 2023
aiaa.org/resources/digital-thread-white-paper

Digital Twin: Reference Model, Realizations & Recommendations
January 2023
aiaa.org/resources/digital-twin-implementation-white-paper

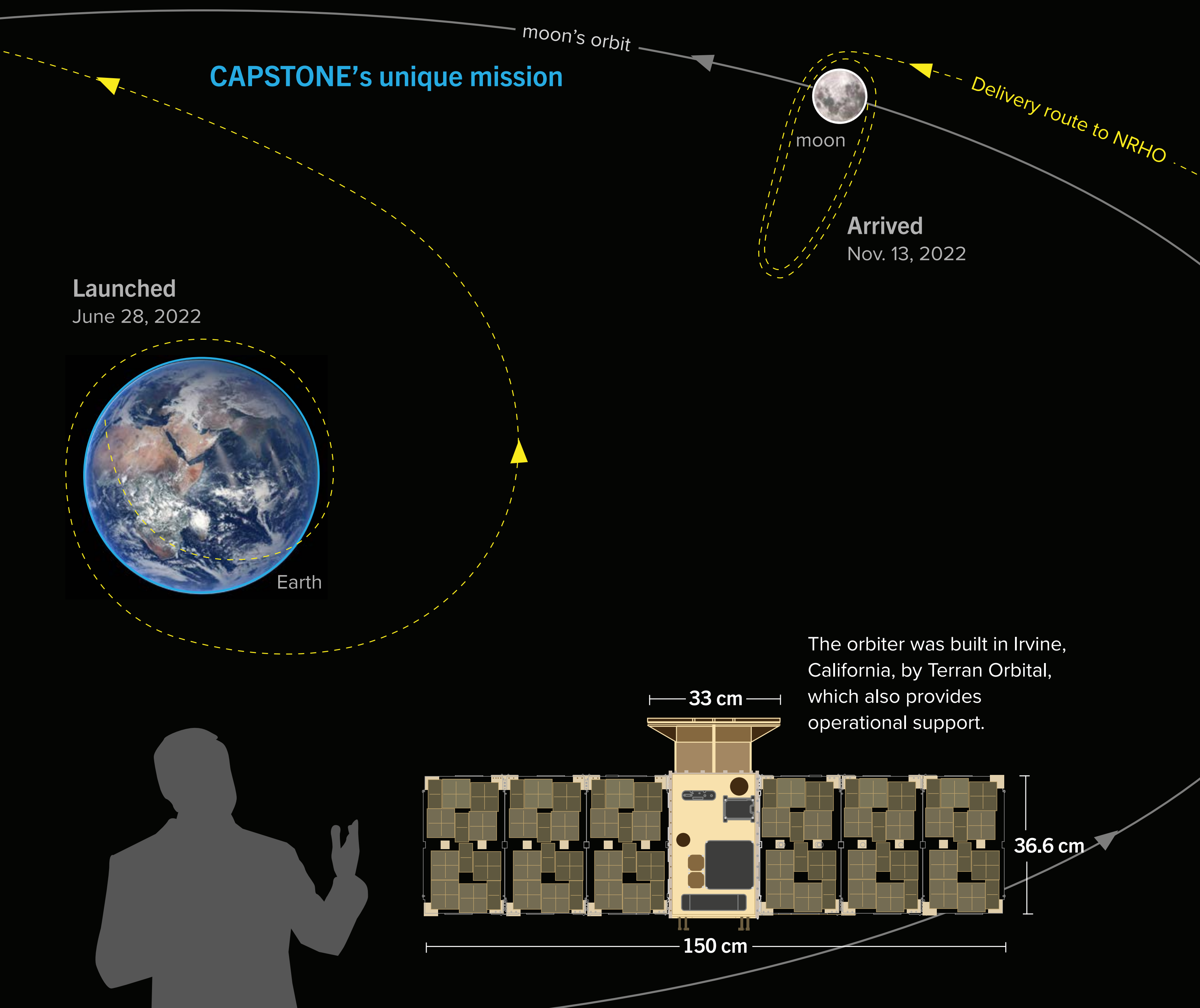
Digital Twin: Definition & Value
December 2020
aiaa.org/advocacy/Policy-Papers/Institute-Position-Papers

Additional AIAA Digital Engineering Resources

Foundations of Digital Engineering – Online Short Course
11–14 September 2023
aiaa.org/events-learning/courses-workshops/detail/foundations-of-digital-engineering-online-short-course

Focus of Gateway experiment shifts to navigation tech

The NASA-funded CAPSTONE satellite in May began a yearlong enhanced mission to test a technique for determining its position without the aid of antennas on Earth, while also continuing to provide lessons about operating in the unusual orbit planned for NASA's Lunar Gateway space station. CAPSTONE establishes crosslinks with NASA's Lunar Reconnaissance Orbiter and deduces position and velocity (estimated states) for itself and LRO relative to Earth. The test partly inspired the name of the satellite and mission: Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment. Accuracy will be judged by comparing the test states to those derived conventionally. Advanced Space of Colorado is in charge of the experiment.

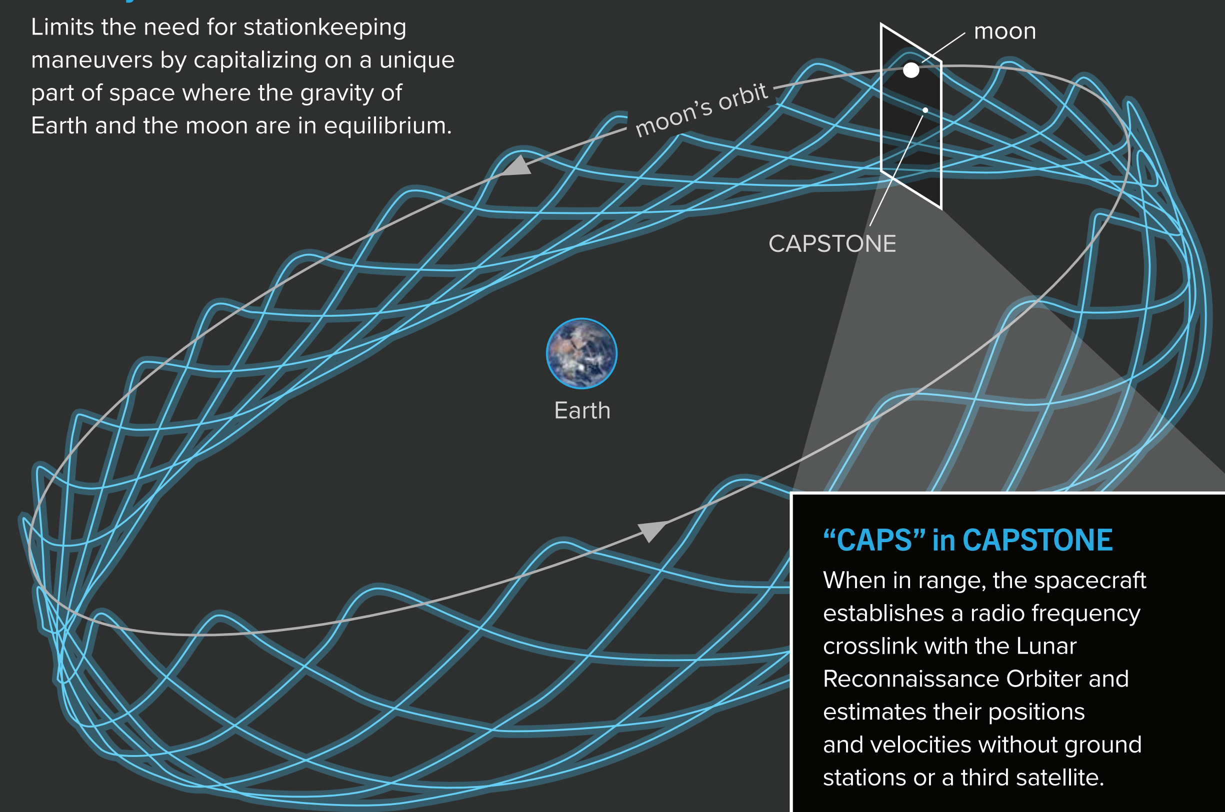


The orbiter was built in Irvine, California, by Terran Orbital, which also provides operational support.

3 benefits for future spacecraft in Near-Rectilinear Halo Orbit (NRHO)

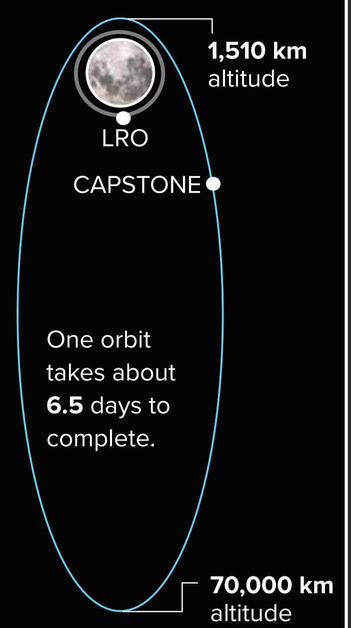
Stability

Limits the need for stationkeeping maneuvers by capitalizing on a unique part of space where the gravity of Earth and the moon are in equilibrium.



"CAPS" in CAPSTONE

When in range, the spacecraft establishes a radio frequency crosslink with the Lunar Reconnaissance Orbiter and estimates their positions and velocities without ground stations or a third satellite.



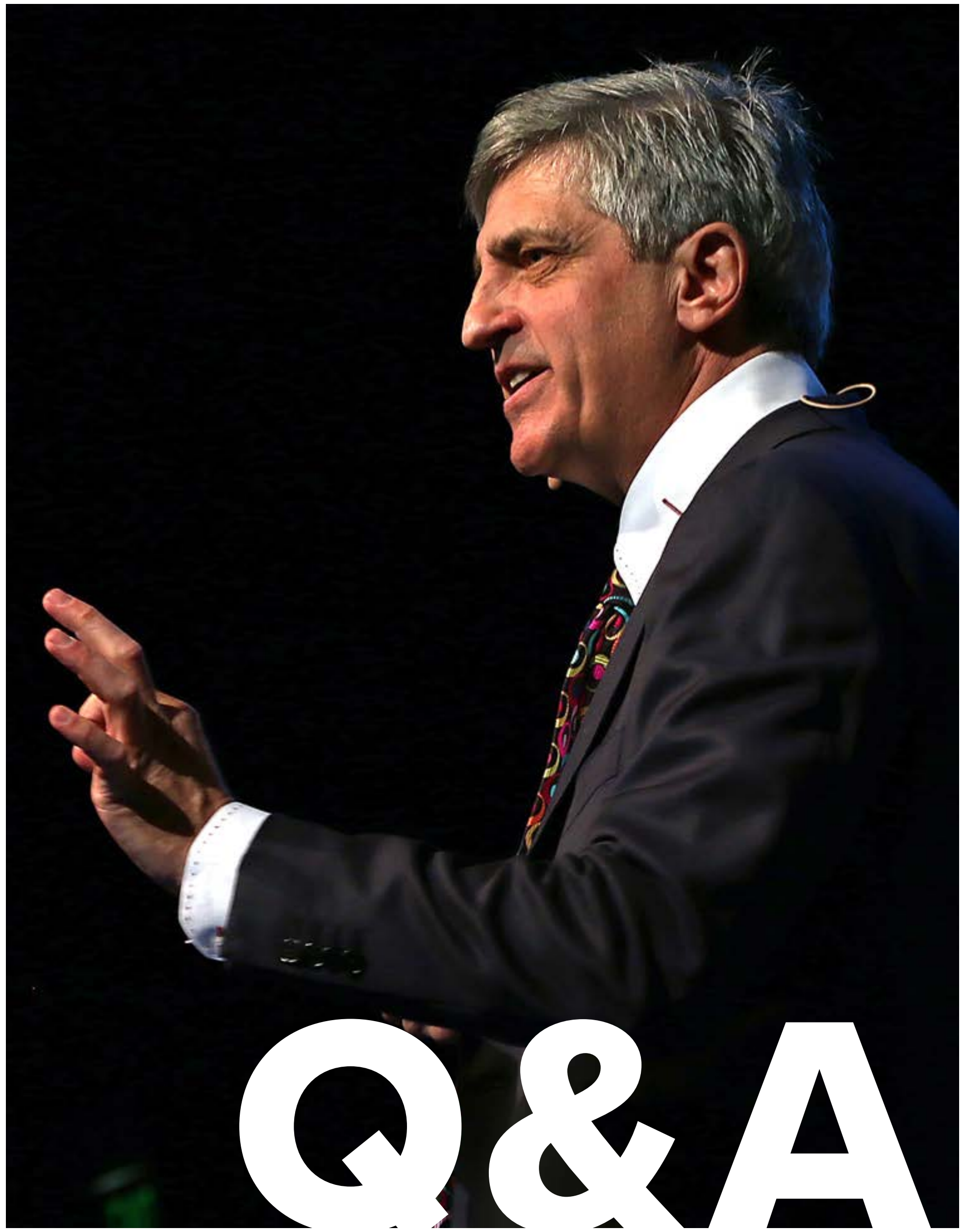
Geometry

Provides almost continual line-of-sight to Earth and extended view of the moon's south polar region, an area of particular scientific interest. Also makes it easier to avoid eclipses and occlusions.

Easy access

Offers frequent opportunities to reach the lunar surface or come back up. Equilibrium makes it easy to head off to other destinations, such as Mars.

Graphic by David Evans, reporting by David Evans and Ben Iannotta
Sources: Advanced Space of Colorado and NASA



Multi-pilot advocate

Former Qantas Captain Richard Champion de Crespigny doesn't believe the safe landing of his heavily damaged A380 airliner with 469 aboard in 2010 could have been accomplished with automation instead of the assistance of his four-person flight crew. That's one reason he opposes ongoing research into reducing the number of pilots aboard passenger airliners. Since 2022, the European Union Aviation Safety Agency and the International Civil Aviation Organization have been studying Extended Minimum Crew Operations, in which two pilots do the takeoff and landing but only one would be at the controls for the cruise phase. EASA originally proposed beginning eMCO in certain airliners in 2025 "as a prelude" to end-to-end Single Pilot Operations (SiPO) beginning in the 2030s, but now says those dates are "unrealistic" and there is "no firm timeline" for either concept. Also, it is now studying SiPO for cargo freighters instead of passenger airliners. I spoke with de Crespigny in April and May. Here are our video conversations, condensed and lightly edited. — *Paul Marks*

RICHARD CHAMPION DE CRESPIGNY

POSITIONS: Since 1987, director of Aeronaut Industries, the Sydney-based software company he founded to create help desk software, among other products, for businesses. 1986-2020, pilot and captain at Australian national carrier Qantas Airways, flying Boeing 747, Airbus A330 and Airbus A380 commercial passenger jets. 1975-1986, pilot with the Royal Australian Air Force, flying the de Havilland Canada Caribou, Aermacchi "Macchi" MB-326H jet trainer and Bell UH-1 Iroquois helicopter.

NOTABLE: Keynote speaker on resilience in crisis situations, especially in aviation. Pilot-in-command of Qantas flight QF32 in 2010, when the A380's inboard left engine shattered due to an oil fire, sending supersonic shrapnel into the plane's left wing, fuel tank and fuselage, endangering the lives of the 469 aboard. De Crespigny and his crew landed the plane after two hours without the aid of much of the plane's automated software. He wrote about the experience and lessons learned from his decades of piloting in his 2012 book, "QF32," and his 2018 book, "Fly! — the Elements of Resilience."

AGE: 66

RESIDENCE: Sydney, Australia

EDUCATION: Bachelor of Science in physics and mathematics, Melbourne University, 1977.

Q: What was your reaction when you first heard that this idea of having a lone pilot at the controls of passenger airliners and cargo jets was being considered?

A: I was amazed that they were even considering it, because it flies in the face of every bit of knowledge and experience gathered over the last 119 years of aviation that have helped make it the safest form of transport. To decide what is required to make any single-pilot operations safe, they need to understand automation, computers, human factors, risk, responsibility, teamwork and trust. And also, how aircraft work. And the best people to ask about all that are the pilots that will be affected. I'm not aware that these organizations have been in cockpits, which have been locked since 9/11, to watch what pilots do. I think it's been motivated simply by airlines that are pressuring the regulators to help shave costs.

The European Union Aviation Safety Agency has not been shy about referring to costs: "A foreseen reduction in operating costs" is among "the driving factors" for considering Extended Minimum Crew Operations and Single Pilot Operations, the agency said at the International Civil Aviation Organization's 2022 assembly. EASA asked ICAO to study how to ensure that such a shift would result in an "equivalent or higher level of safety compared to that achieved in current operations." — PM

Airlines that have budgeted to buy aircraft 10 years in advance haven't budgeted to train or keep their air crews. So a lot of these airlines, coming out of covid-19, are short of air crew. I think this single-pilot idea is a quick tactical fix to solve airlines' strategic failures.

Q: Aviation's post-covid recovery is occurring now, so how can these concepts help when they would be introduced so far in the future? Could there be other drivers?

A: The commercial aviation industry is genuinely curious about the success of drones, which have single pilots, albeit remote ones. Drones are everywhere now, delivering everything from pharmaceuticals to pizzas and parcels. It's a natural succession, then, given the success of the drone industry, that they're curious as to how ultimately we're going to accommodate drone technology in passenger airlines — and yet keep it safe.

Q: One of the premises of eMCO [Extended Minimum Crew Operations] is that one pilot could rest in the cabin or sleep in their bunk while the other is at the controls during cruise, which EASA calls a "less challenging" phase of flight. What do you make of that?

A: EASA is assuming that automation can somehow be as resilient as a second, sentient, human pilot capable of thought, awareness, consciousness and prediction. It's just not the case: Examples abound where automation has been shown not to be at all resilient, and our experience on QF32 was a good example of that. So believing automation is good enough to support eMCO demonstrates ignorance, because automation will never be as resilient as a second pilot — at least, not until we have sentient computers with humanlike intelligence some decades from now.

Q: EASA is proposing that under eMCO, two pilots would be at the helm during system failures, but failures often happen with no notice. So how quickly can a resting pilot come back to full situational awareness to aid the single pilot?

A: When military pilots lose consciousness after experiencing high g-forces, it takes at least 30 seconds for them to come back and be aware of what's going

> "Single-pilot operation breaks the fundamental rule in aviation that every critical system must be replicated for resilience so that there is never a single point of failure. Every critical aircraft system, including the pilots, are duplicated — if not triplicated. That's why we're safe."

on. There's also a thing called sleep inertia, so that when you wake up, it always takes you a while to get your senses back. But it can take up to 20 minutes to get your senses back in an aircraft. So for one eMCO pilot to have a two-hour break — the current eMCO thinking being that two pilots would rotate, two hours on, two hours off — but be called back from their bunk 20 minutes before it is over is ludicrous: Sleep inertia will be a major challenge if the pilot is required [back in the cockpit] quickly because of an emergency, as they will not be coming onboard as an immediately competent pilot. And also, if the automation then fails, you've got a single pilot working with the pilot with sleep inertia — so they're on their own for a critical part of the emergency.

Q: This does not sound terribly encouraging. Do you think the idea behind eMCO has been well thought through?

A: Well, EASA initially said that under eMCO, the single pilot in the cockpit would be allowed to take a toilet break [leaving the automation in control]. Now they're suggesting that's not the case, so their thoughts are changing dynamically.

> *On its website, EASA says one of the topics to be explored under the studies is whether a single pilot could "temporarily leave their station" for "breaks due to physiological needs" while still "ensuring an acceptable level of safety and security." — PM*

Now they're saying they see a pilot having to take a toilet break as being like a malfunction, or an incapacitation, of the pilot. Because now, they don't ever want to have no pilots in the cockpit. This is how little they have thought about it, and this is how mobile the goal posts are.

Q: Regarding end-to-end Single Pilot Operations, EASA has shifted to studying the concept for freighters initially, as opposed to passenger airliners. Is end-to-end flight with one human aboard ever wise?

A: When you're looking at Single Pilot Operations for freighters, then you assume that the automation will take over when the pilot becomes incapacitated. For freighter aircraft flying over the oceans, there'll be no loss of life beyond the pilot because the aircraft can't hit a building, say. So as they experiment, if we imagine that SiPO has the same threat in its probability of failure as eMCO, the difference in risk is the consequence — and the consequence for a SiPO freighter aircraft crashing over water is negligible if a pilot is willing to take that risk.

Q: After initially talking about the late 2020s for introducing eMCO and 2030 for Single Pilot Ops, EASA has done away with the timelines, saying planemakers must demonstrate safety equal to two-pilot operations first. Do you expect automation could entirely replace pilots at some point?

A: Yes. I accept that one day there will be pilotless passenger and commercial cargo aircraft flying — but they will have to have automation based on yet-to-be developed sentient computer systems that can manage it safely. So I don't mind that ICAO and EASA are looking at these eMCO and SiPO schemes, if the automation will support it. They can research anything they like — but don't put an implementation date on it when the technology to enable it does not yet exist. I think it could take 10 years to invent these sentient computers and another 10 years to get them into cockpits.

Q: What role did having two pilots in the cockpit play in achieving the safety levels the flying public has become accustomed to?

A: Aviation has transitioned from initially being the most dangerous to the safest transport system in the world.

> *One hundred fifty-eight people died in commercial aviation accidents worldwide in 2022, the International Air Transport Association reported in March. — PM*

This remarkable improvement in resilience was achieved by the requirement to have two licensed, trained and competent pilots in the cockpit. A problem is that safety, particularly in America where there hasn't been a commercial passenger aircraft crash since 2009, has led people into a false sense of security.

> *He's referring to Colgan Air Flight 3407, in which a Bombardier Q400 approaching Buffalo-Niagara International Airport crashed into a nearby residence, killing all 48 aboard and one person on the ground. The U.S. National Transportation Safety Board concluded that pilots did not react to stall warnings and that their "performance was likely impaired because of fatigue." — PM*

This is the curse of success. People have normalized aviation's incredible safety so much that they've stopped appreciating why it's safe. I had hoped aviation's safety agencies had evolved since the time when we measured safety by the lack of accidents, to identifying the reasons we have become safe, but this latest initiative suggests they don't know what pilots do in the cockpit, so they don't understand why aviation is safe.

◀ During Qantas QF32's brush with calamity, damage to one of the four engines of the A380 (above) ejected supersonic shrapnel that wrecked "half our computer networks" and a litany of other critical components, Richard de Crespigny says. One effect of the damage was that the Electronic Centralized Aircraft Monitor (at left) gave the pilots incorrect instructions.

Australian Transport Safety Bureau

Q: Just what has moved aviation so inexorably to ever safer operations over time, would you say?

A: The industry is moving toward what's called the Safety-II perspective, where we look at the reasons for success to ensure as many things as possible go right, rather than simply ensuring as few things as possible go wrong, as in the past. And if we look at the reasons for success in aviation, there are so many: Modern aircraft are much safer, and terrain and traffic warning systems and fly-by wire-technologies have improved safety. But recent gains in safety have come from the adoption of the field of human factors after the Tenerife airport disaster in March 1977.

> *This collision of two Boeing 747s at an airport in the Canary Islands remains the deadliest in aviation history. A 747 operated by KLM began taking off on a runway in dense fog and crashed into a PamAm 747 taxiing at the opposite end of the runway, killing 583. The disaster prompted changes in cockpit and radio communication*

> "I think it could take 10 years to invent these sentient computers and another 10 years to get them into cockpits."

procedures, including more team-based decision making by crews. — PM

With human factors in aviation, we've learned how humans are built, what they can do, how they respond and how we can build machines to interface to them. And we've had great success with that over the years, and it's not something to be taken for granted because it's not done in many industries. The fact that we're safer has given people a false sense of security, one in which they think they can tamper with things that have made aviation safe.

Q: Are advocates of Single Pilot Operations considering how to progress the idea in a safe and proper way?

A: Firstly, isn't it ironic that the people at ICAO and EASA — who decided they need to work in teams in safe environments on the ground — are deciding on behalf of pilots to take away their team support in high-risk environments in the air? This is arrogance at the highest level. The people pushing single-pilot commercial aircraft don't know what goes on in the cockpit. They don't know what they don't know. Secondly, discussions about Single Pilot Operations must focus on threats, risks and resilience, as technology and security are enemies of each other: One tries to make things happen; the other tries to stop it. Our current technologies are incapable of replacing humans in the cockpit. We need to look no further than Tesla's autopilot, or cybersecurity failures, to realize that computer systems are brittle. Single-pilot operation breaks the fundamental rule in aviation that every critical system must be replicated for resilience so that there is never a single point of failure. Every critical aircraft system, including the pilots, are duplicated — if not triplicated. That's why we're safe. So why are we thinking of breaking that, coming to a single point of failure, with that most critical thing of all: the pilot?

Q: What is it about automation that prevents it from being a human pilot's backup?

A: The key here is that humans are sentient beings. Sentience combines thought, awareness, consciousness and prediction. Sentient computers will be made one day, but they are decades away. Scientists still cannot agree about the definition of consciousness, so coding it up in a computer is a long time away. Large language models like GPT-4 are not sentient.

Q: So in your view, it's safer to have a human crew of at least two pilots, discussing the pros and cons regarding the wisest courses of action in a crisis?

A: If you have a fully functional crew, then you can work your way through the issues, yes. But imagine you only have software in control, and you have an automation disaster like the Qantas flight QF72, which was a failure of the flight computer software in an A330 in stable flight over the Indian Ocean in 2008. Just one faulty computer introduced 42 incorrect stall warnings that commanded many uncontrollable nose-down maneuvers that injured over a hundred passengers. Or our flight, QF32, where 650 wires were cut, affecting 21 of the 22 systems and destroying half our networks. We lost system redundancy and system resilience. Within the fog of these disasters, the only things that got QF72 and QF32 passengers safely to Earth were their crews of many pilots.

Q: Tell me about QF32. It's 10 a.m. local time on Nov. 4, 2010, and you're the captain flying 469 people out of Singapore on an Airbus A380 at 7,000 feet. You have a first officer, a second officer and, unusually, two check captains on the flight deck too. What happened?

A: There were two loud, shuddering booms — a second apart — as the intermediate pressure turbine disc in engine No. 2 exploded into three pieces. Those large pieces in turn energized thousands of supersonic bits of shrapnel into a "cluster bomb" that punctured the wing and fuel tanks in around 15 places, causing 400 impacts on the fuselage and severing 650 wires used for critical systems like the flaps, slats and ailerons. It destroyed half of our computer networks. And our hydraulics went down from eight pumps to two. None of the engines were working normally, either: Engine 2 exploded, the other three degraded down either one or two levels of redundancy but still produced sufficient thrust.

Q: Imagine that QF32 had been a single-pilot operation and the pilot was suddenly incapacitated: How would automation alone have fared at guiding the airliner to a safe landing?

A: We're dead.

Q: Why are you so sure?

A: In the Apollo 13 accident, NASA told Jim Lovell what to do to get back on the ground and how the crew were going to do it, and they did that by creating new checklists in the simulator.

After one of the command and service module's oxygen tanks exploded, mission controllers instructed Lovell, Jim Swigert and Fred Haise to turn their lunar lander into a lifeboat to conserve fuel and electricity in the damaged module. — PM

On QF32, we had no NASA-type support. When David Evans, one of the check captains flying with us, punched into the Airbus laptop computer the failures from 12 different ECAM [Electronic Centralized Aircraft Monitor] checklists to see how we could land, the computer displayed that there was no solution — we couldn't land. Even when David reentered different data that eventually gave us 139 meters of runway margin, independent aircraft warning systems shouted "speed" and "stall" warnings during our approach that proved this second set of speeds and calculations were wrong.

Q: Not what you want to hear with 469 adults and children aboard a double-decker superjumbo out over the ocean.

A: Right. But this was not a normal situation. So many sensors had been broken that the aircraft didn't know shrapnel had cut all wires to the left-side wing brakes. And it could not detect or mitigate multiple holes in the wing that damaged its ability to provide lift. But despite these warnings, I persisted with the approach because we did control checks that proved the aircraft safe — even though we had only a 3-knot margin between stalling or overrunning the runway. Control checks were not written in any airline or Airbus manuals, but we did them because, unlike ECAM [the software that tracks performance], we humans were aware of the wing damage and predicted there could be problems.

Q: You've written in your books that you and your crew were bombarded with a blizzard of erroneous computer messages. What kind of flawed advice were the computers giving?

A: We had many extensive fuel leaks, and because there are not enough sensors in the fuel system to tell us what was wrong and incorrect ECAM logic, ECAM told us to transfer fuel from the good wing into the leaking wing — and that would have spoiled our day. We refused to do those checklists. We also received incorrect warnings about hydraulics and brakes. Dr. Thomas Enders, the chief executive of Airbus at the time, later wrote to me apologizing for the faulty ECAM logic.

Q: Switching gears: Has your experience running a software company helped you as a pilot as cockpits became increasingly computerized?

A: Absolutely, because aircraft are full of black boxes. And if you can understand the logic of how they're meant to work, if you understand computing, you can understand the way they approach the subject.

Q: In closing, what's your message to those pushing for Single Pilot Operations, whether it is by 2030 or later?

A: Think again. It's fine to do disruptive research, but it's naive to publish implementation dates. You need to talk to the pilots because unless you're a pilot sitting in the cockpit when things go wrong, seeing and feeling the things that do go wrong — and they go wrong all the time — you have no idea what the pilots do and why they need as much support from their team in the air as the single pilot operations researchers get from their teams on the ground. You should not degrade safe systems if you don't understand why they are safe. Single Pilot Operations with today's technologies are not just wrong, they are dead wrong, and no safety authority, manufacturer, airline, pilot or passenger should support it. ★

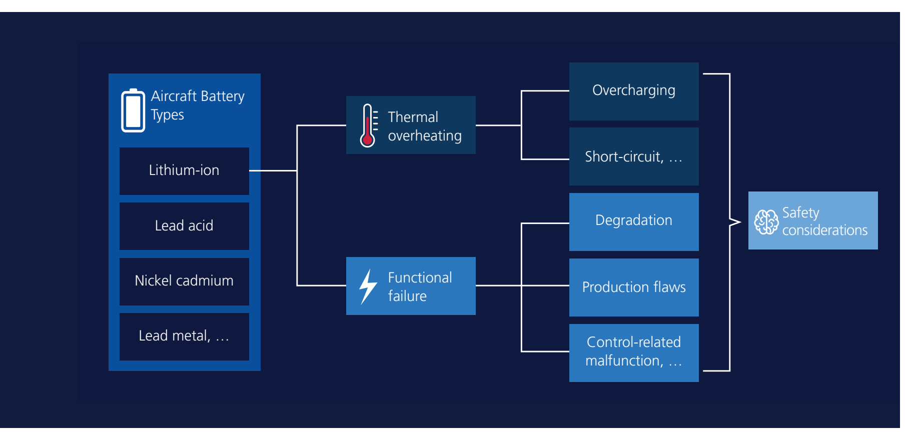
 dSPACE Inc.

Using HIL Systems for BMS Testing to Their Full Advantage

Novel concepts for aircraft electrification are introducing the most profound technological changes in the aerospace industry in decades. In this context, batteries play a key role for storing energy onboard aircraft. In-depth testing of battery systems using hardware-in-the-loop test environments is essential for ensuring reliable and safe aircraft operation.

BY SOEREN REGLITZ AND LUKAS KLESPE

Different types of battery chemistry have been used for aerospace applications in the past. Thanks to recent technological advancements that have led to an increase in performance metrics, the industry is currently focusing on the application of lithium-ion batteries. This also requires additional consideration of potential sources of error such as functional failure, e.g., as a result of degradation, as well as thermal overheating, e.g., due to overcharging (see Figure 1). Consequently, additional safety measures must be established to ensure continuous operation of safety-critical functions onboard aircraft.



▲ Figure 1: Potential sources of error in lithium-ion batteries.

To achieve this goal, lithium-ion batteries are controlled by battery management systems (BMS). The BMS continuously monitors the state of health and controls charging and discharging of the battery. Hence, verification and validation tasks must focus on in-depth testing of the entire battery system. A battery system consists of a battery pack and the BMS, whereas the battery pack contains several battery modules, and each module contains several battery cells. The BMS (see Figure 2) can be divided into cell supervision circuits (CSC) and the battery management controller (BMC). The CSCs are attached to the battery modules to keep them within a safe operating range and perform cell balancing as needed. The BMC serves as the master controller and requests the individual cell information from the corresponding CSCs to monitor the system state of the battery. Based on the information, it determines the state-of-charge (SoC) and state-of-heath (SoH) of the battery. Furthermore, the BMC requests CSCs to start cell balancing, monitors the insulation resistance, and performs the overall thermal and safety management.

Operating Principle of BMS

A multicell high-voltage battery consists of different modules, which are connected in series to increase voltage, or in parallel to increase capacity. The same applies for the design of a battery module. To ensure a safe, efficient, and long-life operation, a battery must be monitored and managed on cell level. Manufacturing tolerances and cell-individual aging may change the electrical inner resistance and energy storage capacity of each cell. To keep the battery within its safe operating range, the CSCs continuously monitor each cell voltage and temperature at different locations. Due to the different charging behavior, some individual cells might reach the maximum SoC earlier than others. Continued charging would lead to overcharging of cells, triggering hazardous failure. Stopped charging would lead to a less efficient utilization of the battery. To prevent both scenarios, the BMS, via the CSCs, balances the respective cells.

Master the Challenges of BMS Testing

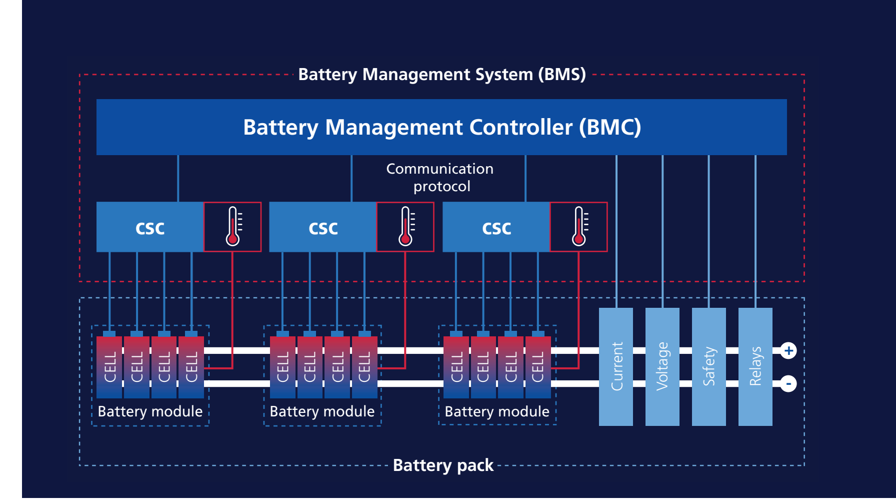
Validation of BMS is essential to ensure efficient, fault-free, and safe operation over the entire battery lifetime. Besides testing the functionality of the BMS, it is crucial to verify the safety requirements and overall integration of the BMS.

The test environment must be flexible to enable tests of different BMS. Hardware-in-the-loop (HIL) systems embed the BMS into a battery-realistic test environment to test various battery types, topologies, and cell chemistries. This allows flexible setup of the desired test conditions as a parameter of the battery model. HIL systems enable function tests in early development stages, due to the virtualization of the entire battery. Additionally, they enable electrical failure tests which are only possible under critical battery conditions, increasing the safety of testing. Defects such as faulty cell conditions or faults inside the cable harness can easily be simulated with the HIL system.

HIL tests on BMS can be performed either on signal or high-voltage level. Tests on signal level focus on the BMC software and the communication with the system (CSCs and battery simulated on HIL system). Tests on high-voltage level focus on the complete BMS connected to the HIL system (only battery simulated on HIL system). The HIL system provides the individual cell voltages and outputs for the temperature sensors of the battery, all controlled by the multicell battery model calculated on the processing unit of the HIL system.

Errors that are detected need to be fixed and verified again. The conditions of failed test cases must be reproduced identically to ensure that the errors have been fixed. The HIL tests are fully reproducible and automatable, increasing test efficiency and depth.

A typical test solution for testing BMS comprises a HIL system equipped with specific hardware boards to satisfy all I/O requirements and a real-time capable multicell battery model for dynamic simulation of various battery conditions (see Figure 3), with high precision and balancing current for cell balancing.

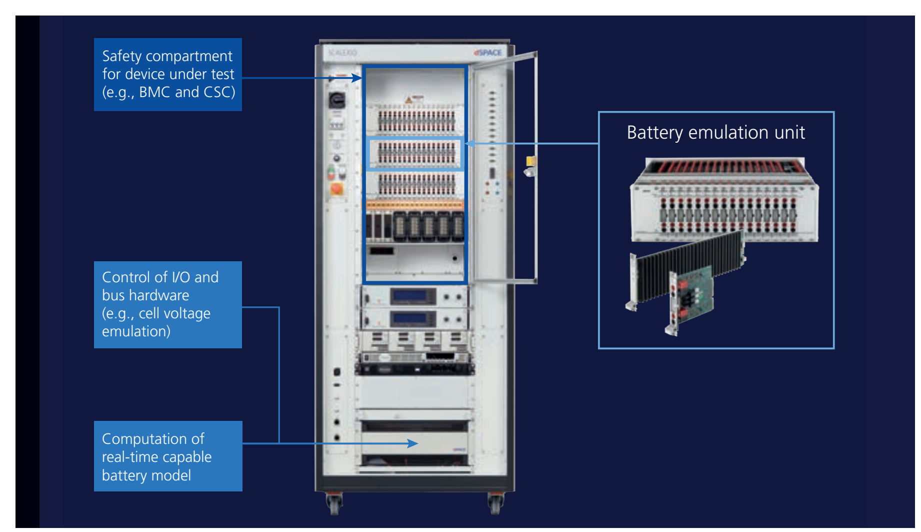


▲ Figure 2: General structure of a battery system.

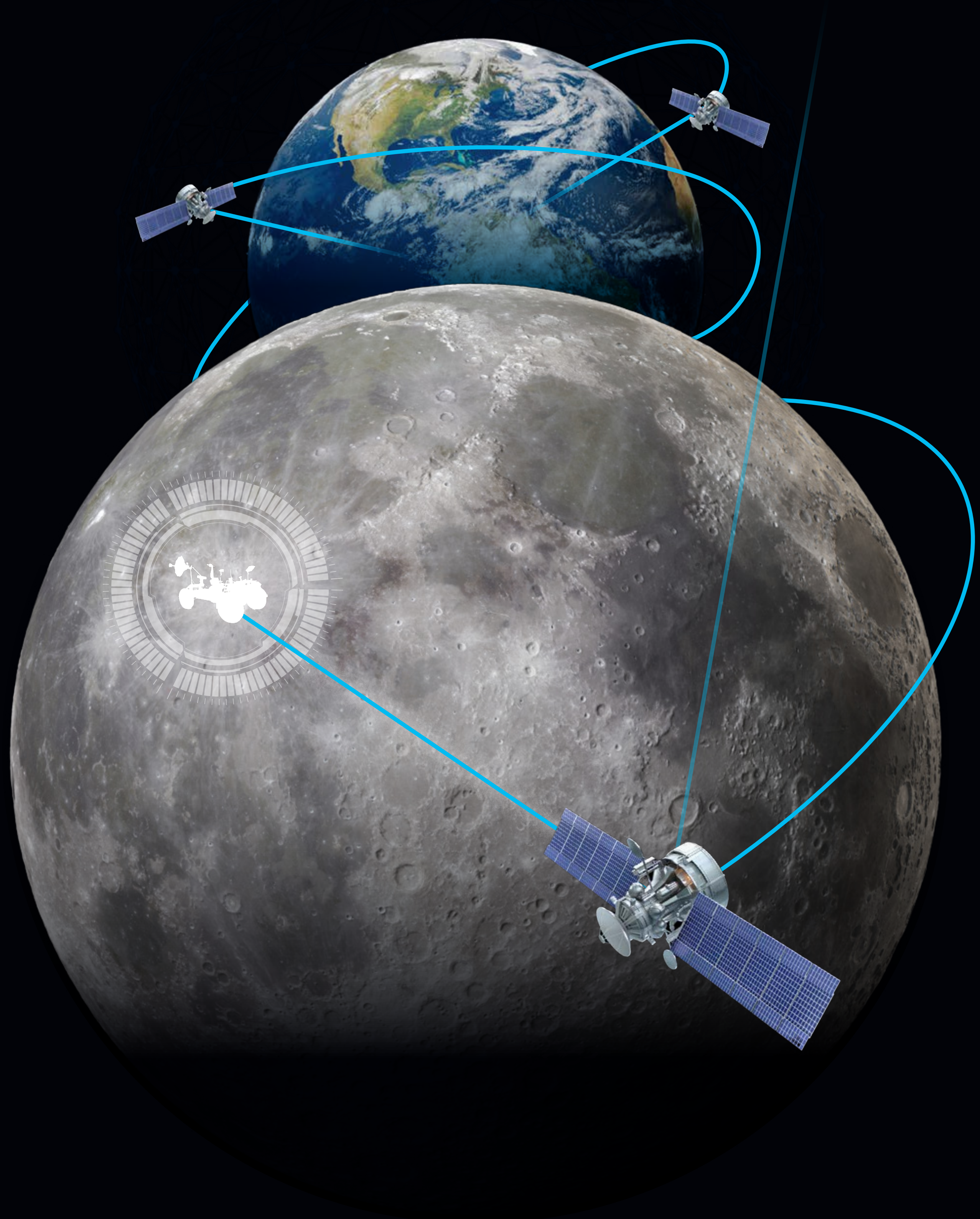
Test Solutions for BMS

dSPACE supports the validation of BMS with pack voltages up to 1,500 V. To ensure safety during commissioning, operation, and maintenance, the test solution includes a central safety controller, isolation monitors, and a safety compartment containing all high-voltage signals. The boards for battery cell voltage and temperature emulation are integrated via scalable battery emulation units as well as all high-voltage and bus signals. This allows for short wiring harnesses and increases the signal quality.

The key component of the system is a cell voltage emulation board which ensures accurate cell voltage generation, down to 300 µV. With the support of peak currents of up to 20 A per channel and high-precision current measurement, the most demanding cell balancing scenarios can be emulated. Each board provides integrated failure simulation capabilities to simulate short circuits and reverse polarity of single cells, open wires between CSC and BMC, and high-frequent disturbance signals. The battery emulation unit integrates seamlessly into SCALEXIO, the individually customizable, market-leading dSPACE HIL testing platform. The low-latency, real-time-capable integration of the cell voltage emulation allows for fast updates, regardless of the number of cells and battery size. Each cell voltage emulation board can be either controlled by the battery model executed on the processor or directly by an FPGA-based application. Any real-time capable battery model based on Simulink® or the Functional Mock-up Interface (FMI) standard can be integrated. The BMS testing solution can be used out-of-the-box with ASM Battery, part of dSPACE's open, real-time capable, and ready-to-use model simulation library. In summary, the dSPACE BMS testing solution offers a flexible, automatable, and safe test environment, which fulfils the most demanding performance and precision requirements.



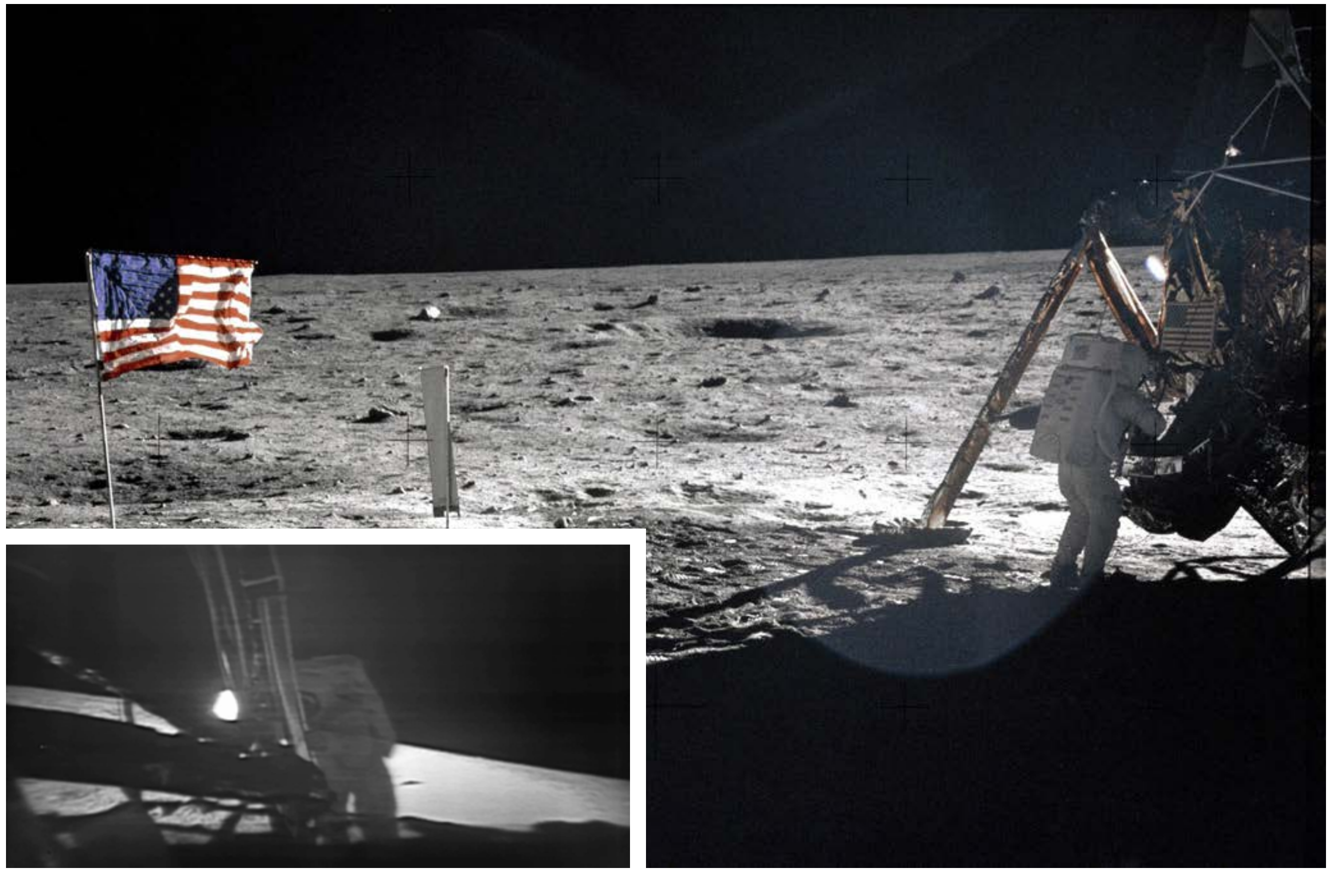
◀ Figure 3: dSPACE solution for BMS testing.



Live from the moon in HD

NASA will soon pick a pool of vendors to help it achieve an ambitious plan: Delivering high-definition video of astronauts on the moon to the public and a torrent of scientific information to scientists. Jon Kelvey tells the story.

BY JON KELVEY | jonkelvey@gmail.com



▲ The footage broadcasted of Neil Armstrong taking his first steps on the lunar surface (inset) was of much lower quality than the top photo, taken by Lunar Module Pilot Buzz Aldrin with a handheld camera. That picture was developed once the crew returned to Earth.

NASA

Under NASA's Artemis program, astronauts will be landing on the moon in a succession of missions into the 2030s to explore deep craters hidden permanently by shadows, learn how to make rocket fuel from lunar ice and eventually set up one or more permanent base camps at the south pole. These human missions, especially the first ones, are likely to enthrall the public, but the bigger purpose of Artemis is provide scientists with details of the moon's composition, temperature, radiation levels, tectonic history and a host of factors. This data could help NASA, its international partners and the private sector permanently settle the moon and exploit its natural resources. The astronauts won't be working alone on that but as a team with robotic landers, rovers and orbiters.

This coming epoch of cislunar learning will create an unprecedented demand for bandwidth in both directions that would overwhelm NASA's existing communications infrastructure.

To avoid that, NASA plans to give companies specializing in space communications a greater role in its Near Space Network, or NSN, a name the agency came up with in 2020 for some of its existing communications satellites and ground antennas. NASA says by 2030, it wants to largely rely on "industry-provided communications for missions close to Earth," meaning out to about 2 million kilometers, or five times farther than the moon but way short of Mars.

To get going on this commercialization initiative, NASA in July or August plans to select multiple companies to augment the network and provide tracking, navigation and communications services through it. This strategy will reduce costs and increase network "responsiveness and availability" by establishing "an abundance of service providers," NASA predicted in 2020 when it initiated the effort.

The hunt for more bandwidth

NSN works today, but not as well as NASA would like. During the 2022 uncrewed Artemis I loop around the moon, NASA stayed in contact with the Orion spacecraft by combining the bandwidth of NSN with that of the Deep Space Network, the antenna sites in three nations that more typically link NASA to its most distant spacecraft. The year before, those expecting to be visually wowed by the 2021 Inspiration4 mission, the first launch of a spacecraft with an all-private crew aboard, were disappointed.

"The public, or at least the space community, was questioning why we weren't getting immediate feedback from the Inspiration4 crew — the livestreams we expect," says Laura Forczyk, a space industry analyst and founder of the consulting firm Astralytical. "Well, it was a communication, bandwidth issue."

▲ Those expecting continuous video from SpaceX's first tourist flight were disappointed. Over the course of their three days orbiting Earth, the Inspiration4 passengers hosted one hourlong livestream. Because of limited bandwidth, that video (a still shown here) was grainy in comparison to the footage in the Netflix documentary.

SpaceX

SpaceX livestreamed the launch of the four passengers in a Crew Dragon capsule, but footage of them in space had to wait for the release of the final episode of a Netflix documentary, she notes. NASA and the International Space Station had priority access to the limited amount of bandwidth for communicating between Earth and low-Earth orbit.

NASA's public affairs office declined to make anyone available to be interviewed for this article, saying it's in a blackout period ahead of the NSN selections. NASA did tell us it plans to maintain ownership of NSN, and in a letter to the competitors, it underscored that selectees must "meet the specific technical acceptability standards" set by NASA. The selected vendors will be eligible to compete for various "task orders" over a period of 10 years.

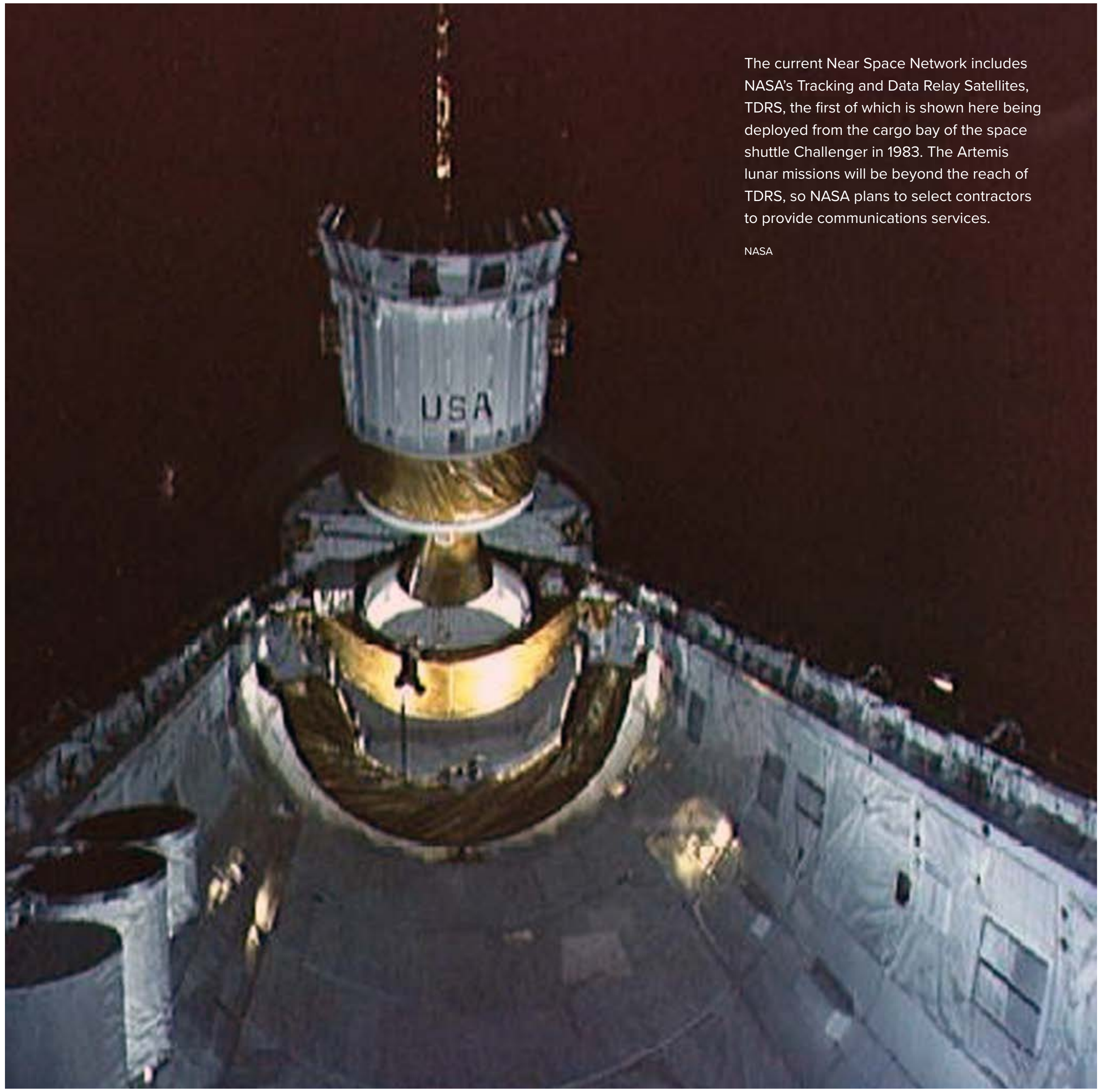
The task order strategy of creating a pool of vendors, if indeed that's NASA's plan for NSN, has become a theme for the agency. In hopes of getting multiple robotic spacecraft to the surface of the moon quickly, NASA in 2018 selected nine companies, and four more in 2019, to compete for task orders to build and land robotic spacecraft on the moon under the Commercial Lunar Payload Services program. To date, NASA has awarded eight task orders with a combined value of $2.6 billion. In another example, NASA in June 2022 selected Axiom Space and Collins Aerospace as the winning bidders in its Exploration Extravehicular Activity Services competition to develop next-generation spacesuits. That September, Axiom was awarded a $228.5 million task order to build the spacesuits for the Artemis III lunar landing, and Collins Aerospace in December won a $97.2 million task order to build new spacesuits for ISS.

In the case of NSN, the request for proposals invited companies to propose how they would build commercial infrastructure to improve and expand NSN operations, and then sell NASA and other customers high bandwidth, secure communications and navigations services.

The speed of need

Can any of this be ready in time for the historic Artemis III return to the moon by U.S. astronauts? Right now, that landing is scheduled for December 2025. It's unclear which, if any, of the NSN upgrades would be in place by then. A slide from the second industry day says NASA could begin "on-orbit testing" in 2025; "on-orbit service verification" in 2027; and "on-orbit validation" in 2028. That would seem to rule out an augmented NSN being ready for Artemis III, but NASA in June said that mission is likely to slip to 2026.

Forczyk sees evidence that a delay is almost certain. NASA needs a variant of SpaceX's Starship upper stage to carry two astronauts from an Orion spacecraft in lunar orbit to the surface of the moon and back. Before



The current Near Space Network includes NASA's Tracking and Data Relay Satellites, TDRS, the first of which is shown here being deployed from the cargo bay of the space shuttle Challenger in 1983. The Artemis lunar missions will be beyond the reach of TDRS, so NASA plans to select contractors to provide communications services.

NASA

that can happen, SpaceX must show that Starship can reach space in one piece, and then demonstrate fueling it in low-Earth orbit from a yet-to-be-built propellant depot for the journey to Orion. And then, in an uncrewed test mission, SpaceX must land a Starship on the moon. That's why April's failure to reach space has injected uncertainty into the Artemis plan. [See feature on p. 34]

It's possible that the Artemis schedule might slip in just the right way as to align with new NSN services, perhaps even optical communications, coming online. But should the Artemis and NSN schedules hold, then 2028 would be just in time for the Artemis IV mission, currently planned for sometime that year.

What history tells us

For those who remember the 1969 moon landing, or who are students of it, it turns out that the state of space technology in 1969 was not the only hurdle to better video. The grainy, washed out black-and-white scenes that the global television audience of 500 million watched were that way partly because of factors here on Earth.

"The cleanup of some old tapes that have been found showed the actual [image] quality from the moon was better than what we got on the TV," says historian Michael Neufeld of the Smithsonian's National Air and Space Museum in Washington, D.C. "The translation of the signal and conversion into regular television standard meant that it was degraded."

This signal was carried back to Earth through what would become the Deep Space Network: at the time, three stations of dish radio antennas that the Jet Propulsion Laboratory constructed in the late 1950s for communicating with the Pioneer and Ranger probes to the moon.

"You need three stations basically, spaced roughly 120 degrees apart around the globe," Neufeld says, "so that the moon is up at least in one of those three stations."

After the last Apollo mission in 1972, NASA shifted the Deep Space Network to cover robotic missions into deep space. Human spaceflight was confined to low-Earth orbit, first with the Skylab missions from 1973 into 1974 and then with the famous Apollo-Soyuz mission in 1975 in which astronauts and cosmonauts shook hands through their docked vehicles. Subsequently, the shuttle program and ISS kept generations of NASA astronauts in low-Earth orbit.

Starting in 1983, communications for human spaceflight were routed through NASA's geostationary Tracking Data and Relay Satellites, TDRS, the first of which was carried into space on the first flight of the space shuttle Challenger. But now that astronauts are heading beyond low-Earth orbit again, "Artemis creates the same problem that Apollo did: You launch out to the moon and pretty soon — in fact, within the first hour or two of launch — you're passing geostationary altitude," Neufeld says, meaning out of range of TDRS.

▲ Lockheed Martin subsidiary Crescent Space is among those competing to augment the agency's Near Space Network of satellites and ground antennas. Crescent plans to develop a network of communications and navigation satellites around the moon dubbed Parsec, shown here in an illustration. Plans call for launching the first satellite in 2025.

Crescent Space

The Deep Space Network could fill the void, but its responsibilities have grown dramatically since the days of Apollo, servicing NASA's Mars rovers and probes studying the sun and outer planets, as well as international missions.

"Every single interplanetary spacecraft is communicating to Earth, pretty much, through the Deep Space Network," says Glenn Lightsey, a professor of space systems technology at Georgia Tech. "It's capacity limited. It really cannot handle hundreds of users and lots of high data rates, and so there needs to be an augmentation or an alternate service to the Deep Space Network."

That's where NSN comes in. Today's NSN consists of 17 commercial and government-owned radio antennas and radar installations stretching around the globe, along with the TDRS constellation. When communicating directly to Earth, NSN can return data at a rate of 3.5 gigabits per second, close to the rate required for high-definition Netflix.

While the Deep Space Network exclusively links spacecraft including the James Webb Space Telescope and Chandra X-Ray Observatory to Earth, the NSN is

▲ NASA is targeting December 2025 for the Artemis III landing, in which two astronauts would descend toward the lunar south pole in a SpaceX Starship lander, shown in an illustration. NASA in June said it's likely the landing will slip to 2026, and further delays could mean that the augmented Near Space Network communications and relay services will be available for the mission.

SpaceX

the sole network for missions taking place from the upper atmosphere to beyond the moon. That includes, for example, the Super-pressure Balloon-borne Imaging Telescope, an astronomy telescope on a high-altitude balloon that's circumnavigated the southern hemisphere multiple times since it was launched in April. NSN also relays communications to and from the Pentagon's STPSat-6, one of its Space Test Program satellites, which carries a nuclear detonation detection payload and an experimental infrared laser communications device for NASA.

Near Space Network 2.0

The request for proposals asks bidders to define how to carry both direct-to-Earth and space relay communications across three regions:

- Earth proximity, which runs from the Earth's surface to geosynchronous orbit at around 36,000 kilometers
- GEO to cislunar, altitudes from geosynchronous orbit out to 500,000 kilometers altitude
- xCislunar, for altitudes from 500,000 kilometers out to 2 million kilometers from Earth, a reach that includes the L1 and L2 sun-Earth Lagrange points

The proposals will have to cover the same frequency bands the NSN currently covers but may also include optical laser communications at the 1,530 to 1,565 nanometer wavelengths. Commercial providers will also have to show their systems can return direct-to-Earth data with no more than 15 seconds of latency.

Reactions to the RFP have been somewhat mixed. Lockheed Martin in March created Crescent Space, a subsidiary that has submitted a bid for the NSN competition. Crescent is developing a system it calls Parsec, consisting of two satellites that will orbit the moon to pick up signals from the lunar surface and the surrounding space and then relay them back to a commercial vendor's radio antenna on Earth. Parsec will use radio frequency communications rather than optical and, regardless of whether it wins the NASA contract, aims to begin offering commercial services to customers in 2025.

"We are excited about NASA's NSN program, and it's a huge opportunity, but we've already started the development of Parsec. We're not waiting," Crescent Space CEO Joe Landon says, noting that while NASA is a major player in the space communications market, it's not the only one. "We're basing this business on the market that we expect to develop."

Italian aerospace company Argotec, which is not an NSN competitor, has been working on a separate lunar communications concept that sounds similar to Parsec. Dubbed Andromeda, the constellation would consist of 24 satellites divided into four orbits around the moon, with six satellites per orbit. In a commentary published in IEEE Spectrum, the head of Argotec's research and development unit, Alessandro Balossino, described the company's end goal as providing 5G broadband coverage of the entire moon. NASA's RFP does not address wireless coverage on the moon, but in 2020, NASA awarded Nokia $14.1 million to develop 4G broadband connectivity for the moon.

Hard questions

Forczyk can't resist looking in the rearview mirror for a moment.

"Why is this now finally happening versus a decade ago when we all saw that it needed to happen?" she says. "Or at the beginning of the Artemis program kickoff, when everybody had the momentum of 'This is going to happen'?"

Vincent Chan is another expert with some questions. The professor of electrical engineering and computer science at MIT questions whether radio frequency communications will cut it, given the scope of NASA's Artemis ambitions, which include multiple missions to the lunar south pole, along with lunar rover and science missions through commercial partners. IBM suggests that on Earth, a 4K resolution high-definition video stream requires 8 to 14 gigabits per second. HD 1080 resolution meanwhile, the high-definition format available to standard-tier Netflix subscribers, requires a bitrate of 4 to 8 gigabits per second.

In April, NASA's Pathfinder Technology Demonstrator 3 used optical communications technology that Chan helped develop at MIT's Lincoln Laboratory to transmit more than 3 terabytes of data — the equivalent of hundreds of hours of high-definition video — from orbit to Earth at 200 gigabits per second. But that's laser communications. Chan says relying on radio waves to carry sensor and instrument data, as well as video feeds, will greatly increase the cost of the commercial NSN.

"If you use radio frequency, the biggest problem is that you need a big honking transmitter because the divergence of the beam is proportional to the wavelength," he says, with microwave beams being about 100 times as wide as a 1.5-micron laser beam. Transmitting lots of data through radio, therefore, requires a lot more power and bigger, more costly satellites.

"If you say they're using RF, I think they're going to fail," Chan says. "They may not fail in a 1-megabit to 10-megabit [region], but they're certainly going to fail in the gigabit region."

Robert Brumley, the founder and chairman of CommStar Space Communications, shares Chan's skepticism about whether a purely radio frequency NSN can achieve NASA's Artemis goals. And from his reading of the RFP, he doesn't believe NASA would be ready to integrate any optical communications into NSN until at least 2027 — too late for Artemis III at least, if the current schedule holds.

"It is a disappointing outcome if optical is not brought forward as a service sooner. We all know RF spectrum is scarce, even in cislunar, and data delivery — especially content like streaming video — requires high capacity throughput," Brumley says. "The result would be, if no optical when the Artemis III crew gets to Shackleton Crater, no Netflix. It is not too late for NASA to clarify its position."

NASA did not respond to requests for clarification about optical communications in the RFP, which merely notes the frequency band for optical communications is 1,530 to 1,565 nanometers. A NASA brochure explaining the NSN's current capabilities describes optical communications as "demonstration only."

But NASA might simply be acting pragmatically, according to Advanced Space CEO Bradley Cheetham. While he acknowledges that the proliferation of instruments producing lots of data on future lunar missions will require much more bandwidth than is available today, he also notes that getting an optical communications system working around the moon will not be easy.

"Just by the projections of demand, we're going to need a higher data rate than we can probably support using X-band, S-band, Ka-band radio frequencies," Cheetham says. So while optical communications are part of future solutions, "moving it from where we are today, with very limited adoption in deep space to the only option in deep space, I think introduces a lot of operational problems for missions that are trying to fly."

Cheetham notes that when Advanced Space lost contact and control of its CAPSTONE spacecraft while it was on its way to the moon last July, for instance, the team never could have reestablished contact using optical communications, since they require a narrow laser beam to maintain pinpoint focus on a receiver. The team regained control of CAPSTONE in October. [See graphic on p. 8]

"On CAPSTONE, as we were spinning out of control in deep space, we needed a wide beam width, low-power RF signal to be able to talk to the satellite," Cheetham says. "If that was a laser spinning around, we never would have been able to hear from it."

Even if NASA were ready to integrate laser communications technology for the NSN and awarded a contract tomorrow, it would take time to build and test the new commercialized network. Even though most of the technology already exists, the Georgia Tech professor Lightsey says, it still takes time to build out new ground-to-space infrastructure.

"I think the idea of getting something up and running within five years is pretty achievable," he says. "It would take that long anyway, just because of the logistics of getting a system like that in space."

And then again, schedules could slip, with NSN development lagging far behind human spaceflight. It is the space business, after all.

"We always expect things to be faster and work on the first time, but it never does," Forczyk says. "It's always more complex, more expensive, slower." ★

Tomorrow's firefighting fleet

The growing frequency and intensity of wildfires has operators clamoring to increase the number of large air tankers in their fleets. Should they turn to refurbished civilian and military planes, or clean-sheet designs? Keith Button spoke to U.S. agencies, industry groups and aircraft developers about the ongoing debate.

BY KEITH BUTTON | buttonkeith@gmail.com

Even at the age of 8, living near an air tanker base in La Grande, Oregon, Jamie Knight was intrigued by the wildfire-fighting planes taking off.

"I just remember growing up all summer long watching the large air tankers," says Knight, now the head of Oregon's aviation firefighting operations. "There's just something about the rumble of a low-flying aircraft as it leaves the valley here that always fascinated me."

Later, as she fought wildfires as a ground crew member for the Oregon Department of Forestry (18 years ago), seeing large tankers appear overhead was bittersweet. "You're really happy to see them and to know that they're there, and it's always really interesting and neat to see a large air tanker release its load of retardant," she says. But the presence of those tankers also signaled to the firefighters on the ground that the stakes were raised: Their fire was now posing a serious threat to lives or property, and the tankers were being called in to slow its advance with retardant.

Today, with the threat of wildfires increasing, firefighting organizations and their backers in the United States and abroad are clamoring for more of these large tankers so they can contain fires before they grow out of control. Discussions are underway over whether the wisest course is to convert military C-130s and airliners into air tankers, or whether the time has come for a clean-sheet design.

Generally, air tankers — from the single-engine versions that carry 3,000 liters up to the very large air tankers with 30,000 liters — are called in to fight fires in the initial attack phase, to try to encircle the fire by dropping lines of retardant 6 to 15 meters from the fire's edge to inhibit burning so ground crews can put it out. The retardant — usually a phosphate-based fertilizer and water mixed to the consistency of a slushy, dyed red for visibility — sticks to the vegetation. If the fire area continues to grow after the first 24 hours, then the task of the air tankers shifts to dropping retardant to protect areas of risk, such as residential areas.

As matters stand, proposals for clean-sheet designs to do this are rare. In Europe, Roadfour, a Brussels-based company, has started assessing the "concept and feasibility" of designing and building amphibious firefighting aircraft and making them available by 2030. The conceptual plane, dubbed the Seagle, would seek customers primarily in the European Union market. By July 2024, the company plans to decide whether to move ahead with preliminary design of the aircraft, based in part on its assessment of the needs of potential government and private buyers in Europe, says Stew Clifford, head of avionics and cockpit systems at Roadfour.

Initial plans call for the Seagle to be capable of scooping up 11,000 liters of water from the surfaces of lakes, rivers or seas, or landing at an airport to load up with a similar amount of retardant. Originally, plans called for including four hydrofoils that would keep the plane above the water's surface during scooping, plus a "slicer" to direct water into the plane. Clifford says the hydrofoils were dropped from the plans for the 2030 version of the plane out of concern that the new technology might delay certification by the European Union Aviation Safety Agency.

January 2020 fires burning in Namadji Park, Australia, cast a dark cloud over nearby Canberra. The Australian Bureau of Agricultural and Resource Economics and Sciences estimates that 10.3 million hectacres of bushland were burned during the 2019-2020 fire season, dubbed Black Summer.

Daniel Charron / Shutterstock.com

Proposals for clean-sheet designs remain rare, even as the threat of fires in the U.S. and abroad looks poised to continue growing. The number of large forest fires in the American West and Alaska has increased since the early 1980s and will continue to increase due to climate warming, predicts the U.S. Global Change Research Program, a congressionally mandated organization that coordinates climate research. In the first half of June, air quality as far south as Alabama was affected by wildfires in Canada that burned 5.3 million hectares, a 1,597% increase from the year-to-date average, creating the worst daily air pollution in history for New York City. In Australia, the Black Summer 2019-2020 bush fire season burned 10.3 million hectares — the costliest natural disaster ever for the country. In 2020, California recorded five of the

▲ Among Cal Fire's fleet of 60-plus fixed and rotary wing aircraft are modified Grumman S-2T air tankers. In May, crews at Sonoma Air Attack Base in California practiced loading the tankers, each of which can carry 4,500 liters of retardant.

California Department of Forestry and Fire Protection

▲ Brussels-based Roadfour plans to decide by 2024 whether it will develop a preliminary design of the Seagle, a conceptual amphibious firefighting aircraft. Early plans call for a design that would store 11,000 liters of water or retardant.

Roadfour

seven largest wildfires in its history, and the entire U.S. had the second-worst wildfire season since records began in 1983, with 4.1 million hectares burned. And over the last decade, the number of people in the U.S. experiencing unhealthy levels of wildfire smoke has increased 27-fold, according to a 2022 study by Stanford University researchers.

For Russ Lane, wildland fire chief for the state of Washington, the scope and severity of wildfires has changed a lot since his start in fire management in Oregon 36 years ago. "The amount of fuel buildup we have in the landscape, the intensity of fires — that is different," Lane says. "We used to consider a large fire as 5,000 to 10,000 acres, and now we're talking about fires in the tens of thousands to hundreds of thousands of acres."

As the wildfire threat has escalated, so has the need for more firefighting aircraft, especially for large tankers capable of dumping upward of 11,000 liters of fire retardant per flight, says Paul Petersen, executive director of the United Aerial Firefighters Association, which formed last year to represent the industry before the U.S. federal and state governments.

"What we have seen, especially in the last 10 to 15 years, is the scope, size and scale of fires have just tremendously, exponentially, grown. And it is outpacing a lot of the crews and equipment that's out there, whether that is crews that are on the ground, dozers, but also air tankers and helicopters," says Petersen, who formerly was the Nevada state fire management officer for the U.S. Bureau of Land Management.

If additional tankers were available, they could be stationed on the ground, ready to be deployed on the initial attack so a wildfire can be contained while it's still small, Petersen says.

This containment strategy is illustrated by the California Department of Forestry and Fire Protection, better known as Cal Fire, which says it has the largest civil aerial firefighting fleet in the world. Cal Fire's goal is to stop 95% of the state's fires at 10 acres or less, says Joshua Nettles, who oversees fixed-wing firefighting operations. Based on the initial 911 call, Cal Fire dispatches two S-2T air tankers — a medium-sized design that can carry 4,500 liters of retardant — as part of its first response, rather than waiting to verify that the call was not a prank or mistake. These planes are airborne within three minutes.

"Our theory is we'd rather hit it when it's small and controllable to be able to put it out than to use that precious time where we could have stopped it to just to send somebody to verify," he says.

Cal Fire, like other organizations contacted for this article, sees a need to add large air tankers to the overall fleet to deploy against wildfires, and the agency has agreed to acquire seven C-130H military planes that will be converted for that purpose.

The shortage of large tankers in the U.S. dates back to 2002, Petersen says, when two heavy air tankers crashed during separate firefighting missions after their wings broke off due to structural fatigue cracks. One plane was flown by the U.S. Navy starting in 1945; the other by the U.S. Air Force in 1957. After the crashes, the U.S. Forest Service and Bureau of Land Management tightened their specifications for heavy air tankers. Before 2002, there were about 45 heavy air tankers available in the U.S., with "heavy" defined as being capable of carrying at least 9,100 liters of retardant. Today in the U.S., there are 27 heavy air tankers that can carry 11,000 liters of retardant, plus four "very large air tankers" — DC-10s that carry 35,600 liters each. All are repurposed from their previous service as passenger airliners, and all are privately owned and contracted to the government for firefighting.

The problem of how to stock the nation's aviation firefighting fleet is also a topic in Congress. In January, a commission established by the 2021 U.S. Infrastructure Investment and Jobs Act published its "Aerial Equipment Strategy Report" recommending to Congress that surplus military aircraft and parts be made readily available to state and local wildfire agencies and to private contractors. This group, the Wildland Fire Mitigation and Management Commission, also recommended that Congress commission a study to evaluate the feasibility of modifying additional aircraft and developing more "purpose-built" aircraft — a category that the commission does not define, but could include clean-sheet designs or existing aircraft expressly designed for firefighting.

▲ As the number of wildfires increases, so does the demand for large air tankers like this modified DC-10 owned by 10 Tanker Air Carrier. The U.S. Forest Service leases such aircraft or contracts companies to operate them to assist in early suppression of wildfires. A DC-10 tanker can hold 35,600 liters of retardant.

10 Tanker Air Carrier LLC

Petersen's firefighting industry group wants Congress and U.S. states to fund exclusive-use contracts between firefighting organizations and the companies that operate the 25 to 30 large and very large tankers out there now. The contracts would ensure that these tankers are kept on constant standby during the fire season for the next five to 10 years, depending on the length of the agreements. That way, the contractors could better amortize their acquisition and refurbishment costs. The industry group is seeking funding for more smaller tankers as well.

If the preceding were done, that would still leave the question of how to buttress the fleet with additional large tankers. While a clean-sheet design would be expensive, the costs of buying and converting an existing aircraft would be significant too: between $2 million and $8 million for the plane, depending on its lifespan and condition; plus the added expense of designing and manufacturing the tanking system; getting it certified by FAA, the Forest Service and the U.S. Department of the Interior; and installing it, says Nicholas Lynn, vice president of operations for Neptune Aviation Services, a Montana-based operator of nine BAe 146 tankers, each of which can hold 11,000 liters.

At Cal Fire, with an influx of large fires over the last five to 10 years in California, the agency needed to add bigger air tankers to its fleet. It has 26 of the 4,500-liter 2-T tankers, which are refurbished S-2E/G anti-submarine U.S. Navy planes.

These tankers can be flown down quickly into canyons to dump retardant, and they can be flown from smaller airports more easily than heavy tankers, Nettles says. But with a 15,000-liter capacity, a C-130H tanker can build a retardant fire line three or four times longer. For large fires, Cal Fire typically employs the tactic of building long retardant lines along ridges away from the fire. "When you're just building line, that's where the larger tankers really come into play," Nettles says.

For Cal Fire's purposes, Nettles says either repurposed civilian or military aircraft can work well for firefighting duties, but the military aircraft is often preferable for cost reasons: A former U.S. military plane can be provided for free to the state through the Federal Excess Personal Property program, Nettles says. Through the program, Cal Fire acquired its S-2T planes and agreed to acquire and operate the seven C-130H planes, which were flown by the U.S. Coast Guard starting in 1985.

Firefighting plane operators in the private sector also seem to be gravitating toward larger air tankers — those with a capacity of at least 11,000 liters — to combat the large fires that are becoming more common, Nettles says. "That's where the trend is going, and that's where the private market has found their niche: delivering or contracting tankers on the larger side."

Cal Fire would certainly consider a new clean-sheet-design firefighting airplane, if one were on the market, but he says the manufacturer of such a plane would find it difficult to cover its development and building costs while competing with the prices for planes available for refurbishing, especially when states can acquire federal planes for free, not including the refurbishing costs.

"The price point is what really comes into play for us and, honestly, for most government entities or anybody that operates air tankers," he says.

Petersen of the aerial firefighters association believes there could be room in the market for a dedicated large tanker built specifically for fighting fires. Currently, the only planes designed and built expressly as firefighting tankers operating in the U.S. are CL-415 Super Scoopers, which skim the surface of rivers, lakes or oceans to ingest up to 6,000 liters of water to drop on a fire, cooling it enough for ground crews to put it out. There are only 11 CL-415s operating in the U.S., he says.

As it is with scooper aircraft, heavy tankers expressly designed and built for dropping retardant would benefit wildland firefighting because the in-flight demands are unique: "The way that these aircraft are flown on fires is unlike anything else that's in the military or definitely flying passengers around," Petersen says.

A passenger plane just has to fly point to point, with 0.5-g turns, a climb to cruising altitude and a descent. Meanwhile, a firefighting tanker is always operating in the summer heat when the air is less dense, making it harder to take off and maneuver at the fire with heavy loads. Then, it has to fly at 45 meters above the vegetation or lower while avoiding power lines and dead tree snags, drop its entire load in 10 to 15 seconds, climb out, land and repeat the process — all while flying in and around the occasional thunderstorm and updrafts or downdrafts created by the fires.

"It's definitely exciting; there's a certain air of adrenaline," says Bradley Baker, lead air tanker pilot for Amentum, a company that supplies Cal Fire's pilots. "Fire creates its own weather. That's the hardest part."

A pilot can take off in dead calm air, 25 kilometers away, but encounter a 20-knot wind shear or 30-knot crosswind at the fire. But pilots learn to read the wind directions from the fire's smoke, Baker says. "It's just a giant windsock."

For their parts, Washington fire chief Lane and the Oregon firefighting executive Knight both have their doubts about the viability of a theoretical clean-sheet-design tanker versus the refurbished options.

"For the foreseeable future, I think that you'll continue to see a lot of use of the refurbished, repurposed aircraft," partly because of the economics, says Knight, whose state has an 11,000-liter MD-87 air tanker under exclusive-use contract for firefighting.

Lane says, "There's a lot of varieties out there; there's a lot of opportunity," but "I doubt that we'll see the purpose-built large air tankers because it has worked really well to convert civilian airliners."

Also, the heavy tanker fleet in the U.S. has been updated to significantly newer planes in the past several years. "Not too many years ago in Oregon, we were flying DC-7s that were way older than I was," he says.

Neptune Aviation's Lynn is another skeptic. "To get a manufacturer to tool up, design, build and produce, the economics just aren't there," he says. "What that would do to the costs for the contractor and the government would be prohibitive, in my mind." ★

FACT

THE DISCUSSION over clean-sheet versus refurbished tankers looks likely to continue. The U.S. Wildland Fire Mitigation and Management Commission plans to follow its "Aerial Equipment Strategy Report," released in January, with a set of more comprehensive recommendations to Congress in September.

FIXING STARSHIP

Starship days before its inaugural launch in April.
SpaceX

Looking at history, the safe bet is that SpaceX will ultimately resolve the troubles that marred its first attempt to get a Starship spacecraft into space. At the moment, SpaceX faces technical and legal challenges that could slow its hopes for a quick return to flight for its Starship-Super Heavy combination and also complicate efforts to start launching the vehicles from Florida. Jonathan O'Callaghan investigates.

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

The messy Starship launch in April was the latest example of SpaceX learning on the fly, failures be damned, in the same way it developed its Falcon fleet of rockets. Despite the excitement about launching a Starship atop a Super Heavy booster for the first time, the explosive liftoff and fiery ending over the Gulf of Mexico well short of space presents the company with a host of technical, regulatory and legal hurdles that are just now coming into full view.

SpaceX in all likelihood will need to clear each of these hurdles to resume test flights from its Starbase site in Boca Chica, Texas. That would be a step toward achieving Starship's $2.9 billion role of shuttling astronauts between lunar orbit and the surface during the planned return of U.S. astronauts to the moon under the Artemis program. That historic mission is now likely to slip to 2026, according to NASA, in part because of the Starship setback.

Also at stake is the eventual launching of Starships from Kennedy Space Center in Florida. The center's location on Cape Canaveral provides easy access to ascent over the Atlantic Ocean, away from populated areas, whereas Starbase is located on the Gulf of Mexico, a body of water ringed almost entirely by land. That said, NASA public affairs tells me the agency "does not have a requirement for Starship to launch from Florida."

Requirement or not, over the last two and a half years, concrete and steel structures for launching Starships have slowly sprouted from the scrub of Cape Canaveral seashore across the way from NASA Kennedy's business offices and media site. Unlike Boca Chica, where Starships are the only rockets around, the Cape hosts a variety of launch providers and is home to infrastructure that NASA, presumably, won't permit SpaceX to put at risk, although the agency would not make anyone available for an interview about this topic.

The new pad is emerging on Launch Complex-39A, just meters from the Falcon pad where astronauts Bob Behnken and Doug Hurley climbed into a SpaceX Crew Dragon capsule in 2020 and flew to the International Space Station. That mission marked the restoration of the U.S. ability to deliver astronauts to ISS on American-made spacecraft. Thirty-six spacefarers have since been launched from that pad, including three all-private crews. Students of history will also recall that this pad is the one where Apollo 11's Saturn V lifted off in 1969 and where the first space shuttle lifted off in 1981.

The notion of launching the world's most powerful rocket so close to such important infrastructure might seem foolhardy, were it not for a notable addition planned for the Cape, and ultimately for Boca Chica: a method to redirect the thrust of liftoff away from the pad. Traditionally, this would be accomplished via a flame trench, but SpaceX has instead opted for a "water-cooled steel plate" — a flame diverter. The trouble was, one was not installed for the inaugural launch in April. Two and a half years earlier, Elon Musk issued a now famous tweet: "Aspiring to have no flame diverter in Boca, but this could turn out to be a mistake." Forgoing the diverter was indeed a mistake, judging by the fact that the ignition of Super Heavy's Raptor engines blew a crater into the concrete launch pad and spewed a plume of pulverized concrete for kilometers. At the Cape, long before the April launch, NASA made clear that it had no intention of taking such a risk even for one launch: A 2019 environmental assessment conducted by NASA and SpaceX for the Cape site said a "water cooled flame diverter" consisting of metal piping would be constructed and "positioned directly under the rocket," in lieu of a flame trench like the one at the Falcon pad. (NASA would not say whether this is still the plan.) The day after the April launch, Musk tweeted that construction of a diverter for Boca Chica had begun three months earlier but wasn't ready. "We wrongly thought, based on static fire data, that Fondag" — an industrial concrete — "would make it through 1 launch."

In follow-up comments on Twitter, Musk suggested Starship could return to flight some three months after the test flight. That prediction now seems optimistic. FAA as of late June had yet to receive the "final mishap investigation" report it requested of SpaceX following the test flight, emphasizing in response to my questions that it will be "involved in every step of the process." That report must identify "final corrective actions" that SpaceX will have to implement before FAA permits another Starship launch.

"The FAA isn't going to speculate when the SpaceX Starship / Super Heavy vehicle returns to flight," the agency said. "Public safety and actions yet to be taken by SpaceX will dictate the timeline."

At Boca Chica in April, SpaceX took "too much of a risk," says Philip Metzger, a planetary scientist at the University of Central Florida who has been studying the aftermath of the pad's destruction. As bad as it was, things could have been worse. "The concrete chunks could have struck the vehicle and resulted in catastrophic loss of the vehicle while it was still low. That could have destroyed the entire launch structure."

Plans call for the same infrastructure at the two sites: an elevated concrete ring on six stout concrete legs, a flame diverter under it, and a launch tower with the two "chopsticks" that will hold a fully stacked Starship and Super Heavy booster and catch the booster on its return to the launch pad.

An open question is whether SpaceX's water-cooled steel plate apparatus, rather than a flame trench, will be enough to satisfy NASA now that the power of Super Heavy has been demonstrated so vividly at Boca Chica. In a response to my questions, the agency said it was "working with SpaceX to ensure the updated pad remains compliant with the requirements of the property agreement for the use of LC-39A." Those requirements include "construction, safety and environmental concerns," with SpaceX's designs "reviewed by NASA for their impact to the center." SpaceX did not respond to a request for comment.

NASA and SpaceX have long been working together closely. In 2021, at SpaceX's request, NASA began an environmental assessment about launching Starships from a yet-to-be-constructed pad, Launch Complex-49, that would be located north of LC-39A and LC-39B, the Space Launch System site. LC-49 is referenced in the Kennedy Space Center Master Plan. If dedicated to Starship, it "would provide redundancy and capacity and allow SpaceX to increase the flight rate of Starship," according to NASA. That might be necessary for the multiple refuel flights needed to get a single Starship to lunar orbit, where it would pick up astronauts from an Orion capsule and bring them to the surface and back. Two towers might be built at LC-49 for launching Starships, giving the Cape three separate Starship launch sites.

Bad ending

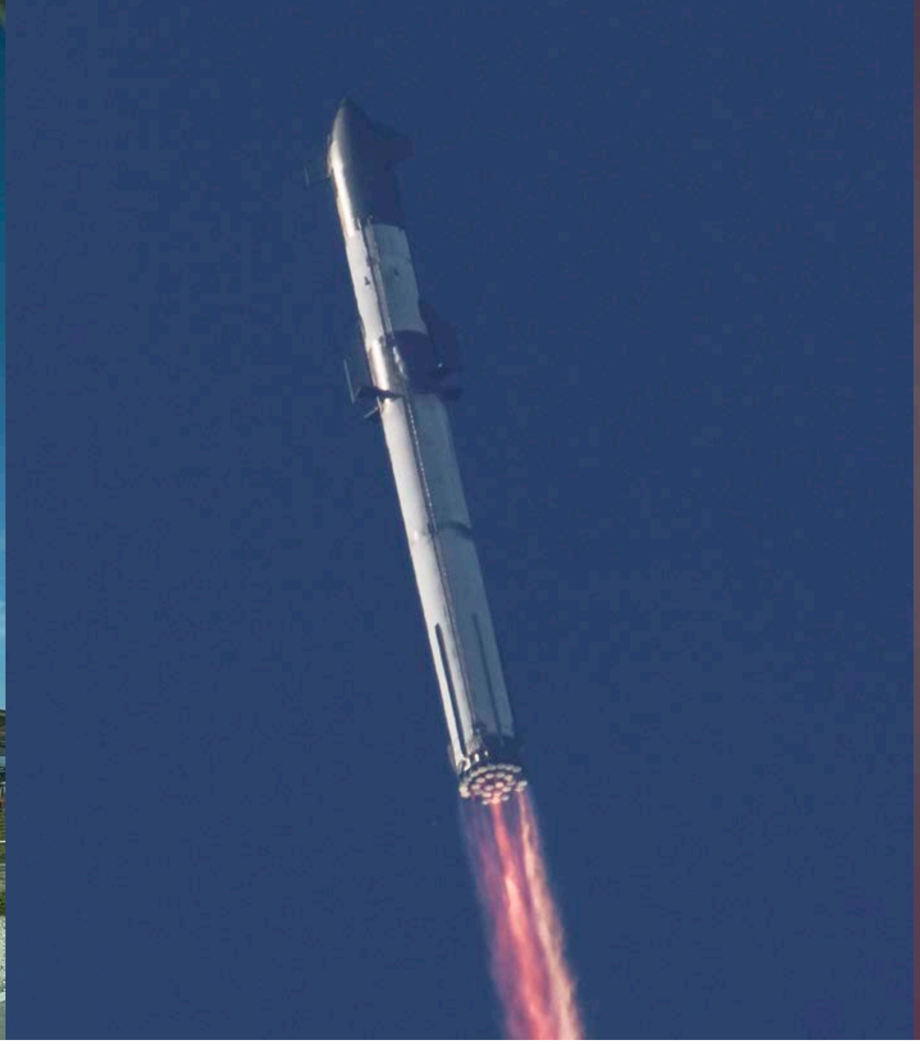
The corrective actions required for return to flight seem certain to involve the flight termination system, or FTS, which failed to immediately destroy Starship when it began to tumble about four minutes into the launch. Musk tweeted that the final destruction came as the rocket fell back into the thicker atmosphere, about 40 seconds after the command for detonation was sent.

"That was bad," says Charlie Garcia, chief engineer at Colorado-based Agile Space Industries, who follows SpaceX's operations. "As far as the most concerning things about the flight, that one would be at the top of my list."

A wayward rocket that doesn't respond to a

"RAPTOR IS A VERY COMPLICATED AND RELATIVELY NEW ENGINE. I THINK THERE'S DEFINITELY A LOT OF LEARNING TO DO. I DON'T SEE ANY MAJOR STUMBLING BLOCKS; IT'S JUST A LOT OF WORK BY THE ENGINEERS."

— Charlie Garcia, Agile Space Industries



▲ SpaceX is constructing its Starship launch pad near the pad that the Apollo 11 crew took off from and where Falcon rockets are now launched. This photo was taken in September, about a month before a Falcon 9 launched a crew of four to the International Space Station.

John Tylko

self-destruct command could fly off course and potentially rain debris over inhabited land, rather than the ocean as intended. "The risk is always that the rocket goes somewhere you don't want it to," says Garcia. "That's why the FTS exists."

Jim Knauf, a retired U.S. Air Force colonel and former chair of AIAA's Space Transportation Technical Committee, says the FTS problem was "unacceptable" but solvable. "I think the fix will be relatively straightforward," he says. "Then they've got to get FAA approval and convince them they've fixed it."

Then there was the apparent failure of up to seven of Super Heavy's 33 methane-fueled Raptor engines. Given the "unprecedented" number of engines, says Knauf, failures would have been expected. But ironing out those issues will be crucial before Starship can safely launch from the Cape.

Former NASA official Daniel Dumbacher, executive director of AIAA, says that data displayed by SpaceX in its livestream showed that "some of [the engines] did not start, and some of them did not operate going uphill." SpaceX needs to "understand what, if any, impact that had on the control systems that led to the aerodynamic breakup," he says.

The engine failures could take some time to solve. "I doubt there's a simple solution," says Garcia. "Raptor is a very complicated and relatively new engine. I think there's definitely a lot of learning to do. I don't see any major stumbling blocks; it's just a lot of work by the engineers."

There is another potential barrier to the return to flight: a lawsuit filed against FAA in May in the U.S. District Court for the District of Columbia by five environmental groups. The lawsuit alleges that the potential for damage to the pad and surrounding wildlife at Boca Chica was not properly investigated by FAA before the launch as part of its environmental assessment. The suit asks the court to instruct FAA to "vacate" its original finding of "no significant impact" and order creation of a full EIS, the term for an environmental impact statement required by U.S. law in many instances. This full EIS should replace the "considerably less thorough" programmatic environmental assessment that FAA concluded in 2022, the suit says.

"Our position is a relatively straightforward one," says Jared Margolis from the Center for Biological Diversity, the lead counsel on the case, who notes it could take months or even years to resolve the dispute. "It's that the launch on April 20 proved that the impacts of the Starship Super Heavy program are more than significant."

SpaceX currently has a license for 20 Starship launches from Boca Chica over the next five years and would need to reapply or request to modify its license if it wants to conduct more. Margolis wants that possibility to be carefully considered. "Maybe this isn't the right place to be blowing up giant rockets," he says. "This is one of the most important and biologically diverse areas in the country for wildlife. This is not some sacrifice zone, which is what they're using it as. Moving it to Florida would resolve our concerns."

▲ Multiple Raptor engines on Starship's Super Heavy booster either did not fire or failed during SpaceX's first attempt to launch a Starship into space atop a Super Heavy.

SpaceX

Another crucial aspect yet to be tested is the refueling of Starship in space. Perhaps a dozen or more fuel-laden Starships would need to be launched, and these would transfer fuel to a depot in low-Earth orbit. Propellant would then be transferred to the moon-bound Starship to ready it to reach lunar orbit, where it would take the astronauts to the lunar surface and back.

How exactly that will be carried out needs to be tested, says Dumbacher. "The technology for that refueling process has not been demonstrated at scale," he says. "All of that orchestration of those launches has to work correctly. There are some hurdles ahead that have to be addressed."

Despite the issues at hand, however, there remains optimism that Starship can succeed. "NASA knows that the development of a new launch vehicle takes time and likely will have setbacks," says Laura Forczyk of the Astralytical consultancy. "I do not think Starship's messy progress is a surprise to NASA at all. NASA has a long working relationship with SpaceX and understands how the company prefers to test its prototypes."

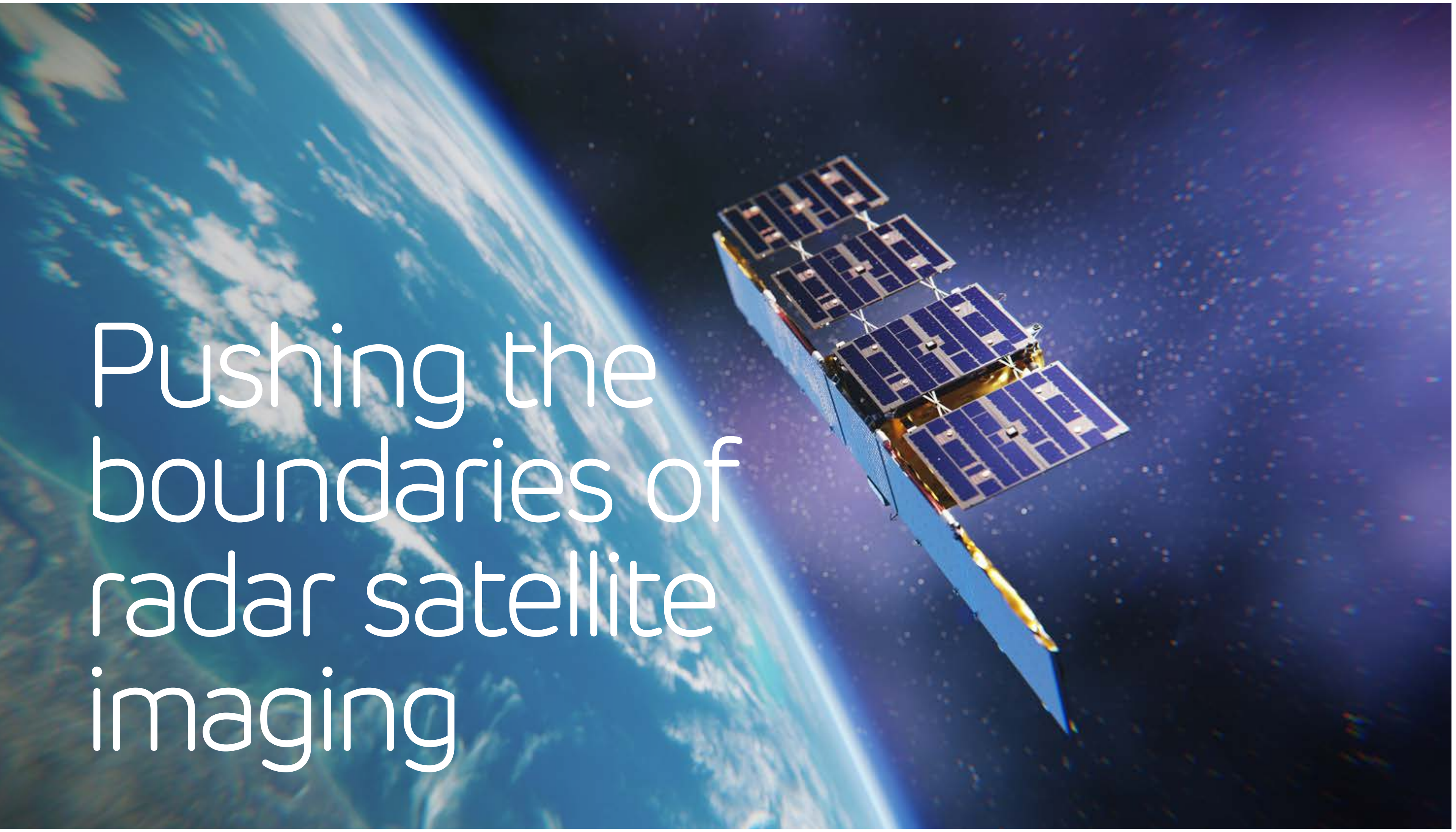
Adds Garcia, "I expect SpaceX to once again surprise people with how rapidly it is able to transition from a very experimental vehicle to operating an incredibly efficient launch system." That could ultimately see a refined Starship launching from multiple sites, including the Cape and Boca Chica. "If SpaceX really is trying to fly this thing 1,000 times a year, they may need more launch pads," says Garcia. "That would be three flights a day."

Dumbacher is similarly bullish. "I have no doubt that it's going to be successful. It's just going to be a matter of how much time and effort it's going to take."

Given Starship's potentially transformative capabilities, both with the amount of mass each rocket could take to space — up to 250,000 kilograms — and the design's touted low-cost of operations, many are eager to see fully operational launches soon.

Whether those launches will predominately take place from the Cape or Starbase remains to be seen.

"Two years ago, the idea was that Boca Chica would be this major launch facility," says Eric Roesch, a U.S.-based environmental compliance and policy expert. "I think that is very much to be determined." ★



Pushing the boundaries of radar satellite imaging

When imaging a ground target, the amount of detail a synthetic aperture radar satellite can depict depends in part on how long it can observe the target. One of the commercial leaders in the field, the Finnish company ICEYE, has nearly tripled how long each of its satellites can observe a target. ICEYE's John Cartwright explains the history of its Dwell product inaugurated in May.

BY JOHN CARTWRIGHT

How do you spot military equipment in a dense forest on a cloudy day? How do you tell if a ship has moved in the last few hours and where it's heading? These are the kinds of questions those in the defense and intelligence community are faced with every day as they endeavor to make strategic decisions to protect their people and their national interests in situations with otherwise sparse and imperfect information.

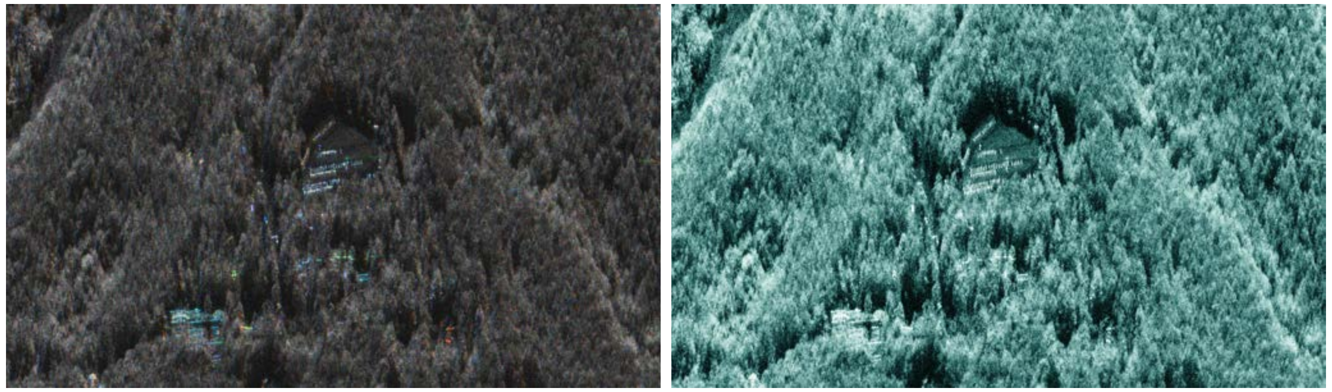
Nowhere is that truer than in Ukraine, a land with cloudy winters and millions of hectares of forests lush with pine, oak and beech trees. In the year and a half since Russia invaded, the country has also become the most high-profile example of the role of satellite imagery in executing security missions. Flooding from the Kakhovka Dam breach last month further demonstrated the importance of highly detailed imagery and rapid monitoring so decision-makers can understand the changes taking place on the ground and make better, data-driven decisions.

More help is on the way. I work for ICEYE, the Finland-based radar satellite operator and data provider. In May, we inaugurated Dwell, a new imaging product that was born from an experiment four years ago. This is the story of how we brought Dwell to market to address the need for a high density of detailed, actionable information delivered at a high frequency. It's the latest innovation under our corporate mission of providing Earth observation data for risk mitigation, natural disaster response, infrastructure monitoring and defense and security, among other uses.

We maintain the world's largest constellation of synthetic aperture radar (SAR) microsatellites, which provide persistent monitoring of locations anywhere on Earth in near-real time, 24 hours a day, in any weather. SAR offers a distinct advantage over traditional electro-optical imagery. While EO requires a light source to illuminate locations, SAR images are constructed by rapidly bouncing radar waves off the terrain so that the movement of the satellite creates

▲ ICEYE technicians conduct tests on the company's first satellite, X1. The microwave-sized satellite, equipped with a single X-band synthetic aperture radar, was launched by an Indian Polar Satellite Launch Vehicle in January 2018. The operational satellites are the size of washing machines.

ICEYE



the equivalent of a large camera aperture. Because radar waves pierce cloud cover, dust and smoke, SAR satellites can detect what is happening on land or sea, day or night, in any weather.

We have two dozen SAR satellites in orbit that can acquire and deliver images daily or subdaily. While previously our satellites could illuminate a specific location up close for 10 seconds, with Dwell we can now focus on an area for 25 seconds, giving much more insight into what's happening on the ground in near-real time. This was achieved through the agility of our satellites, an adjustment of the aspect angle and the creation of a new SAR processor. As a result of the longer data collection time, we were able to develop data products that combine increased image fidelity with colorized imagery and video outputs — which previously didn't exist in the commercial imagery industry.

The development journey

When we germinated the idea for Dwell in 2019, it was simply an experiment. We wanted to see what would happen if we shined the radar beam from one of our SAR satellites on one spot for a very long time. What could we generate from that data, and what would the functional applications be?

We started with a proof of concept just to see whether it was even possible. Early data was collected from a variety of locations, including an array of reflectors ranging in size from nearly 5 meters to less than a meter in Rosamond Dry Lake bed in California's Mojave Desert.

Because our satellites are small and light, about the size and weight of a washing machine, we're able to maneuver them easily with their electrically powered ion thrusters, and this gives us more control over the radar beam. Fuel constraints aren't a concern, because the thrusters are powered by electricity derived from sunlight. Ultimately, 25 seconds struck a balance that provides significantly more data while still fitting within the space and ground segment capabilities of our constellation.

For some background on that, our satellites employ three main modes of image collection — Strip, Scan and Spot. Scan mode focuses on a 100-by-100 kilometer area and is useful for monitoring large-scale events, like searching for and monitoring maritime traffic on vast sea areas. Strip covers a 50-by-30 kilometer swath of the Earth. This mode is invaluable for activities such as monitoring icebergs for marine and maritime safety.

Spot zeros in on a 5-by-5 or 15-by-15 kilometer area, allowing for detection of objects as small as a set of tire tracks when two images acquired with identical geometry are compared. Our team recognized that finding a way to enhance the level of detail and visual acuity with a view this close up could be transformative for defense and intelligence agencies in the United States and other upstanding members of the community of nations.

Going from 10 seconds for a Spot image to 25 seconds of collection time for a Dwell image was no small feat. We had to physically rotate the satellite for a period of 25 seconds to keep it on target, while keeping it physically stable and to maintain focus. In the end, we built and installed an entirely new SAR processor on the satellite to utilize the reflected radar pulses at these extreme angles and efficiently process the approximately 20-times-greater amount of data.

The development process moved slowly by our standards because we had to ensure we could produce and deliver product rapidly enough to meet our partners' needs. Decisions must be made quickly in defense and intelligence; it doesn't take long for intel to become too stale to be of much use. We also had to make sure we had the capacity in place to provide the end product at scale. Our satellites can be upgraded during their entire operations life cycle, so we've been able to implement Dwell mode on spacecraft already in space. Our ground terminal network, backhaul, ground systems and distribution systems can all handle the heavier data weight of the Dwell product.

Along the way, we continued to refine Dwell, calibrating and validating the data on test areas. We were thrilled by the amount of information gained from a single satellite pass and how exceptional the level of detail was. Individual gravestones in a cemetery appeared from beneath a forest canopy. Objects as narrow as a power line popped out easily from the trees.

▲ One of the features of ICEYE's Dwell mode is a method of distinguishing human-made items and structures. In the image at left of a forest, the buildings are highlighted in color to make them stand out from the surrounding trees.

ICEYE

Clarity, color and video

The result is a bundle of three components. The Amplitude product significantly reduces the speckle that makes images appear grainy by integrating numerous independent looks into a multilooked product. Now analysts can more easily interpret what they're seeing and classify objects with more confidence. We can distinguish between a bulk cargo ship and an amphibious assault ship. What once would've been an indeterminate aircraft is now an SU-35 fighter jet.

The Color Sub-Aperture Image product distinguishes human-made objects from the natural environment. Objects with human-made features appear brightly colored in images, with differences in colors indicating different reflection angles — versus natural backgrounds, which tend to be rendered in gray in the Color Sub-Aperture Image component of the Dwell bundle. This not only makes objects stand out from between trees and other natural cover, but it also helps differentiate between large single objects like buildings and clusters of smaller individual objects like military vehicles.

The Dwell data is processed into multiple image frames. Similar to animation, these images are overlapped and stacked to create a video, the third component of the Dwell bundle. This video capability allows for monitoring of movements and tracking of behavior patterns. Analysts can track the motion, heading, velocity and speed of land vehicles and marine vessels. Bright reflections of human-made objects pop through dense forests.

Our team released a preview of the forthcoming video capability at the Satellite 2020 Conference & Exhibition in Washington, D.C. Sample videos of Heathrow Airport in London, the Bingham Canyon mine in Utah, a port in Busan, South Korea, and the bustling cities of Las Vegas and Tokyo highlighted the broad applications of Dwell for detecting and monitoring human-made moving objects like motor vehicles, airplanes, helicopters and aquatic vessels.

We began our pilot phase with a few customers in March 2021. The feedback we received was overwhelmingly positive. It was immediately clear that the product filled a critical need for our partners.

Launching the future of SAR

We launched Dwell during the GEOINT Symposium in St. Louis in May so that we could share it with the broader geospatial intelligence community. We're collecting Dwell images daily for our customers now.

There's still much more we hope to do with Dwell as we continue to explore the possibilities of SAR technology. There is potential to collect data for even longer durations. We are working on developing new imaging modes and exploring other capabilities to expand our offerings. In June, we launched four more satellites that will further add to Dwell's capabilities.

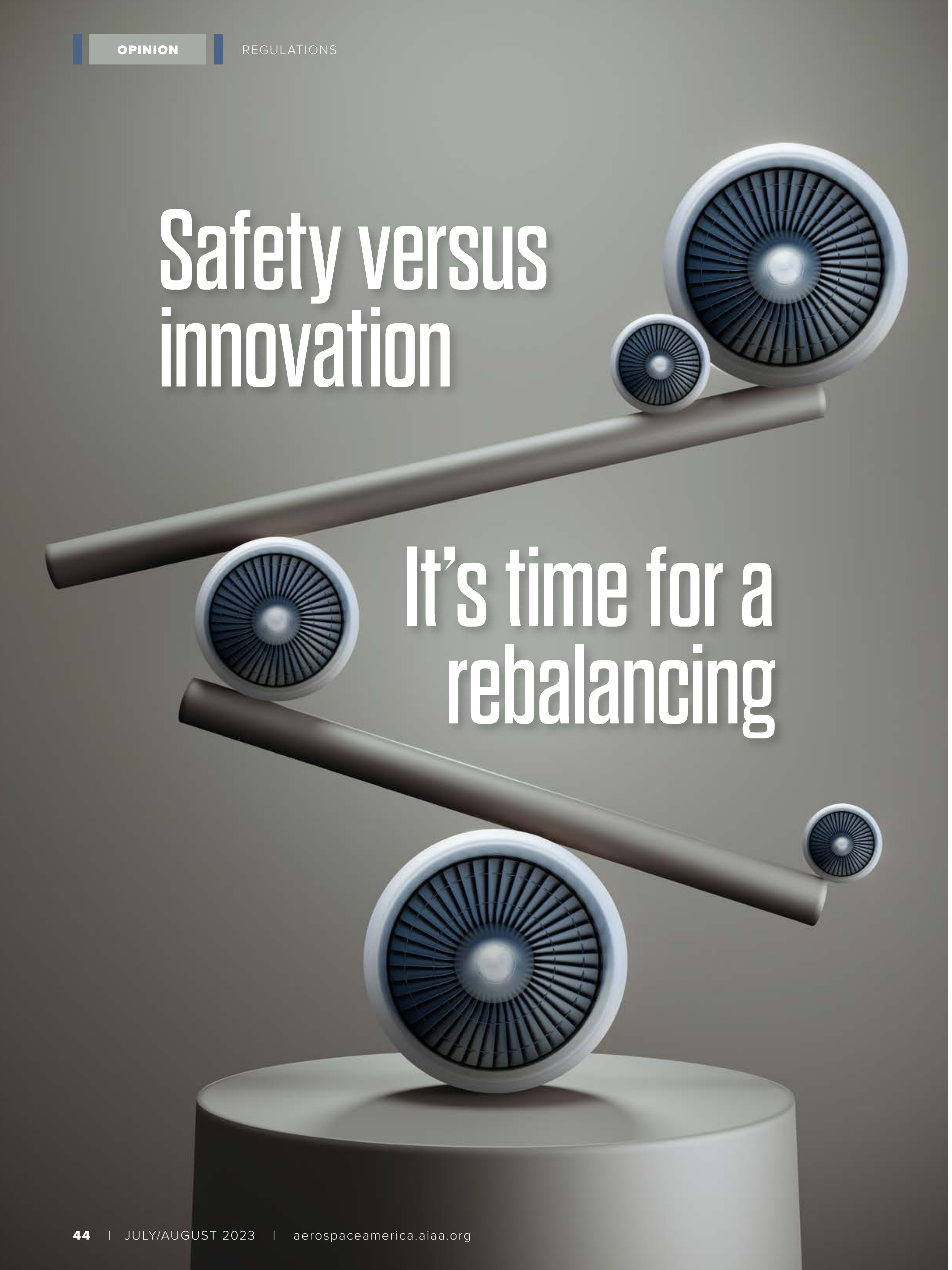
Demand for more advanced Earth observation and change-detection products is growing — the events of the last 18 months have made that clear. Last August, we partnered with the Government of Ukraine to provide SAR satellite imaging capabilities and help fulfill its need for objective data and technological support.

Space technology and innovation — once led by a handful of the world's governments — is now driven by commercial companies large and small. ICEYE moves quickly, with both new generations of spacecraft and also rapid advances in processing technology, to respond quickly to customers' needs with innovative new products. Our aim is to continue developing reliable, timely solutions that burst through the barriers of conventional imaging. As the new space industry grows and evolves, it will expand the limits of what's possible, be ready to meet moments of global consequence and change the way we look at our world from space. ★

▲ ICEYE used images taken by its synthetic aperture radar satellites to create this visualization of Kherson Oblast, Ukraine. The June 6 destruction of the nearby Kakhovka Dam prompted flooding of the Dnipro River that partially or completely submerged surrounding towns and villages.

ICEYE

John Cartwright works in Denver as head of product for the data line of business of ICEYE, headquartered in Helsinki. He holds a Ph.D. in astrophysics from Caltech.



Safety versus innovation

It's time for a rebalancing

The air transportation industry has for years toyed with radical new designs but in the end has always stuck with the familiar tube-and-wing approach in the face of FAA's safety standards. Mislav Tolusic of the venture capital firm Marlinspike argues that accepting more risk will spark needed innovation. BY MISLAV TOLUSIC

Safety has its costs. Some are visible, as in the cost to install seat belts in cars. Others are invisible, as in the opportunity cost of innovations that are never made. These invisible costs are hard to calculate, but they are very real. In the 1960s, U.S. regulatory agencies started imposing more stringent performance standards on industry. Congress in 1962 granted the Food and Drug Administration powers to require proof of efficacy of new drugs before their release. This regulation not only increased the costs of developing and manufacturing drugs but also slowed the rate of innovation. Much like FDA's actions, FAA regulatory efforts have slowed innovation in aviation and, in some cases, completely stopped it.

If the United States wants to lead the way in aviation innovation, Congress should fundamentally revisit the regulatory approach applied by FAA.

Risk aversion

Before we turn to aviation, consider that FAA long ago established an expected casualty rate for members of the public from commercial rocket launches. FAA's acceptable expected casualty rate (injuries and deaths) stands at 30 per million missions, which works out to 0.00003 casualties per mission. As of now, exactly no one (excluding astronauts) has ever been killed in a rocket launch from the U.S. or by falling debris, my research shows. Meanwhile, in our daily lives, we accept that 20 people out of 100,000 will die each year in nonoccupational accidents, compared to an expected .003 casualties (injuries and deaths) each year in commercial space operations. These rates might have changed a bit in the years since FAA published them in an "Advisory Circular" in 2000 but not enough to undermine the point: For every death associated with rocket launches, we can expect 6,666 deaths from everyday risks.

Turning specifically to aviation, a person is almost three times more likely to die by lightning than in a commercial or general aviation plane crash, according to Allianz, the global insurance giant based in Germany. The reality is that our aviation safety standards have become excessive. Better would be to align aviation risks with those of automobile travel.

Cost of innovation

The economic costs of safety regulations are visible when one examines the cost of developing aircraft through history in constant 2004 dollars. The DC-6 was introduced 12 years before FAA was established, and it cost $144 million to develop. The Boeing 707 was introduced in 1958, the same year FAA was established, and it cost $1.3 billion. Costs exploded from there to $14.4 billion for the Airbus A380 introduced in 2007 and to $13.4 billion for the Boeing 787 introduced in 2012 [See graphic on p. 46].

Development costs are, of course, related to duration of aircraft development cycles. The development of the DC-3 started in 1934; two years later, the aircraft was in service with American Airlines. Today, according to FAA, certification of a new aircraft can take between five and nine years. Despite the technological advances of the last 90 years in computer simulation, software, aeronautics, materials science and other areas, the time and cost to develop aircraft have dramatically increased.

Not only are development costs soaring, but the speed of air travel is declining. The 1950s-designed Boeing 707 had a cruising speed of 525 knots, while today's Boeing 787 cruises at 488 knots. Most modern airlines have cruise speeds between 480 and 510 knots. In 1973, FAA finalized a regulation banning civilian aircraft from flying faster than Mach 1 over land in the United States and from a certain offshore distance where sonic booms could reach land. FAA's ban on supersonic flights effectively shut down innovation on commercial supersonic aircraft.

High regulatory costs also make it more financially advantageous for manufacturers to stay with established designs. Certifying changes to an existing aircraft design takes three to five years. It took five years to certify the MAX version of the Boeing 737 and eight years to certify the 787, a new design. It is no wonder that Boeing continues to make incremental improvements to the existing tube-and-wing jet concept it pioneered in the 1950s and '60s, rather than shifting to more advanced designs like the X-48B Blended Wing Body and X-48C Hybrid Wing Body, whose flights Boeing concluded a decade ago. Another byproduct of the regulatory environment is today's market duopoly between Airbus and Boeing. If regulatory costs were reasonable, new companies could be expected to enter and disrupt the market with newer and better products.

As matters stand, the principle of creative destruction in a marketplace has ceased to function.

Beyond air transportation, the drone industry has also been a casualty of an excessive regulatory environment. California-based Zipline offers drone delivery services. Despite being based in the U.S., one of the largest logistics markets in the world, the company has yet to roll out nationwide delivery services. Currently, the company offers limited services in Utah, Arkansas and North Carolina. However, it has been operating widely in Rwanda since 2016 and Ghana since 2019 and reportedly has logged some 400,000 flights and traveled some 43 million kilometers under autonomous operations. The main obstacles to a U.S.-wide rollout are the incredibly low risk of a collision with a passenger aircraft or injuries to those

Aircraft development costs (2004 dollars)

FIRST YEAR OF SERVICE	AIRCRAFT	COST IN MILLIONS
1936	Douglas DC-3	$4
1946	Douglas DC-6	$144
1958	Boeing 707	$1,300
1970	Boeing 747	$3,700
1995	Boeing 777	$7,000
2007	Airbus A380	$14,400
2012	Boeing 787	$13,400

Graphic by Thor Design | Source: "The Geography of Transport Systems," 5th Edition

Boeing calls the eight-year certification process for its 787 Dreamliners, shown here at the factory in Everett, Washington, "the most rigorous" in the company's history.

Boeing

on the ground. These excessive safety concerns by FAA are standing in the way of billions of dollars in economic activity and innovation and ironically are preventing drones from delivering lifesaving medical supplies and equipment to rural areas.

The way forward

To reignite the engines of innovation and entrepreneurialism, Congress should instruct FAA to revise regulatory goals, adjust risk standards and revisit regulatory cost-benefit analysis protocols.

Let's first look at regulatory goals. FAA's mission statement says: "Our continuing mission is to provide the safest, most efficient aerospace system in the world." However, FAA's Aircraft Certification Service describes its contribution to FAA's mission purely in terms of safety: "AIR supports this mission by assuring aircraft that operate in the [National Airspace System] meet safety standards and society's expectations for safety." This singular focus on safety means that the organization is not concerned with economics or overall suitability of the standards, and that's why the aircraft certification process is long and expensive. To pressure FAA to deliver on the efficiency aspect of its mission, Congress should require the agency to state its goals for the year in the following three parameters, and in a report to Congress, reconcile those goals with what has actually been achieved:

1) Creation of economic activity

The Bureau of Economic Analysis breaks down contribution to gross domestic product by industry. Using BEA's analysis, we can see how the aerospace industry contributes to gross domestic product. FAA's mandate should be tied to the creation of economic activity; this would be a huge incentive for FAA to be more cautious when investigating accidents and deeming one-off problems as systemic. It would also incentivize the agency to develop less onerous rules and regulations, shortening the certification process and allowing innovative companies like Zipline to more quickly develop domestic operations.

2) Increase in speed of travel

Most passengers would agree that the ultimate reason for air travel is speed — the less time aboard the plane, the better. Measuring aircraft speed would align goal incentives of FAA with a general performance matrix that passengers value. Increasing the speed of travel should lead to faster airplanes; commercial supersonic flights should not be a distant memory from the 20th century.

3) Duration and cost of certification process

Product cycles in information-technology industries are less than two years. In IT terms, the five years that it takes, at best, to certify a new design would be the equivalent of a lifetime; the nine years it can take is an eternity. If FAA were incentivized to shorten the certification process, we could expect aircraft product development cycles to decrease. Likewise, we should also expect a decline of aircraft development costs. If aircraft development costs were again measured in millions versus billions, we could expect an aerospace revolution. New companies would enter the market, there could be a path to hypersonic travel, electric vertical takeoff and landing aircraft would not be a distant dream and, perhaps, we might even have personal flying cars.

Adjust the risk standards

Baseline safety standards should reflect everyday risks. While FAA likes to remind us that flying is safer than driving, the general public doesn't consider driving to be a dangerous activity. It is perfectly reasonable for airplanes and cars to have the same safety standards. As a starting point for reform, FAA should ease its current safety standard, which says that fatal events (like a complete loss of an aircraft's flight control system) should happen no more than once in a billion flying hours. This standard is unrealistically high; the 737 is Boeing's best and longest selling aircraft. As of 2014, these aircraft had collectively flown 264 million hours, meaning that the cumulative flying hours for all 737s ever built are still nowhere close to a billion. If we lower the risk standard, we can expect a decrease in the product development cycles, which should lead to shorter aircraft service lives as new aircraft are developed at a faster rate. End results will be cheaper aircraft and a more innovative industry.

Adjust the cost-benefit methodology

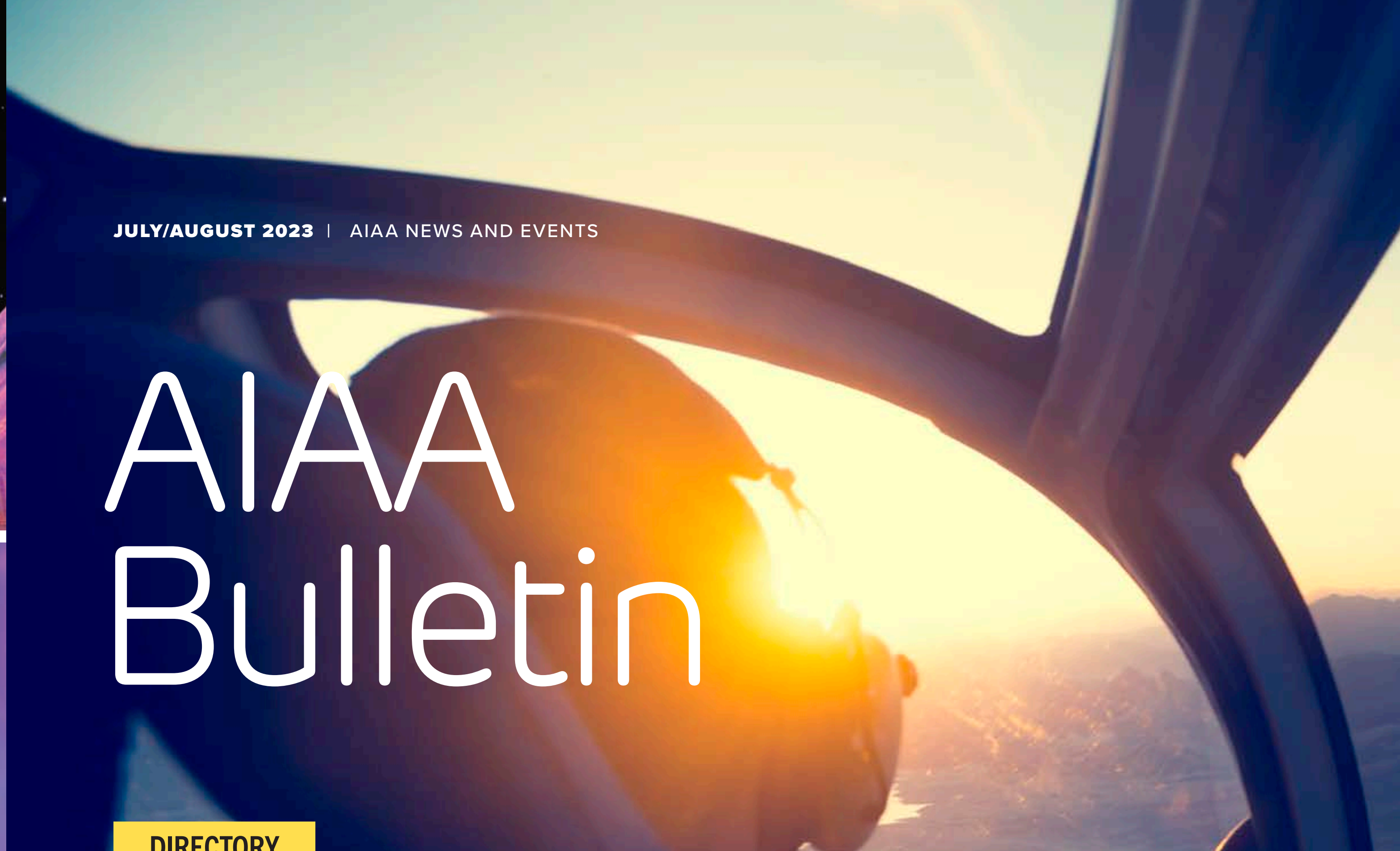
Some government agencies use value of statistical life estimates to effectively put a price on human life. The idea behind the VSL is to understand how much people would pay to reduce the possibility of dying; that reduction is then converted into how much the public values a life. The VSL is used to ensure that the benefits of regulations exceed the imposed costs.

The Department of Transportation sets the VSL used by FAA. Today, the VSL is set at $12.5 million. However, according to recruitment firm Zippia, an average U.S. worker earns $1.7 million over a lifetime, meaning the VSL is valuing lives at seven times the average lifetime earnings. The current VSL approach does not deliver realistic results, and it would be more logical to adjust the VSL to our economic realities. For every fatality, the economy at large loses one unit of lifetime earnings. Resetting the VSL to actual lifetime of earnings would make much more sense.

Current elevated VSL levels allow government agencies to easily enact costly mandates. For example, if a new regulation would save 80 lives, a billion-dollar regulatory burden, in this view, becomes justified. FAA only needs to prove that one aircraft would be saved from crashing. As a result, aircraft manufacturers are spending hundreds of millions of dollars just to certify a commercial airliner. Implications on innovations are very real — investors shy away from investing in commercial aircraft manufacturing companies. If we reduce the VSL, we can expect regulatory costs to come down and investor interest to increase.

The current regulatory system is highly restrictive and, as a result, the rate of innovation has slowed and, in some cases, stopped altogether. In the 1960s as we entered the jet age, the Jetsons showed us what a future with flying cars could look like. Sixty years later, personal flying cars are still only garage projects; flying from New York to London takes longer than it did in the last century; and drone deliveries at scale are only possible in countries with underdeveloped regulatory agencies. This is the status quo we have been living in for the last couple of decades. The time has come to analyze the outcomes of current regulatory approaches and revise these approaches to foster more innovation. ★

Mislav Tolusic is a managing partner at Marlinspike, a venture capital firm in Washington, D.C.



AIAA Bulletin

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

Calendar

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.).

FEATURED EVENT

23–25 OCTOBER 2023
Las Vegas

Building our sustainable off-world future requires long-term thinking. Strategic planning, innovation, scientific exploration, and effective regulations and standards will help us preserve space for future generations. Join us at ASCEND and participate in the technical exchanges and collaboration that will help forge a sustainable off-world future for all.

www.ascend.events

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2023			
14–16 Jul*	2023 International Conference of Unmanned Aerial Systems	Toronto, Canada (www.icuasa.org)	
19–28 Jul	Aircraft Maintenance Management Course	ONLINE (learning.aiaa.org)	
13–17 Aug*	2023 AAS/AIAA Astrodynamics Specialist Conference	Big Sky, MT (https://space-flight.org)	
11–14 Sep	Foundations of Digital Engineering Course	ONLINE (learning.aiaa.org)	
12–13 Sep	Fundatmentals of Space Domain Awareness Course	ONLINE (learning.aiaa.org)	
18 Sep–25 Oct	Spacecraft Design, Development, and Operations Course	ONLINE (learning.aiaa.org)	
18–28 Sep	Aircraft Reliability & Reliability Centered Maintenance Course	ONLINE (learning.aiaa.org)	
19 Sep–12 Oct	Fundamentals of High Speed Air-Breathing and Space Propulsion Course	ONLINE (learning.aiaa.org)	
22 Sep	AIAA Rocky Mountain Annual Technical Symposium 2023	Fort Collins, CO (www.aiaa-rm.org/)	
26 Sep–19 Oct	Practical Approach to Flight Dynamics and Control of Aircraft, Missiles, and Hypersonic Vehicles Course	ONLINE (learning.aiaa.org)	
2–6 Oct*	74th International Astronautical Congress	Baku, Azerbaijan (iac2023.org)	
2–18 Oct	Overview of Python for Engineering Programming Course	ONLINE (learning.aiaa.org)	
10–13 Oct	Applied Model-Based Systems Engineering (MBSE) Course	ONLINE (learning.aiaa.org)	
10–26 Oct	Metal Additive Manufacturing for Aerospace Applications Course	ONLINE (learning.aiaa.org)	
16–19 Oct	Space Domain Cybersecurity Course	ONLINE (learning.aiaa.org)	

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2023			
23–25 Oct	ASCEND Powered by AIAA	Las Vegas, NV	22 March 23
24 Oct–2 Nov	Technical Writing Essentials for Engineers Course	ONLINE (learning.aiaa.org)	
28–29 Oct	SmallSat Education Conference	Kennedy Space Center, FL	25 May 23
30 Oct–15 Nov	Hypersonic Applications: Physical Models for Interdisciplinary Simulation Course	ONLINE (learning.aiaa.org)	
31 Oct–16 Nov	Space Architecture: Designing an Orbital Habitation System Course	ONLINE (learning.aiaa.org)	
7–16 Nov	Business Development for Aerospace Professionals Course	ONLINE (learning.aiaa.org)	
17–16 Nov	Wind Tunnel Testing for Aircraft Development Course	ONLINE (learning.aiaa.org)	
17–18 Nov	AIAA Young Professionals, Students, and Educators (YPSE) Conference	Laurel, MD (www.aiaaypse.com)	
27–28 Nov	AIAA Region VII Student Conference	Canberra, Australia, & Online	7 Sep 23
4–7 Dec	Aircraft and Rotorcraft System Identification Engineering Methods for Piloted and UAV Applications with Hands-on Training Using CIFER® Course	ONLINE (learning.aiaa.org)	
2024			
6–7 Jan	2nd AIAA High-Fidelity CFD Verification Workshop	Orlando, FL	
6–7 Jan	Design of Experiments Course	Orlando, FL	
8–12 Jan	AIAA SciTech Forum	Orlando, FL	25 May 23
2–9 Mar*	IEEE Aerospace Conference	Big Sky, MT (www.aeroconf.org)	
16–18 Apr	AIAA DEFENSE Forum	Laurel, MD	17 Aug 23
29 Jul–2 Aug	AIAA AVIATION Forum	Las Vegas, NV	30 Nov 23
30 Jul–1 Aug	ASCEND Powered by AIAA	Las Vegas, NV	
9–13 Sep*	34th Congress of the International Council of the Aeronautical Sciences	Florence, Italy (icas2024.com)	
14–18 Oct*	75th International Astronautical Congress	Milan, Italy (iac2024.org)	

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

● AIAA Continuing Education offerings

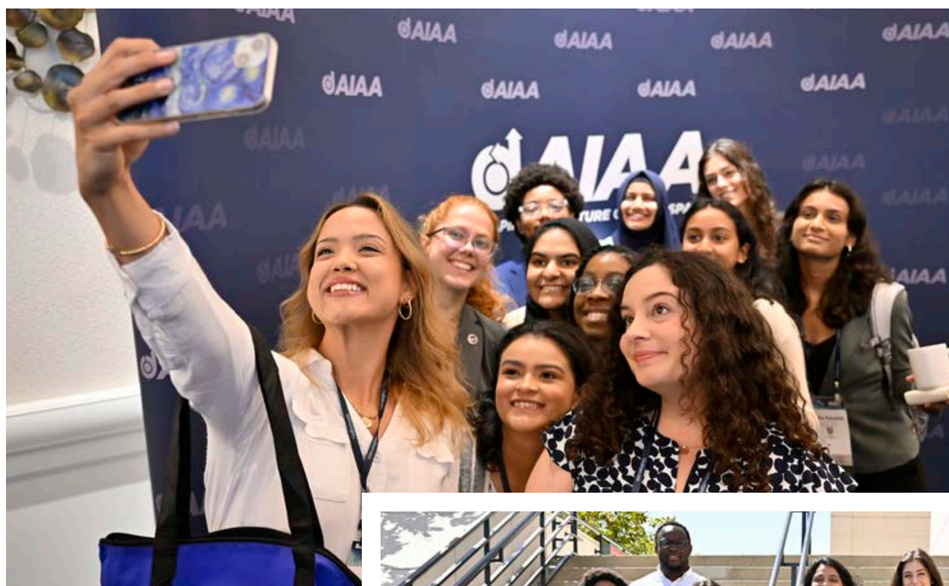
MAKING AN IMPACT

AIAA Diversity Scholars at AIAA AVIATION Forum

Eighteen AIAA Diversity Scholars attended AIAA AVIATION Forum, 12–16 June, in San Diego. A collaboration between the AIAA Foundation and The Boeing Company, the AIAA Diversity Scholarship was created to provide networking and engagement opportunities at AIAA events to students from backgrounds that are traditionally underrepresented in the industry. These students receive round-trip airfare, a complimentary hotel stay, event registration, and additional targeted programming that may help them succeed in the aerospace industry. They also receive a complimentary AIAA student membership.

Scholars at AIAA AVIATION Forum attended the plenary and Forum 360 sessions, as well as the Rising Leaders in Aerospace events and other special sessions targeted specifically for the scholars.

Diversity scholarships will be offered at the upcoming ASCEND space event and 2024 AIAA SciTech Forum. AIAA welcomes applications from minority students in all disciplines with an interest in aerospace, including but not limited to STEM fields, communications, law, industrial design, journalism, and political science. Please visit **aiaa.org/diversity scholars** for more information.



AIAA Sections Host Students To Launch Program

On 20 May, two local AIAA sections hosted Students To Launch (S2L) Hub events in their communities. Sponsored by the AIAA Foundation, S2L focuses on inspiring middle school students from underrepresented communities to learn more about aerospace, aviation, and STEM fields and careers. Local AIAA section members joined the fun and participated as volunteers as students built and launched water bottle rockets.

Cedric Turner, a 2022 recipient of the Trailblazing STEM Educator Award, is leading STEM efforts and activities in his community through his non-profit, Empower Yourself LTD. Sixty-eight middle school students attended the Hub event at Brockton High School, Brockton, MA, with support from the AIAA New England Section.

Robin Houston, a volunteer on the AIAA STEM K-12 Outreach Committee and founder of the FIRE Rocket Challenge, hosted 52 middle school students at Capitol Technology University, Laurel, MD. Members of the AIAA National Capital Section and Mid-Atlantic Section helped support this event.

Students To Launch works with informal educational institutions across the country call "S2L Hubs." Middle school students are invited to participate in hands-on role-playing challenges to complete NASA-inspired missions together in small teams under the guidance of the program leaders, called Mission Directors. For more information please visit **aiaa.org/get-involved/k-12-students/students-to-launch.**

Are You Teaching Model Rocketry to Your Elementary School Students? Would You Like to?

AIAA and our partners, Estes Education and National Science Teaching Association, are excited to announce three new lesson plans for elementary-aged students. Dive into the new Weather and Model Rockets Playlist, especially designed to ignite curiosity and enthusiasm for model rockets, while also promoting equitable learning experiences, and aligning with the Next Generation Science Standards.

Every lesson is free! Students will dive into scientific concepts related to forces and motion, climate, and weather for successful model rocket launches. They will ask and discover the answers to questions like, "How can weather conditions affect the flight of a rocket?", "How can we predict and measure weather conditions to choose a safe launch date?", and "How can we plan a safe and successful model rocket launch?"

View all the free lessons at **nsta.org/exploration-generation**.

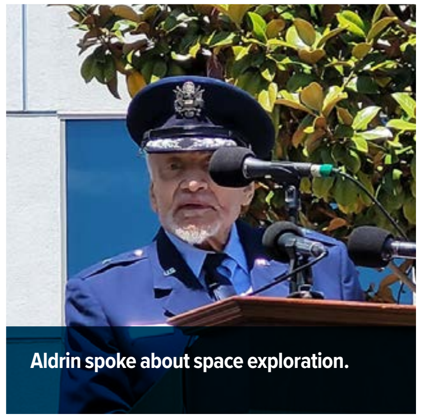
AIAA LA-LV Section Members Attend AIAA Fellow Aldrins' Honorary Appointment to Brigadier General

By Kenneth Lui, Rick Garcia, and Jeff Puschell, AIAA LA-LV Section

Aldrin's family places the new Brigadier General's shoulder patches.

Members of the LA-LV Section attending the ceremony: (l to r) Rick Garcia, Ken Lui, Jeff Puschell, and Ben Price.

Aldrin reaffirms his military oath, administered by Maj. Gen. Guetlein.



Aldrin spoke about space exploration.

On 5 May, members of the AIAA Los Angeles-Las Vegas (LA-LV) Section attended a ceremony honoring Apollo 11 astronaut and fighter pilot Buzz Aldrin's honorary appointment as U.S. Air Force Brigadier General. Maj. Gen. Michael Guetlein, USSF, Commander of Space Systems Command, gave the opening remarks before Congressman Ken Calvert (R-CA-41) explained the process for making the promotion proposal. Gen. Lester L. Lyles, USAF (Ret.) highlighted the importance of pursuing the sciences, engineering, and research fields in astronautics and space studies, noting how crucial they are as an essential pathway for U.S. Air Force Airmen and Space Force Guardians to excel.

The placement of Aldrin's new Brigadier General's shoulder patches was done by his wife, Anca Aldrin, and another family member. Maj. Gen. Guetlein then reaffirmed the military oath with Aldrin on his promotion to (Honorary) Brigadier General (USAF) from his previous USAF Colonel rank (retired).

Aldrin spoke next, mentioning the legacy of our American space heritage and the challenges in venturing from the aerospace to astronautic realms. He also discussed his involvement with the National Space Council in outlining the new NASA Gateway program, which will serve as a multi-purpose outpost orbiting the moon providing essential support for long-term human return to the lunar surface and a staging point for deep space exploration. The ceremony also included a special flyover of two F-18 and a reception.

Outreach and community engagement are essential activities of the AIAA LA-LV Section and on this occasion a few members of the U.S. Space Force, Space Systems Command expressed interest in the Institute and its section activities. Engagement with the men and women of the U. S. Space Force, U.S. Air Force, U.S. Navy, and DoD components during these prized events provides us an integral part in building an aerospace community. As a result, we are continuously able to socialize the value, impact and foster AIAA membership.

Nominations for Speaker of the AIAA Council of Directors Are Being Accepted Through 15 September 2023

The Institute is currently seeing nominations for the Speaker of the AIAA Council of Directors for the term May 2024–May 2027. AIAA members may self-nominate or nominate members qualified for the open position. The AIAA Council of Directors Nominating Committee will compile a list of potential nominees for the Speaker of the AIAA Council of Directors; this list will include nominees who will be selected to go to the next step of competency review held by the nominating committee. The nominating committee will select specific candidates for the Speaker position who will be voted on by the AIAA Council of Directors in January 2024.

The Speaker is the presiding officer of the Council of Directors and is the point of contact between the Council of Directors and the Board of Trustees, thus providing the communication conduit between the membership and the Board. The Speaker is responsible for developing the agenda for the Council and leading all Council meetings. The Speaker works with the Council to ensure implementation of the Institute's strategic initiatives as well as integration of activities across the Regional Engagement Activities Division (READ), Technical Activities Division (TAD), and Integration and Outreach Division (IOD). The Speaker works closely with the AIAA President, AIAA Executive Director, and AIAA Governance Administrator to ensure coordination of volunteer and staff activities throughout the Institute.

The Speaker should possess an understanding of the AIAA governance structure and operation and have a working knowledge of the operations within the three functional divisions (READ, TAD, and IOD) that operate under the Council of Directors. The Speaker must have excellent communication and organizational skills.

Please go to AIAA Nominations and Elections (**aiaa.org/about/Governance/nominations-and-elections**) to learn more and submit nominations no later than 15 September 2023, 1800 hrs ET.

VFS photo by Warren Liebmann.

Johnson Receives Guggenheim Medal

On 18 May, the Vertical Flight Society held its awards ceremony at the 79th Annual Forum & Technology Display. The Daniel Guggenheim Medal was presented to **Wayne Johnson** for his landmark contributions to vertical flight aeronautics and resulting computational codes enabling the design of tiltrotor aircraft, electric vertical takeoff and landing (eVTOL) aircraft, and the Mars Helicopter Ingenuity.

The Guggenheim Medal was established in 1929 to honor innovators who make notable achievements in the advancement of aeronautics, and is jointly sponsored by AIAA, the American Society of Mechanical Engineers (ASME), SAE International, and the Vertical Flight Society.

Diversity Corner

Dianne Chong, Ph.D., AIAA Associate Fellow

NAME: Dianne Chong, Ph.D.

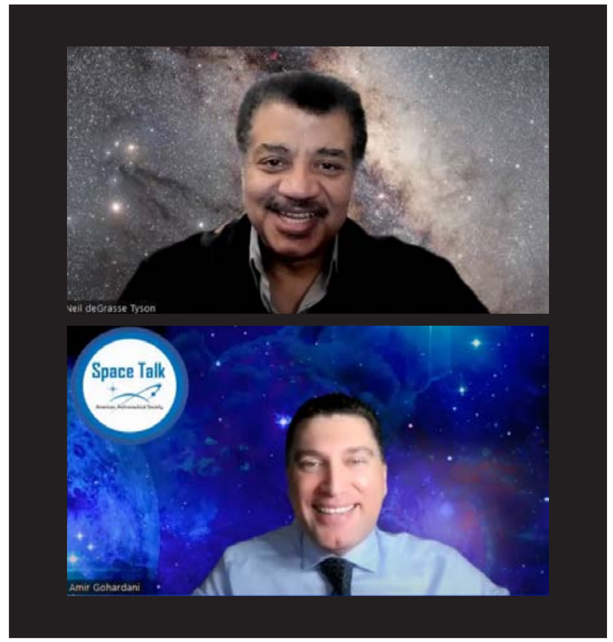
NOTABLE CONTRIBUTIONS: Chong was the vice president in The Boeing Company's Engineering, Operations & Technology organization, where she managed materials and manufacturing processes, as well as program integration. In 2019, she received an award for alumna achievement from the University of Illinois and she has received numerous other technical and diversity awards. Chong earned bachelor's degrees in biology and psychology from the University of Illinois. She also holds master's degrees in physiology and metallurgical engineering. In 1986, Chong received her doctorate in metallurgical engineering from the University of Illinois. She has an Executive Master of Manufacturing Management degree from Washington University and a green belt in Six Sigma.

POTENTIAL SOCIETAL IMPACT OF CONTRIBUTIONS: In 2017, Chong was elected to the National Academy of Engineering (NAE) and the Washington State Academy of Science. She is a member of the NAE Council, co-chairs EngineerGirl, and serves on multiple NAE committees. Chong is also a member of the National Academies' Governing Board and a member of the Division of Behavioral and Social Sciences and Education Advisory. She is the past-president of ABET and serves on its Inclusion, Diversity, and Equity Advisory Council. Chong has served on the ASM International board, is a fellow of ASM, and was elected its first female president (2007–2008). Additionally, Chong is the immediate past president of SME and a Fellow of SME.

*In collaboration with the AIAA Diversity and Inclusion Working Group and Claudine Phaire, SAT OC is highlighting prominent members of the wider aerospace community in the Diversity Corner.

SAT OC and the 2023 Activities

By: Amir S. Gohardani, SAT OC Chair



The AIAA Society and Aerospace Technology Outreach Committee (SAT OC) recently held a committee meeting to greet new committee members, update the membership about ongoing endeavors, and focus on new initiatives and the need for further planning. With its membership at an all-time high, SAT OC is becoming increasingly involved in upcoming technical conferences. For AIAA forums, the SAT OC typically solicits papers for the Society and Aerospace Technology track that examine the societal benefits of aerospace technologies/products, as well as the relationship between aerospace and society, culture, and the arts. The committee has seen significant interest in this track during planning for the 2024 AIAA SciTech Forum in Orlando, FL. Contemplating the impact of aerospace technology on society is an ongoing process, and the SAT OC is pleased to provide a forum for discussions about this topic.

Continuous outreach and formation of subcommittees is also one of the many activities of this committee. SAT OC welcomes new opportunities to engage with other AIAA committees in pursuit of its committee goals. One of the latest outreach activities has been to underline aerospace-related activities in collaboration with other organizations outside of AIAA, including on Space Talk by the American Astronautical Society. Space Talk's episodes are planned to spread knowledge about space-related activities to anyone with Internet access, free of charge. As the host of Space Talk, I recently had the opportunity to speak to Neil deGrasse Tyson about several topics including his new book, *Starry Messenger*. SAT OC continues to look for opportunities to serve the community and bring important aerospace-related topics to light.

AIAA Awards Special Service Citations to Members

The Regional Engagement Activities Division (READ) awarded two Special Service Citations to volunteer leaders who have gone above and beyond in serving AIAA.

Emily Matula, NASA Johnson Space Center
For inspiring future engineers through exemplary STEM outreach to students and outstanding mentorship and engagement of engineers and teachers in STEM.

Humberto "Tito" Silva III, Sandia National Laboratories
For outstanding service in identifying active regional student branches and creating a regional student conference rotation order for advance planning.

AIAA New England Section Hosts Honors & Awards Event

On 19 April, the AIAA New England Section hosted an Honors & Awards event at Draper Laboratory to recognize members of the New England aerospace community for their contributions in engineering and education. Amanda Simpson, vice president, Research and Technology, Airbus Americas, gave a keynote focusing on sustainable aviation and Airbus' role in developing sustainable technologies and solutions.

Tony Kourepenis, vice president, Engineering, Draper, gave an overview of his organization and recognized the contributions of AIAA Associate Fellows, Fellows, and volunteers. Christian North, a founder of the Model Aviation Club (funded with the support of the New England Section) also gave a talk on his entrepreneurial journey in building the club, sharing the passion in aerospace with his peers, and expanding the programs across the high schools in New England.

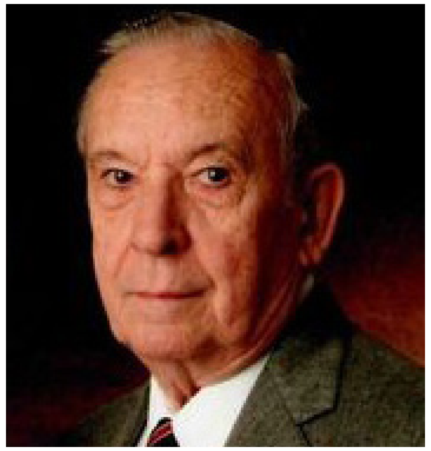
The New England Section also presented two new awards. The Young Professional Award was presented to Anthony Hazlett, GE Aerospace, for his contributions in hypersonic propulsion. The STEM Educator of the Year Award recognized three individuals from the New England region who took strong initiatives and showed consistent efforts and commitment to promote STEM education, mentorship, diversity, and equity during the past year: Durgesh Chandel, founder, WeLEAP Aerospace – Global; Nancy Gifford, educator, Middle School Science and Robotics at Monomoy Middle School; and Yiannis Levendis, Distinguished Professor, Mechanical and Industrial Engineering, Northeastern University. The awards ceremony was moderated by Shreyas Hegde, incoming section chair.

This event also served as a platform for students to network with AIAA professional members and hear about aerospace career. The students also learned more about AIAA and its role in informing and supporting their academic and professional development, and honing their professional skills.

Thank you to the event team for their significant contributions: Draper team: Jimmy Wetzel and Matt Damaniaco; AIAA team: Shreyas Hegde, Hiro Endo, Osa Osaretin, and Charlie Wilson.

Obituaries

AIAA Associate Fellow Bruyette Died in August 2020



Gerald (Jerry) W. Bruyette died on 8 August 2020. He was 95 years old.

Bruyette enlisted in the U.S. Navy in June 1941 and served as an aviator on the USS *Princeton* during World War II. Following his discharge from the Navy in 1946, Bruyette attended Syracuse University. He received his bachelor's degree in mechanical engineering in 1950.

Bruyette held many roles at McDonnell Aircraft and McDonnell Douglas throughout his career, including serving as Senior Engineer for Project Mercury Field Operations at Langley and Wallops Island, Virginia. There he helped conduct simulated flight missions in support of the manned flight program launched from Cape Canaveral. He served as Senior Group Engineer on the F-111 escape module and served as Branch Chief for the F-15 and F-18 test programs.

AIAA Senior Member Schuyler Died in April 2023

Fred Schuyler died on 5 April. He was 86 years old.

Schuyler attended Brooklyn Technical High School and earned Bachelor's and Master's degrees in aeronautical engineering from the Polytechnic Institute of Brooklyn. He received his Ph.D. from Illinois Institute of Technology in Chicago.

Upon completion of that degree, Schuyler moved to Pennsylvania where he worked for the General Electric Company in programs serving NASA's projects in designing heat shields for the manned space program. In 1969, he moved to Washington and joined the federal workforce; he retired from the Department of Energy in early 1997.

AIAA Fellow Klineberg Died in December 2022

John Klineberg, whose 25-year senior management career at NASA helped usher in many groundbreaking aeronautics and space science advances, including repairing the Hubble telescope, died on 31 December. He was 84 years old.

In 1960, Klineberg earned a B.S. in engineering from Princeton University and, in 1968, an M.S. and Ph.D. from the California Institute of Technology. Like many talented engineers at the time, Klineberg was drawn to the space program, inspired by President Kennedy's call to public service as a noble endeavor for America's best and brightest, especially to fulfill his ambitious goals for manned spaceflight.

Klineberg's career at NASA began at Ames Research Center and Headquarters in Washington, DC, where among other achievements, he championed several aeronautics research projects, and was credited with advances like new airplane wing designs, turbulence detectors, more fuel-efficient engines and research on wingtip devices that reduce drag and improve fuel consumption. In 1987 he was appointed director of NASA Lewis Research Center, a position he held until 1990 when he was appointed director of NASA Goddard Space Flight Center, winning numerous medals and awards of distinction, including an Emmy, the Presidential Rank of Distinguished Executive, and Meritorious Executive.

More importantly, in these roles, Klineberg worked with his large team, politicians, businessmen, and local union leaders to establish partnerships with local universities and businesses to source talent, support local communities, and re-invigorate investment in basic research, including aeronautics. Under his leadership, the GOES satellite network was launched to measure the impact of humans on our environment, and a successful mission to repair the Hubble Space Telescope was conducted.

In 1995, Klineberg left NASA and continued to make significant contributions to aeronautics and space systems through private industry, including at Space Systems/Loral where he lead the development and deployment of the Globalstar satellite constellation and at Swales Aerospace as interim CEO.

In addition, he continued to serve our nation as the chair of several bipartisan Congressional committees for the National Academy of Sciences and as a member of the U.S. Air Force Scientific Advisory Board until his retirement in 2010.

AIAA New Standards Project Approved and Call for Experts

The AIAA Standards Steering Committee (SSC) recently approved a new project, AIAA S-158, *Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) – Prepared Free-Flyer Capture and Release*. This document provides current industry best practices for functional and operational requirements and norms associated with the design, testing, and operations of prepared Free-Flyer Capture between Servicing Vehicle and a Client Space Object. The intent is to provide guidance to developers and operators of both the Servicing Vehicle and the Client Space Object. If you wish to participate as an expert on the committee or if you have questions, please contact Nick Tongson (nickt@aiaa.org).

JAHNIVERSE

CONTINUED FROM PAGE 64

By combining traditional observations of salmon behavior with genetic analysis, they have implemented targeted habitat restoration measures to restore the local salmon population. This harmonious collaboration exemplifies the potent synergy that emerges when indigenous wisdom and scientific innovation intertwine.

Indigenous communities also wish to contribute to the preservation of cultural heritage in space. Consider the pressing issue of space debris: For the space industry, the thousands of defunct satellites, spent rocket stages and other objects orbiting Earth threaten to render crucial orbits unusable for generations. For indigenous peoples who have long revered the night sky as a priceless tool for celestial navigation, the knowledge that humanity is polluting the heavens erodes an important part of their cultural heritage. Through partnerships between space agencies, governments, indigenous communities and scientific institutions, we can develop frameworks that prioritize sustainable practices.

Indigenous communities possess profound knowledge of ecological balance and sustainable resource management. The TEK of the Kanaka Maoli of Hawaii and the Inuit community of Canada provide insights into the delicate interplay among land, sea and sky. By integrating this knowledge with Western scientific expertise, we can develop sustainable deployment strategies for satellite megaconstellations. This collaboration could minimize creation of space debris and mitigate the impact on astronomical observations, preserving both the ecological integrity of our home planet and celestial bodies with the awe-inspiring wonders they offer.

Holistic scientific inquiry is not only a theoretical concept but also a practical and powerful approach to sustainable space exploration. By engaging with indigenous communities and integrating TEK, we can gain a deeper understanding of our interconnectedness with the cosmos. The success stories of indigenous contributions in managing environmental detriment, preserving cultural heritage, promoting sustainable utilization and embracing holistic time perspectives exemplify the transformative potential of this approach.

In our age of unprecedented data abundance, machines become indispensable allies in navigating the vast expanse of information. By applying advanced algorithms and artificial intelligence, we will unlock the potential to validate our interconnectedness. Enter the correlation pleiades, a term coined in 1931 by Russian evolutionist Paul Terentjev to describe how in some organisms there are correlations among measurable characteristics of seemingly discrete elements, making these elements a cluster, or pleiades. Taking inspiration from this concept, we can harnesses the power of machine learning to decipher hidden patterns within massive, diverse data sets. With this technological leap, we can swiftly identify correlations and gain a deeper understanding of the intricate web that sustains life on our planet.

We stand at the crossroads of a rapidly changing world. We should unite as one humanity, propelled by the power of holistic scientific inquiry to address the pressing challenges that lie ahead and forge a resilient and sustainable future for all. ★

LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1923

July 4 U.S. Army Air Service 1st Lts. Robert Olmstead and John Shoptaw win the National Elimination Balloon Race. Their S6 Army balloon travels from Indianapolis to Marilla, New York, a distance of 803.9 kilometers (499.5 miles). Several contestants experience trouble from leaky gas bags and other faulty equipment. **Aviation**, July 16, 1923, p. 71.

July 19 U.S. rocket pioneer Robert H. Goddard receives a copy of Hermann Oberth's newly published "Die Rakete zu den Planetenräumen" ("The Rocket into Interplanetary Space"). Oberth sends the book in exchange for receiving a copy of Goddard's "A Method of Reaching Extreme Altitudes," published by the Smithsonian Institution in 1919. The **Robert H. Goddard Papers**, Vol. 1, pp. 513-514.

1948

July 5 The Soviet Air Forces exhibit a number of Yak-15 jet fighters and Tu-4 bombers to Premier Joseph Stalin for Aviation Day. Pilot E. Savitskii leads a formation of five Yak-15s in the first Soviet display of group aerobatics in jet aircraft. A. S. Yakovlev, **Fifty Years of Soviet Aircraft Construction**, p. 103; **The Aeroplane**, July 30, 1948, p. 121.

1 **July 12** George Lewis, former director of aeronautical research for the National Advisory Committee for Aeronautics, dies at age 66. Lewis was named the first executive officer of NACA in 1919. He held the position until 1924, when he became director of aeronautical research. Under his leadership, NACA grew to an organization of 6,000 employees across three research centers. NACA later this year renames its Flight Propulsion Laboratory in Cleveland the Lewis Flight Propulsion Laboratory in his honor. **Aeronautical Engineering Review**, September 1948, p. 7; **Aviation Week**, July 19, 1948, p. 14.

2 **July 16** Vickers test pilot Joseph Summers completes a 20-minute "exceptionally smooth" first flight in the Vickers Viscount prototype at Wisley, near Weybridge, England. The first transport aircraft designed from the outset for turboprop engines, the Viscount becomes one of the most successful postwar transports. **The Aeroplane**, July 23, 1948, p. 94.

July 20 Sixteen Lockheed F-80 Shooting Star fighters in the U.S. Air Force's 56th Fighter Group arrive in Great Britain. Dubbed Fox Able One, the multileg journey marks the first trans-Atlantic flight by U.S. fighter jets. Led by Col. David Schilling, they left Selfridge Field, Michigan, on July 12, making stops in Maine, Labrador, Greenland, Iceland and Scotland. After arriving in Great Britain, they flew from Stornoway to Odiham, England, and then went on to Fürstenfeldbruck, Germany. **The Aeroplane**, July 9, 1948, p. 40.

1973

3 **July 4** U.S. Air Force Lt. Col. Charles Manning, Maj. Paul Schaefer and Tech. Sgt. Ed Schindler fly a Grumman HU-16B Albatross seaplane from Homestead Air Force Base, Florida, to an altitude of 32,883 feet, a new record for twin-engine amphibian aircraft. The previous record was set in 1936 by Boris Sergievsky, who flew a Sikorsky S-43 to 24,951 feet. **National Aeronautic Association News**, August 1973.

July 11 The Soviet Union launches its Molniya II-6 communications satellite from Plesetsk. The satellite is to provide long-range telephone and telegraph radio communications in the country and to transmit Soviet TV programs to the Orbita network. **New York Times**, July 12, 1973, p. 4.

July 16 NOAA's Improved Tiros Operational Satellite is launched on a two-stage Thor-Delta booster, but the rocket begins tumbling a few minutes into flight and fails to achieve orbital velocity. The meteorological satellite, which would have been designated NOAA 3 if it had reached its sun-synchronous orbit, was designed to take day and night cloud-cover photos and take global-scale measurements of Earth's atmospheric structure. NASA, **Aeronautics and Astronautics, 1973**, p. 212.

July 19 NASA's X-24B Lifting Body completes its first captive flight from NASA's Flight Research Center, California, attached to a modified Boeing B-52 Stratofortress. Following a glide flight by NASA test pilot John Manke on Aug. 1, the craft is propelled on subsequent flights by its Reaction Motors XLR-11 rocket engine, the same design that powered the Bell X-1. NASA, **Aeronautics and Astronautics, 1973**, p. 216.

July 19 U.S. heart specialist Dr. Paul Dudley White sends the first telegram between the U.S. and the People's Republic of China via the Intelsat IV F-4 satellite to inaugurate direct communications between the General Administration Telecommunications in Peking and the New York headquarters of Western Union International. White was one of the first U.S. physicians to visit the PRC in 1972. **New York Times**, July 20, 1973, p. 27.

4 **July 21 and 25** The Soviet Union launches its Mars 4 probe from the Baikonur Cosmodrome, the first of two orbiters launched toward Mars this month. Mars 4 approaches Mars in February 1974 but is unable to slow itself enough to enter orbit, due to the failure of two onboard computers. The spacecraft takes 12 photographs as it flies past Mars, making a closest approach of 1,844 kilometers. On July 25, the Mars 5 probe launches from Baikonur and also reaches Mars in February 1974. This orbiter enters Mars orbit but ceases operations weeks later. It returns 180 photographic frames, 43 of which were of usable quality, as well as data on the nature of the Martian surface. **New York Times**, July 12, 1973, p. 8 and later issues. **Washington Post**, July 25, 1973, p. B19 and later issues.

5 **July 23** Retired U.S. Army Air Corps Capt. Edward Rickenbacker, the most decorated U.S. pilot of World War I, dies at 82 at Zurich, Switzerland. A race car driver, he became a pursuit pilot in 1918 after receiving five weeks of training — 25 hours in the air. He shot down his first enemy plane that April, the first of 26 aircraft he brought down during the war. He also downed four enemy balloons. After the war, he joined Eastern Airlines and retired as chairman in 1963. **Washington Post**, July 24, 1973.

July 23-28 The first U.S. women's helicopter team competes in the World Helicopter Championships at Middle Wallop, England. **National Aeronautic Association News**, August 1973, p. 1.

July 26 This date marks the 10th anniversary of the launch of NASA's Syncom 2, the first communications satellite to relay digital data, telephone conversations, picture facsimiles and TV programs from geosynchronous orbit. **NASA Release** 73-140.

July 28 NASA astronauts Alan Bean, Jack Lousma and Owen Garriott are launched in their Apollo spacecraft by a Saturn IB rocket from NASA's Kennedy Space Center in Florida for the Skylab 3 mission. Hours later, they dock with the Skylab 1 orbital workshop. Their 59-day stay, the second crewed mission of the Skylab program, consists of scientific experiments in the areas of medical activities, solar observations and Earth resources, among others. **Washington Post**, July 28, 1973, and later issues.

1998

July 4 Japan launches its Nozomi spacecraft, the country's first Mars probe. Nozomi is equipped with 14 scientific instruments, with contributions from the U.S., Canada, Germany and Sweden, and is to test the effect of the solar wind upon Mars' carbon dioxide atmosphere and photograph the dust storms. While en route, the spacecraft loses an unspecified amount of propellant due to a faulty valve, delaying its planned arrival at Mars by four years. In 2003, days before Nozomi is scheduled to reach Mars orbit, its main thruster fails, so the spacecraft completes a flyby 1,000 kilometers from the Martian surface. **Flight International**, July 15-21, 1998, p. 24.

6 **July 7** Two remotely controlled satellites dock for the first time. Mission controllers in Japan commanded the Orihime and Hikoboshi satellites, built by Japan's National Space Development Agency, rendezvous, maneuver and dock to test how future uncrewed spacecraft might dock with the International Space Station. NASA, **Astronautics and Aeronautics, a Chronology: 1996-2000**, p. 151.

7 **July 21** Former NASA astronaut Alan Shepard Jr. dies at 74, two years after being diagnosed with leukemia. A naval aviator, Shepard was one of the original Mercury Seven astronauts and became the first American to go to space in 1961 when he completed a 15-minute suborbital flight in the Freedom 7 spacecraft. Shepard later commanded the Apollo 14 moon landing, delighting television viewers when he hit two golf balls using a modified lunar sample tool fitted with a 6-iron head. Shepard later served as chief of NASA's Astronaut Office and retired from the agency and the U.S. Navy in 1974 with the rank of rear admiral. NASA, **Astronautics and Aeronautics, a Chronology: 1996-2000**, pp. 154-155.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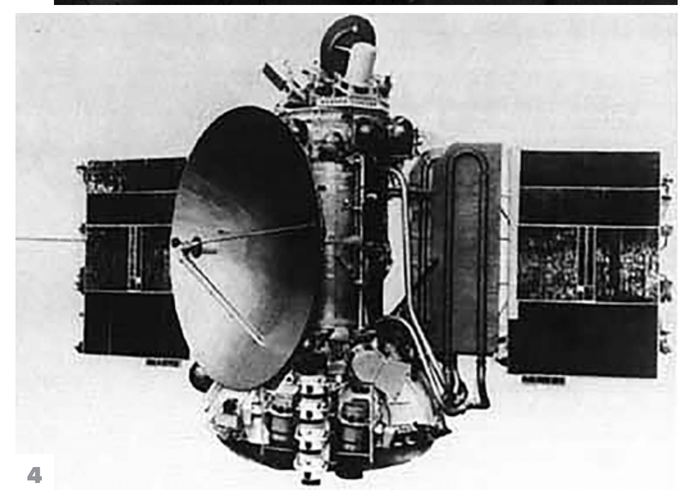
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LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1923

1 **Aug. 20** The giant U.S. Navy airship ZR-1 floats for the first time at Lakehurst Naval Air Station, New Jersey. Later renamed the USS Shenandoah, it measures 207 meters in length and 24 feet in diameter. It is the first rigid airship built in the United States. **Jane's All the World's Aircraft**. 1924, p. 5d.

Aug. 20 In "the greatest demonstration of air power in this country since the World War," the U.S. Air Service carries out a series of maneuvers under simulated war conditions in a flight along the Eastern Seaboard from Langley Field, Virginia, to Bangor, Maine. An armada of 16 Martin bombers covers the nearly 1,300 kilometers in 8.5 flying hours. At Mitchell Field near Garden City, Long Island, seven DH-4B planes join the Martins; together they simulate bombings along the route. **Aviation**, Sept. 10, 1923, pp. 305-306.

Aug. 21 Electric-arc beacons are illuminated at 42 landing fields on a route between Chicago and Cheyenne, Wyoming, in preparation for an around-the-clock demonstration of air mail service conducted Aug. 22-25 by the U.S. Post Office's Air Mail Service. U.S. Air Force, **A Chronology of American Aerospace Events**, p. 25.

2 **Aug. 22** The six-engined Barling bomber makes its inaugural flight at Wilbur Wright Field, Ohio. Piloted by U.S. Army Air Force Lts. Harold Harris and Muir Fairchild, the plane flies 25 miles in 28 minutes and reaches 150 kph. Walter Henry Barling, designer of the craft, was one of the crew members. With a wingspan of 37 meters, height of 12 meters and length of 20 meters, the Barling is the world's largest aircraft. **Aviation**, Sept. 3, 1923, p. 281.

3 **Aug. 27-28** U.S. Army Air Service Capt. Lowell Smith and Lt. John Richter set several world records in an aerial-refueled flight from Rockwell Field, California. They fly their de Havilland DH-4B for 37 hours, 15 minutes, traveling a total distance of 5,300 kilometers (3,293.26 miles). **Air Service News Letter**, Oct. 27, 1923, pp. 5-8.

1948

Aug. 7 Frederick "Casey" Baldwin, the first British and Canadian subject to fly an airplane, dies at 66. In 1907, Baldwin, formed the Aerial Experiment Association with Alexander Graham Bell, Glenn Curtiss, Douglas McCurdy and U.S. Army Lt. Thomas Selfridge. One of the first aeronautical research bodies in the world, the AEA concentrated on the development of flight vehicles, including aircraft and large kites. Baldwin piloted the inaugural flight of the first AEA-designed vehicle, the "Red Wing," in 1907. He later designed a second aircraft, the "White Wing." After two years, the members dissolved the AEA to carry out their individual work with greater interchange of information on a broader scale. **The Aeroplane**, Aug. 20, 1948, p. 208; J.H. Perkin, **Bell and Baldwin**, pp. 40-69.

Aug. 15 Francis Rogallo flies his first flexible-wing kite, or parawing, at Merrimac Shores in Hampton, Virginia. He refines the "Rogallo wing," and NASA later studies its use as an auxiliary wing to aid in takeoff of heavily loaded aircraft, among other applications. Helicopters towing the flexible Rogallo wings can transport six times as much weight in troops, cargo or fuel. Rogallo's work began with toy kites, and then he and his wife, Gertrude, built several "truly flexible wings" of cloth. It was these that they first successfully flew. **Letter** to F.H. Winter from Francis M. Rogallo, May 15, 1973; **Ryan Reporter**, February 1962, pp. 7-9; **Washington Post**, June 25, 1961, p. E3.

4 **Aug. 16** The prototype of Northrop's XF-89A Scorpion all-weather fighter completes its first test flight at Muroc Dry Lake, California. The twin-engine turbojet becomes one of the mainstays of the U.S. Air Force Air Defense Command during the 1950s. The final F-89J featured 104 unguided air-to-air rockets mounted in wingtip pods. **Jane's All the World's Aircraft**, 1949-50, p. 264c; **Aviation Week**, Aug. 9, 1948, p. 16.

5 **Aug. 23** The tiny McDonnell XF-85 Goblin parasite fighter makes its first flight. Designed for air launching and air recovery from the forward bomb bay of a Convair B-36 bomber, the aircraft is propelled by a single Westinghouse J34-WE-22 turbojet engine. **Flying Review International**, December 1967, pp. 1060-1062; William Green and Roy Cross, **The Jet Aircraft of the World**, p. 85.

1973

Aug. 1 NASA's X-24B Lifting Body makes its first glide flight. After release from a B-5 aircraft, NASA test pilot John Manke maneuvers the X-24B to evaluate its flight characteristics and makes a practice approach that ends in a 230 kph unpowered landing on the dry lake bed near NASA's Flight Research Center at Edwards Air Force Base, California. **Los Angeles Herald-Examiner**, Aug. 2, 1973.

6 **Aug. 3** NASA's Flight Research Center announces that former astronaut David Scott has been appointed deputy director of the center. Scott was commander of the 1971 Apollo 15 moon landing and commander of the 1966 Gemini 8 mission that achieved the first docking of two spacecraft in orbit. He was also command module pilot of the 1969 Apollo 9 mission. NASA, **Aeronautics and Astronautics, 1973**, p. 238.

Aug. 5 and 9 The Soviet Union launches its Mars 6 and 7 probes four days apart. The spacecraft, each consisting of an orbiter and lander, both carry Soviet and French science instruments to study the sun's radio emissions and characteristics of the solar plasma and cosmic rays. Mars 6 and 7 reach Mars in 1974, but only the Mars 6 lander begins a descent toward the surface. The lander's descent stage stops transmitting data shortly before it is scheduled to touch down. The Mars 7 lander deploys from the orbiter prematurely and never reaches the planet. **New York Times**, Aug. 7, 1973, p. 19. NASA, **Aeronautics and Astronautics, 1973**, p. 242.

Aug. 7 The Johns Hopkins University Applied Physics Laboratory in Maryland holds the first public demonstration of a heart pacemaker that uses electronics designed by NASA for spacecraft use. The pacemaker has modified satellite power cells and is smaller and longer lasting than conventional models, among other advantages. **Washington Post**, Aug. 8, 1973.

Aug. 20 This date marks the 20th anniversary of the first Redstone missile launch. After five years of test launches, the U.S. Army declares the design operational in 1958. Months later, a modified version of the Redstone design launches Explorer 1, the first U.S. satellite. In 1961, a Mercury-Redstone launches the first U.S. crewed spaceflight: astronaut Alan Shepard Jr. in the Freedom 7 capsule. **Marshall Space Flight Center Release** 73–112.

Aug. 23 An Atlas-Centaur rocket launches the Intelsat-IV F-7 communications satellite. From its geosynchronous orbit over the Atlantic Ocean, the satellite is to add a dozen TV channels to those available between the U.S. and other countries and increase the telephone capacity by 3,500 two-way circuits. NASA, **Aeronautics and Astronautics, 1973**, pp. 250-251.

Aug. 24 NASA announces that scientists at its Ames Research Center in California have developed a miniaturized radio transmitter in pill form to monitor temperatures in the human body. During trials in a simulated space environment, the transmitter detected minute temperature variations to alert doctors about possible infections. **NASA Release** 73-167.

Aug. 27 NASA's Manned Spacecraft Center in Texas is officially rededicated the Lyndon B. Johnson Center in a ceremony attended by NASA Administrator James Fletcher, Texas Gov. Doph Briscoe and former First Lady Lady Bird Johnson. A bust of former President Johnson, who died in January, is also dedicated by the Houston Chamber of Commerce, and the Johnson Spaceflight Center Visitor Center opens a Johnson Room to display the original U.S. copy of the Treaty for the Peaceful Uses of Outer Space, signed in 1967 during Johnson's administration. **New York Times**, Aug. 28, 1973, p. 24.

Also in August The Naval Research Laboratory in Washington, D.C., reports that it is converting a number of Minuteman 1 second stages into large-payload-capacity, high-performance sounding rockets for X-ray astronomy research. The surplus second-stage motors are adapted with specially designed nosecones and scientific payloads for forthcoming experiments. NRL scientists are to use instruments aboard the new sounding rockets, named Aries, to determine ultraviolet background levels of the stars from above the atmosphere. **Naval Research Reviews**, August 1973, pp. 27-28.

1998

Aug. 13 The penultimate crew of cosmonauts to visit the Russia's Mir space station is launched into orbit from the Baikonur Cosmodrome. The three-person crew consists of cosmonauts Sergei Avdeyev and Gennady Padalka and former Kremlin defense adviser Yuri Baturin. After 12 days on orbit, Baturin departs Mir with cosmonauts Talgat Musabayev and Nikolai Budarin, who had spent 207 days aboard the station. NASA, **Astronautics and Aeronautics, a Chronology: 1996-2000**, p. 159.

Aug. 26 The inaugural launch of a Boeing Delta III rocket ends shortly after liftoff when the rocket explodes over the Atlantic Ocean, destroying the Galaxy X communications satellite it was carrying. NASA, **Astronautics and Aeronautics, a Chronology: 1996-2000**, p. 161.

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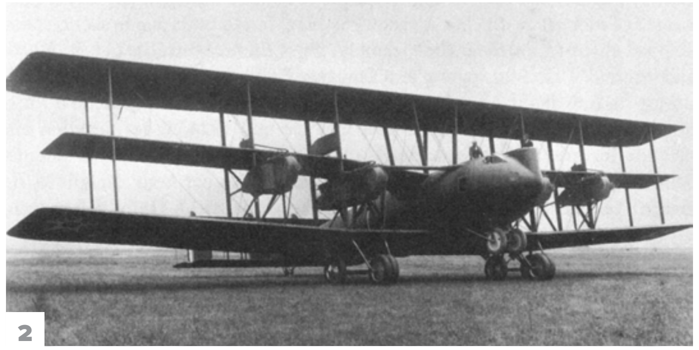
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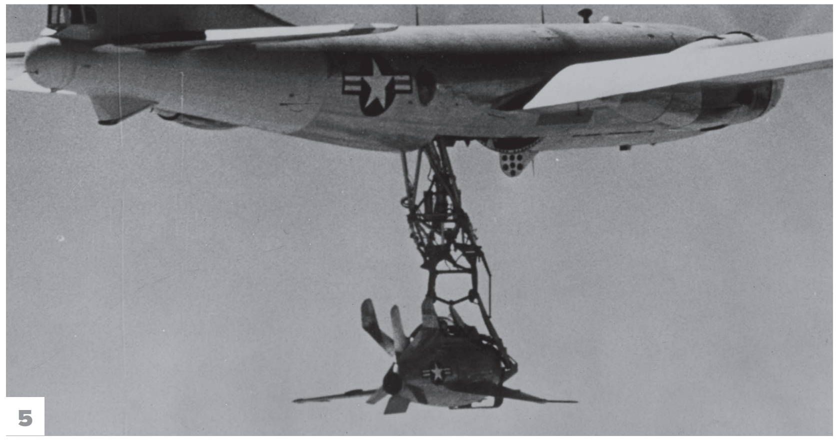
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Indigenous peoples have much to teach us about sustainability, even in space

BY MORIBA JAH | moriba@utexas.edu

Moriba Jah is an astrodynamicist, space environmentalist and associate 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.

To avoid the perils of self-extinction, we need to renew our commitment to an intergenerational contract of stewardship, one that acknowledges our responsibilities as custodians of the planet. Indigenous communities worldwide have long understood this profound connection, integrating their wisdom into sustainable practices that harmonize with nature.

The time-honored traditions of Native American tribes, the Kanaka Maoli of Hawaii, the Aboriginal people of Australia and others demonstrate the power of traditional ecological knowledge, or TEK. This term is used by anthropologists, environmentalists and others to describe the timeless practices that indigenous people apply to protect ecosystems and promote resilience. By fusing TEK with Western science and leveraging cutting-edge machine learning, we can validate our interconnectedness and ignite empathy. Acceptance of our interconnectedness and empathy toward others are the driving forces for solving the world's wicked problems. Our collective future hinges on embracing this holistic approach and nurturing a shared sense of stewardship for generations to come.

For the space community, part of that stewardship entails understanding and mitigating the environmental impact of expanding our activities beyond Earth's atmosphere. Traditional scientific methods alone are insufficient in addressing this impact. Instead, we must adopt an approach that integrates TEK and Western science — a method I call holistic scientific inquiry.

To see the effectiveness of this approach, look no further than the inspiring efforts of the Haida Nation, an ancient tribe that resides on an archipelago off the coast of British Columbia.

CONTINUED ON PAGE 59