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It might seem natural: Fly optionally piloted helicopters to do the dangerous business of fighting wildfires at night. But not everyone agrees.

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AEROSPACE AMERICA

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Keith Button

Keith has written for C4ISR Journal and Hedge Fund Alert, where he broke news of the 2007 Bear Stearns scandal that kicked off the global credit crisis.

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Adam Hadhazy

Adam reports on astrophysics and technology. His work has appeared in Discover and New Scientist magazines.

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Cat Hofacker

As our staff reporter, Cat covers news for our website and regularly contributes to the magazine.

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Moriba Jah

Before becoming an associate professor at the University of Texas at Austin, Moriba helped navigate the Mars Odyssey spacecraft and the Mars Reconnaissance Orbiter from NASA's Jet Propulsion Lab and worked on space situational awareness issues with the U.S. Air Force Research Laboratory.

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Jan Tegler

Jan covers a variety of subjects, including defense. He's a frequent contributor to Defense Media Network/Faircount Media Group and is the author of the book "B-47 Stratojet: Boeing's Brilliant Bomber," as well as a general aviation pilot.

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Debra Werner

A frequent contributor to Aerospace America, Debra is also a West Coast correspondent for Space News.

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▲ **The Perseverance** rover, scheduled to arrive on Mars in February, is part of the Mars Sample Return Campaign, an international collaboration.
NASA

The broader significance of sampling Mars

A successful Mars Sample Return Campaign, whose complexities we chronicle in the feature starting on Page 32, would exemplify the amazing feats that governments can achieve when they coordinate to harness private-sector innovations and honor their commitments from one political administration to the next.

In fact, it's tempting to declare that the sample return endeavor could become a template for how to solve just about any problem that's too big for one nation, entrepreneur or billionaire. The trouble is the timeline. We won't know for a decade if NASA and the European Space Agency succeed at bringing home some Martian dirt and rocks. We can't wait that long to find a template for more effective global responses to pandemics, climate change, wildfires and whatever is next.

So, we should look at Mars Sample Return in another way. The work to date shows that international coordination and planning can unfold efficiently even in a highly politically charged environment, one in which the United States has fallen out of sync with its European partners on matters from the environment to national defense to the response to the pandemic.

I know that NASA has established an independent review board to examine the feasibility of the complex orchestration of space launches and rendezvous encounters still to come to complete the campaign. I don't view this review as evidence of weakness. The likely outcome will be a stronger plan and higher odds of success.

Of course, it's space exploration, so this is where a wise writer acknowledges that success can't be guaranteed. No matter what happens, the Perseverance rover, on its way to Mars now as the first step in the broader sample return effort, will fascinate us with its views and in-situ studies of this once watery region, provided it arrives safely on the surface in February. Dropping tubes of samples to be picked up later by a European rover will be a huge bonus. ★

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

Amassing metrics for space system management

Moriba Jah has written a thoughtful and constructive assessment of the need for assembling reliable metrics to facilitate the proper management of operational space systems ["Acta Non Verba: That should be the motto for NASA's Artemis Accords," July/August]. He observed that "you can't enforce what you don't know, and you don't know what you can't measure, like where objects in space are located."

It is the case, as pointed out by Jah, that individual countries lack the resources to generate this situational awareness, and "collectively they lack a common pool of globally collected and shared space situational awareness measurements and information, such as the locations of objects and their sizes, shapes, materials and purposes."

Jah concluded: "The key to making the Artemis Accords a reality lies in such monitoring and assessment of the activities of partners for compliance. Those who fail to comply should be held accountable with clear and quantifiable consequences that must still be established. One country or entity cannot do this alone: continued supervision will require global cooperation."

Political, economic and cultural competition has been long practiced among the nations of the Earth. From time to time, the dominantly competitive spirit has been set aside, for various reasons and accords have been reached between and among nations in their common interest. When the need exists, the agreements are reached.

In brief, the number of nations participating in space activities is continually increasing. A quick check of the United Nations Office of Outer Space Affairs in Vienna shows that there are, in addition to all the relevant international agreements relating to space activities, at least 25 recorded sets of national laws in place to provide the supervision and some possible continued monitoring of space activities as required by the 1967 Space Treaty's Article VI. What has yet to be seriously considered is satisfying the need for an international agency that would be competent to assemble, maintain and report the appropriate metrics to allow proper monitoring of space activities.

Perhaps it is time for the United States representative to the next meeting of the United Nations Committee on the Peaceful Uses of Outer Space recommend the committee study dealing with means of securing needed and appropriate metrics to monitor and report on the activities of states in the exploration and use of outer space, including the moon and other celestial bodies. Through constructive discussion at the U.N. it may be possible to move realistically toward an effective means to assemble the needed metrics. ★

Stephen Doyle, AIAA member
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CLARIFICATION

The article "Cosmic GPS" [May] should have noted that while the OSCAR-40 experiment marked the first full demonstration of GPS signal availability above the altitude of the GPS constellation, at least two other signal experiments were run separately prior to OSCAR-40. The U.S. Air Force Academy's Falcon Gold satellite in 1997 and the European Space Agency's Equator-S satellite in 1998 both received timing and positioning signals from GPS satellites, making initial characterizations of this signal availability beyond the constellation.

Let us hear from you

Send letters to letters@aerospaceamerica.org. Letters may be edited for length and clarity and may be published in any medium.


SCITECH FORUM
REIMAGINED
The 2021 AIAA SciTech Forum, the world's largest event for aerospace research and development, will be a comprehensive virtual experience. The reimagined forum will explore the role and importance of diversity in advancing the aerospace industry. The diversification of teams, industry sectors, technologies, design cycles, and perspectives can all be leveraged toward innovation. The virtual program is being developed with a global audience in mind, allowing you to tune in from every time zone. Join fellow innovators in a shared mission of collaboration and discovery.
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Now Is the Time

Diversity and inclusion are fundamental to innovation and creativity, principles that guide the aeronautics and astronautics fields. In the face of recent racially charged injustices, we have a critical opportunity to pause to assess where we are as a society and where we need to be as an industry. As so many long-standing space-related barriers have been shattered — including the first all-female spacewalk in October 2019 made by Jessica Meir and Christina Koch and the first commercial-based space mission and recovery — the potential in our industry is endless.

Martin Luther King Jr. succinctly stated, "Injustice anywhere is a threat to justice everywhere." It is hard to envision a just future when our community remains plagued by inequity and systemic discrimination. In a time reminiscent of the Civil Rights Era, society has taken to the streets in the form of the Black Lives Matter movement to demand change. Change begins with the steps we consciously make within our own communities. It begins here. Having been part of the aerospace community for over two decades, I would be remiss if I didn't encourage the AIAA community to seize the moment to make everlasting change. Real change is achieved through persistent dialogue, empathy, education, and most importantly — action.

The aerospace industry owes a substantive amount of its success to its diverse citizenry. Black women such as Katherine Johnson, Dorothy Vaughan, and Mary Jackson made it possible to put man on the moon, yet their thanks were belated by decades. Diversity is not achieved by meeting a quota for the inclusion of people of differing races, genders, and so on; diversity is achieved when those people have an equitable seat at the table. Diversity and inclusion in the aerospace community is pivotal for everyone to see themselves represented at every tier.

AIAA is the world's largest technical society dedicated to the global aerospace profession, encompassing nearly 30,000 members hailing from 91 countries and welcoming the support of 95 corporate members. With such a global, strong internal community, now is the time to build upon the progress of our past and our recent milestones to boldly chart the way forward. While we take pride in our diverse membership and in educating the community about diversity and inclusion, we still have a significant way to go. We must epitomize a diverse leadership full of role models to establish a positive mentoring and nurturing environment.

Now is the time to shape the future of the aerospace industry by utilizing and optimizing the contributions of the entire workforce. Taking a step in this direction, AIAA created the Diversity and Inclusion Working Group with the aim to encourage participation and collaboration across all genders, ethnicities, and races to enhance our representation of the entire industry. I encourage all members to collaborate with this working group to improve the overall success of our industry.

To meet the challenges of the 21st century and rise to the expectations of civil unrest, we must continuously strive for a diverse workforce. Successful execution of this is dependent upon an environment that promotes individual respect, values dignity, and encourages professional growth. The complexity of aerospace problems is not diminishing; it is surging. The power to meet rising challenges head on and overcome them lies in diversity. Multifaceted problems demand multifaceted solutions, which can only be derived from a group of people with different identities, strengths, backgrounds, and ideas. This is the meaning, the benefit, and the celebration of diversity.

While many programs target increasing diverse engagement in the STEM fields, we must do more. We must direct our effort at supporting and retaining new entrants to the aerospace workforce to ensure a sustainable future for the industry. Our efforts to increase diversity in the workforce must be coupled with an increasing support of a culture of inclusion. Failure to do so is not an option; our ability to attract, develop, and retain a quality diverse workforce is the key to the industry's continuing success.

Over the past two years, AIAA has hosted 159 Diversity Scholars from underrepresented backgrounds to attend AIAA forums. The AIAA Diversity Scholars Program seeks to provide opportunities to underrepresented university students who have an interest in or are pursuing an aerospace degree to attend an AIAA forum, the goal being allowing Scholars the opportunity to experience first-hand the breadth and depth of opportunities across aerospace-related fields.

Our industry is well equipped to tackle the challenges that lay before us. I applaud the actions already taken in the commitment to advancing diversity and inclusion. Each of us has a vital role to play in onboarding diverse staff; creating a culture of inclusion to assist in retention; providing deliberate mentoring, advocacy and sponsorship; and holding ourselves and our industry accountable to addressing diversity and inclusion challenges. This industry has proven that the sky is no longer the limit. We will not only rise to the occasion—we will soar. ★

Jandria Alexander
Booz Allen Hamilton
Chair, AIAA Diversity and Inclusion Working Group

AERO PUZZLER

Do you have a puzzler to suggest? Email us at **aeropuzzler@aiaa.org.**

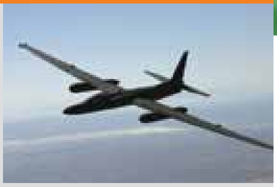
Not so dicey

Q: A simulation expert known for her wry sense of humor is headed to a famous casino on the French Riviera to celebrate the 100th successful flight of a prototype maneuverable hypersonic aircraft. The sponsor had fretted that the aircraft would fly out of control, but after inputting the results of numerous subscale component trials and conducting rigorous statistical sampling and simulations, she accurately predicted that the odds of that were low. What is the name of her destination, and what is its significance for simulation?

Draft a response of no more than 250 words and email it by noon Eastern Sept. 10 to aeropuzzler@aiaa.org for a chance to have it published in the October issue.

FROM THE JULY/AUGUST ISSUE

MAGNIFICENT MATCH: We asked how a U-2 pilot flying in the tropics might be able to fly at just a few knots of ground speed, like a magnificent frigatebird.



WINNER: This is possible due to the high winds associated with tropical weather in the magnificent frigatebird's habitat, the relationship between indicated airspeed, true airspeed and ground speed, and the low stall speed achievable by the U-2. For the U-2 to remain airborne and achieve this feat, the U-2 wing must produce sufficient lift at the low speed. We will assume that the pilot is flying into a severe tropical storm. Tropical storms have winds up to ~63 knots and have lower pressure and higher temperature than normal standard atmospheric conditions. The U-2 has a stall speed of ~65 knots indicated airspeed during tropical storm conditions (higher temperature, lower pressure). Under this condition the U-2's knots true airspeed is ~68 knots. With a headwind of ~63 knots, the U-2 pilot can achieve a ground speed of just a few knots. The basic lift equation for a wing confirms that even with the lower pressure and higher temperature present during a tropical storm, the knots true airspeed of 68 knots and headwind of 63 knots creates enough lift to maintain flight with a few thousand pounds of fuel and a reasonable angle of attack.

Derek Brookover
AIAA member
Temecula, California; dbrookover@gmail.com; Brookover is an aerospace engineer at General Atomics-ASI in Poway, California.

For a head start ... find the AeroPuzzler online on the first of each month at https://aerospaceamerica.aiaa.org/ and on Facebook, LinkedIn and Twitter.

No-contact cleansing

BY CAT HOFACKER | catherineh@aiaa.org

Honeywell Aerospace has a bright idea to help airlines reduce transmission of covid-19.

The company in June unveiled the UV Cabin System for no-contact sanitization of cabins and flight decks via ultraviolet light, a technique long relied on by hospitals. The machine bathes surfaces in UVC, or ultraviolet C light, whose wavelengths between 200 and 280 nanometers are energetic enough to warp the genetic material of pathogens, including the SARS-CoV-2 virus that causes covid-19, according to trials at the University of Boston.

Eight of the machines were delivered to the first customer, JetBlue, in July. The airline will test the machines in airports in New York and Fort Lauderdale, Florida, to see how it fits in with other cleaning methods.

At roughly the size of an aircraft beverage cart, the machine fits in the aisles of most passenger aircraft, says Brian Wenig, vice president and general manager of the Honeywell division building the machines. Wings extend over the top of passenger seats and are each embedded with six 35-watt and 95-watt bulbs; they can extend up to 24 meters to cover the wider rows on double-aisle planes.

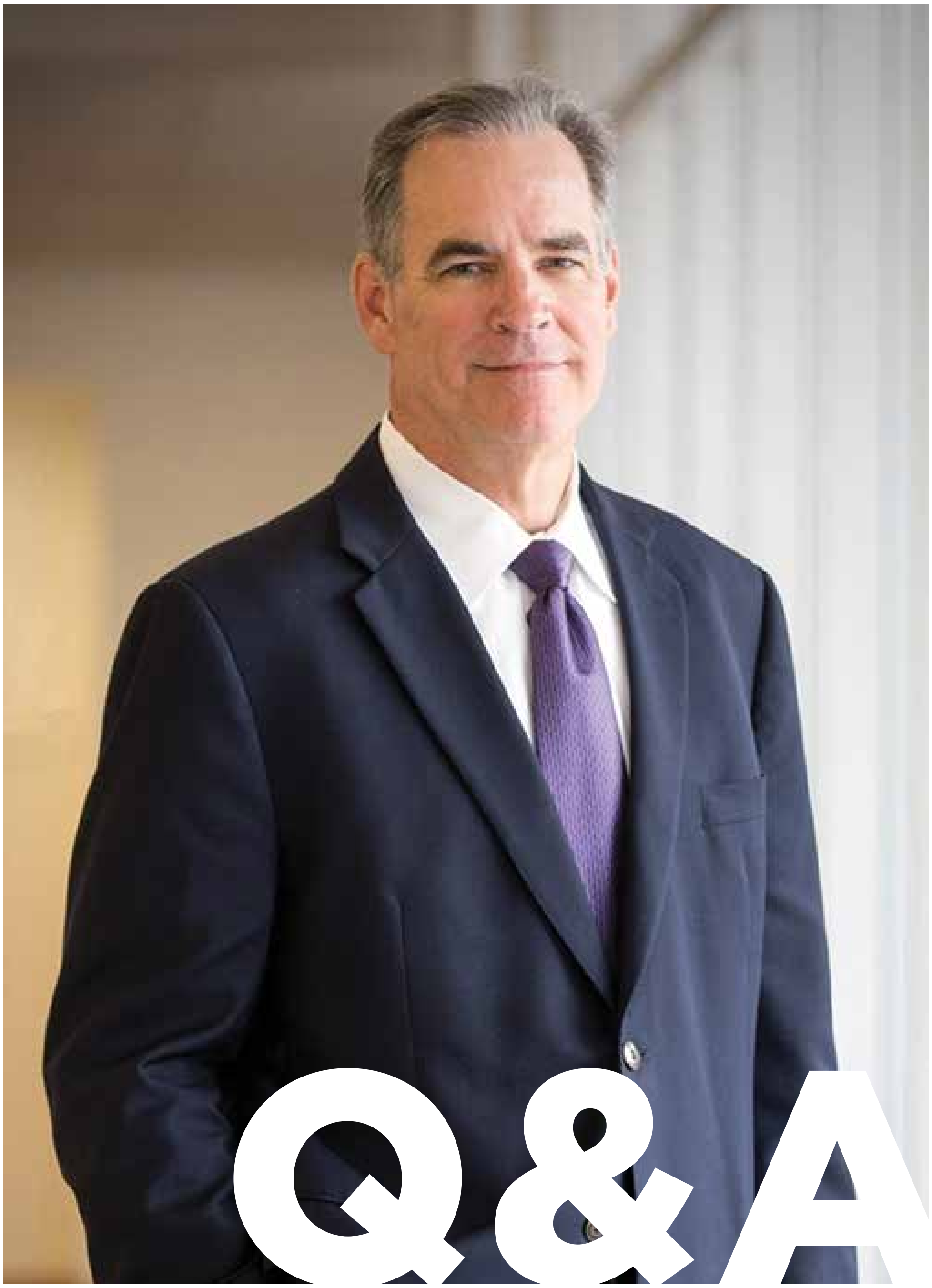
Because the more powerful UVC rays would be damaging to human eyes and skin, the person operating the UV Cabin System is safeguarded by plastic shields on either side of the controls.

Cleaning begins at the front of an aircraft, with a crew member or hired cleaner holding down two spring-loaded switches to turn on the UVC lights. They push the cart down the plane aisle while the arms beam UVC light onto seats, seat belts and video screens, Wenig says. To ensure the correct dosage, a speedometer on the dashboard displays the cart's speed. For narrower areas such as the on-board lavatories, the worker can turn the cart sideways to extend one of the wings inside, folding the other with the touch of a button.

The cart is one of a handful of UV sanitation devices companies have proposed for cleansing aircraft, including a hand wand Boeing is developing for harder-to-reach areas. Honeywell favors its cart design because "it is very repeatable and very consistent in the way it applies the dose of UV light," Wenig says.

"It is one piece of equipment that [airlines] can use very consistently to clean the aircraft surfaces," he says. "There's other areas that will need to be cleaned" by hand wiping or electrostatic spraying, including seat-back pockets and underneath tray tables, "but this gives them in under 10 minutes a solution to clean all the high-touch surfaces in the aircraft." ★

▲ **A cart is pushed down** a plane aisle while the arms of the UV Cabin System beam UVC light onto seats, seat belts and video screens to sanitize the high-touch surfaces.
Honeywell



Anti-covid leader

This is not the 2020 Mike Delaney expected. After the record number of travelers reported in 2019, the air transport industry now predicts demand and revenue won't reach pre-pandemic levels before the mid-2020s. Key to this recovery will be keeping passengers healthy, so Boeing in May appointed Delaney to lead the just-created Confident Travel Initiative. Delaney's staff members have been conducting research on new sanitation methods including ultraviolet light and advising airlines that fly Boeing jets on sanitizing cabins and cockpits via disinfectants already approved by the U.S. Environmental Protection Agency. I spoke with Delaney via Zoom during AIAA's virtual Aviation forum in June to learn more. — *Cat Hofacker*

MIKE DELANEY

POSITIONS: Head of Boeing's Confident Travel Initiative, established in May; vice president of digital transformation, 2017-present; vice president of engineering for Boeing Commercial Airplanes, 2010-2016.

NOTABLE: Became a Boeing employee in 1997 with its purchase of McDonnell Douglas, where Delaney conducted airplane performance flight testing. Oversaw the design, testing and certification of all Boeing commercial aircraft from 2016 to 2017, including the 737 MAX, 777X and 787-10. Became an AIAA associate fellow in 2011 and a fellow in 2013.

AGE: 57

RESIDENCE: Seattle

EDUCATION: Bachelor of Science in aerospace engineering, Hofstra University, 1985; Master of Business Administration, Toulouse Business School, 2001.

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IN HIS WORDS

Minimizing covid-19 risk

In thinking about covid-19, I try to bring the best of aerospace principles and practice to solve the problem. We're not doctors or medical people; we're airplane people and we're aerospace folks. As an old chief project engineer, I think about how we assess airplanes from a threat point of view, whether that threat is lightning strike or windshear or malfunction or cessation of function. So for me, it's natural to think of the covid-19 virus as a threat to that too, to the passengers and crew in the airplane. How we would solve that in the aerospace industry is we would design around the requirement to minimize that risk. So if you think about it in your public life, you hear about 6-foot social distance or wear a mask or use hand sanitizers or wash your hands. Those are all solutions for people in the medical community. You're giving guidance to lower the replication rate of the disease. In an airplane, we want to lower the replication rate to below what you would experience in your everyday life, because we think the air travel system can do that. But we also know that a design solution of 6-foot social distancing won't work on an airplane, so it will have to be some other design solution, maybe masks, sanitizers, something else that we'll put into the model to say, "This is equivalently safe or safer than what you would experience in your day-to-day life." And then we have to provide the information for people so that they can make decisions on that risk, because while the air travel system is built on an average risk, people have to think about their own personal situation — their health, their risks, their comorbidities — and take that into account.

Making an anti-covid-19 manual

We laid three layers of protection, the first being try to minimize the virus entering into the travel experience. That's things like temperature screening and people choosing not to fly when they don't feel well; it's really the whole experience from when you leave your house to you get to your destination. The second layer is to have a clean airplane environment. That involves us putting together a cleaning program that we think about a lot like the maintenance service program or the engine maintenance program, where Boeing provides information in the maintenance manual, how to do a task. Then we provide the frequency and inspection update in the maintenance planning document. And then the third layer of protection is just like anything else in analysis: you assume that the virus gets on the airplane, so what inherent features in the airplane and in the operation can minimize the spread of transmission? And then we take those three layers of strategy and think about them against three time horizons. And we've been thinking about it in terms of zero to 90 days, and then 90 days or three months to about a year, and then a year to two to three years.

Assurances on cabin air quality

The current system is a mixture of fresh air and recirculated air. It's about 50/50. The air that is recirculated goes through what's called a HEPA filter. Those HEPA filters are 99.9-plus percent efficient at removing all particles. They are also efficient in the size range of viruses, bacteria and molds. No one in the industry has covid-19 [pathogens] to actually test against the filter, but the HEPA filter manufacturers have tested the range of viruses, and the covid-19 molecule is the exact same size as the virus range they've tested. I've talked to our supplier, and they would say it is an absolute legitimate statement to say that we believe the filters on the Boeing airplanes are effective against that size molecule.

> **"As an old chief project engineer, I think about how we assess airplanes from a threat point of view, whether that threat is a lightning strike or windshear or malfunction or cessation of function. So for me, it's natural to think of the covid-19 virus as a threat to that too, to the passengers and crew in the airplane."**

Cleaning smarter, not longer

It can't be a technology play by itself in terms of modifying the airplanes. The Boeing fleet today is almost 13,000 airplanes. To modify that many airplanes is probably a 10-year time horizon. So when we look at our first horizon of zero to 90 days, it's really providing the airlines with the tools to keep the airplanes sanitary and clean today. And so that's making sure that they're using cleaners at a greater frequency than they historically would have. The next thing would be what can we do to relieve [airlines] and make this increased cleaning an easier burden as the fleet comes back? And that's where you get to things like antimicrobial coatings. There are off-the-shelf antimicrobial coatings; we've already approved one. Then long term, you start looking at inherently building parts that have that antimicrobial coating characteristic in the part itself, as opposed to a coating. We've also looked at our ecoDemonstrator self-cleaning laboratories, where you bring in things like UV light.

Investigating UV light

We're working with some university researchers to see if we can qualify ultraviolet light as a way that airlines can clean particularly sensitive areas like the flight deck, where you worry about fluid intrusion and other potential risks. We think there's a

▲ **A Delta Air Lines** employee cleans the passenger cabin on a Boeing 757 with a sanitizing solution.
Delta

lot of promise in UV light for a sanitizing capability, but the devil's in the details. You need to understand the intensity and the duration. Both of those factors are important to whether or not it is effective. So if you look at a consumer example, you'll see people can buy on Amazon UVC phone sanitizers, but they're a 10-minute dwell time. So in order to have a faster cycle, you need greater intensity, right? That's what a lot of the research is: How do you get something that provides the intensity and the power to have the short enough time to be effective and still be efficient in the airplane environment?

The cost factor

The good news about the urgency is it takes a lot of things off the table that could be on the higher end of cost, especially when you have a large fleet. And remember, any modifications need to go through more than just the certification, but the efficacy. I think when you start getting to people who are promoting things like UV lights that are always on, those things will start to become more expensive, but those are also not going to happen in the short term. And those will also have to go through not only the [FAA's] Part 25 and the Part 121 operational certifications, but they'll also have to prove their efficacy, because all cleaners and the things we recommend, we have guidance from the EPA that says, "This is what you need to do to use this, to have an effective cleaner." We're going through that process now with our UV wand. So even though we have a lot of hope for the wand, think about the industrialization of now getting that out there to the world's flying fleet, and how many does an airline need for their fleet and the number of destinations and city pairs that they fly [between]. And so it's going to take care of itself a little bit. When you get to the longer term, airlines are going to go through the break-even analysis: Is it better to use solvents and cleaners and the maintenance practices over here, or is a long-term thing, proving that efficiency?

"Things like antimicrobial coatings [such as on tray tables] probably are going to be here to stay. My personal belief is, if you believe we're 102 years from the last pandemic, I don't think it's going to be 102 years to the next one."

And the good news is that that'll be a year out, but right now it's getting a good cleaning program, and getting a good operational set of procedures to have a clean airplane and to minimize the ability for the disease to transmit in the travel experience.

Building changes into the system

In the midterm, we would bring things to bear that could help with the efficiency as the air traffic system comes back. So today the airlines can deal with a lot of things simply because the frequency is down. The number of flights is down, the passenger load is down and the gate and the turnaround times are longer. But as the system comes back, load factors go up, capacity goes up, turn times go down. It's going to be harder and harder. The next phase is bringing them things that enable them to support the return to flight. And then in the long term, we have to build things in and provide things that enable airlines to provide the level of service or operational models that they have. So if you're a 737 operator and your airline is built around frequency, say eight to 12 flights of that airplane a day with a 40-minute turn time, we have to provide a cleaning program that can be supported in that turn time. We want to add the economy and efficiency to the level of cleanliness and safety that we expect and are going to demand from the industry.

The new way of flying

Things like antimicrobial coatings [such as on tray tables] probably are going to be here to stay. My personal belief is, if you believe we're 102 years from the last pandemic, I don't think it's going to be 102 years to the next one. So as an industry, we should learn the lessons from this one. I think that UV light will also become something that probably becomes a tool in the toolbox of the industry and airlines because we are always going to have sensitive electronic equipment in airplanes, and liquids of any form are always — if it's not a safety issue — going to lead to an economic issue, clogged filters or disruption to the systems. And then while all the original equipment manufacturers design airplanes around air quality and comfort, it's primarily around the smell of kerosene and jet fuel, those things not ingressing into the cabin, but it was also about not having drafts or temperature, gradients or velocities in the cabin. Those design features were really good for us in terms of covid-19, but we never actually had specifically "prevent the spread of an airborne virus" in our requirements documents. And we're looking at that; should those things be brought now into the fundamental requirements documents that we design the next generation or two?

Requirements for future aircraft?

We're always careful about bringing in new requirements because writing a good requirement is actually one of the art forms and one of the best skills that we have in the aerospace industry. And so, we've got a team who's looking at how would we write those requirements. You have to think through it, not only the consequences of a requirement but the unintended consequences of a requirement. And then you say, "Should it be a requirement? Should it be an objective? How would we validate that requirement? How would we allocate that requirement?" So we would always be very careful, just like any new requirement. Everyone thinks of the 787, the first all new composite airplane, but it was built on years and years of composite development in components on other airplanes or other parts of other projects that were then put together as a complete package. This conversation is really about the next new Boeing airplane. Then we sit there and say, "OK, with the fleet we have today, are there things that we could offer to the fleet?" Just like airplanes get better through time, you're probably talking about looking at the things you can do with that existing platform. It's always a compromise between all those: What you can do and what you'd like to do, and what is practical and pragmatic, and time and financially efficient, without compromising the fundamental safety requirements of the airplane. ★

Designing for energy efficiency

Creating a new breed of aircraft can require extensive prototyping and flight testing. Some of that work might be avoided if software could accurately model the aircraft's electrical demands under various flight conditions and with different choices of components. Keith Button spoke to engineers at Argonne National Laboratory in Illinois who next year plan to unveil software to do this.

BY KEITH BUTTON | buttonkeith@gmail.com

The aviation industries in the U.S. and abroad have bold plans for transforming our lives with a variety of hybrid or fully electric rotorcraft, including advanced air mobility aircraft, versions of which would ferry us around locally or deliver packages to our doorsteps on tethers. Quiet, clean electric power is attractive for these package delivery and urban air mobility applications, sometimes together with combustion in larger designs. Even designers of large jets seek to make the most efficient use possible of electric power.

Designers of these aircraft need to anticipate how much electricity will be required when flying in various roles, such as carrying passengers versus cargo; whether the power demands decrease as expected when cargo is unloaded or passengers get off; whether choosing a particular battery or batteries will reduce or increase the range of an electric aircraft and by how much.

Engineers at Argonne National Laboratory, a U.S. Department of Energy-sponsored research center in Illinois, are writing software that could empower engineers to answer these and a host of related questions before they build and fly their creations. The engineers think the tool could be especially helpful for anticipating the energy needs of nontraditional designs, such as those relying on distributed electric propulsion.

Inspired by automobiles

The project is the brainchild of Dominik Karbowski, a mechanical engineer who immigrated to the United States from France in 2006 to help Argonne develop software to simulate the functioning of cars and trucks, whether conventional, hybrid or electric. Today, auto engineers rely on this software, called Autonomie, to digitally assemble simulated cars and trucks from a menu of individual components — motors or engines, batteries, transmissions, wheels and accessory power loads likes radios and headlights — each represented by their own mathematical models. Engineers can then assess and compare energy efficiencies of various designs and choices of components. Sensing the growing interest in electrification of aircraft for urban air mobility and other applications, Karbowski in 2018 started leading development of similar software for aircraft designers. The software, which at the moment exists in a pre-beta form, is called Aeronomie from the "aerospace" and the Greek "nomy," for a system of rules or knowledge, and of course as a play on Autonomie. The software must quickly and accurately assess the energy efficiency of a design based on the particular combination of power components in it, much as Autonomie does for automobiles.

As he got to work, Karbowski realized that he needed to bring in an aviation expert to help lead the new project. As a teenager growing up in France, Karbowski was obsessed with Microsoft's Flight Simulator game, and he remains passionate about aviation. But he did not pursue an aerospace engineering degree or piloting. To fill that void, Argonne hired Nirmit Prabhakar, an aerospace engineer and post-doctoral research fellow who received his doctorate at Embry-Riddle Aeronautical University.

Karbowski, Prabhakar and their teammates started with a blank slate. Aeronomie will consist of an overarching, generic aircraft model — a collection of equations, formulas, computer code and data — consisting of submodels of kinds of components. Users will then plug in design characteristics and components to create a model of a certain kind of aircraft. The engineers structured the larger Aeronomie model and its underlying models of aircraft components with the idea that design complexities could be wrapped in later. With this flexibility, a particular airframe with one propeller might be modeled with multiple propellers in the future, for instance. They also made sure that these models would be easy to read and reuse.

The main challenge is ongoing in developing Aeronomie and adapting the automotive simulation approach: Swapping components can have a much different outcome for aircraft than for road vehicles. "In a car or truck, when you change things inside, it does not have too much impact on the overall performance," Karbowski says. But adding too much weight to an airplane by switching to a larger battery, for example, can mean that the plane won't fly.

As they build the software, meeting the challenge requires the Argonne engineers to continue to determine which kinds of components can be swapped out or reconceived in a simulation without invalidating the larger Aeronomie model. "You have to be cognizant of what the design space is," says Karbowski. Changing wing sizes, for example, would be beyond the scope of the tool.

Big universe; small bites

Another challenge is the much larger and more diverse universe of aircraft as compared to autos. Aeronomie must simulate everything from small uncrewed aircraft to 747s, including fixed-wing and vertical takeoff designs and hybrids of the two. That means the overarching Aeronomie model must account for a wide variety of missions: flying passengers and cargo across a spectrum of ranges, altitudes and speeds, compared to cars and trucks that are driven within similar envelopes.

The engineers decided to start small, with uncrewed aircraft, and expand from there. They built a simple motor component model, then added more component models until they had a complete model of a simple, small uncrewed fixed-wing aircraft. Then they moved on to a small uncrewed rotorcraft.

Luckily, while the parameters of the Aeronomie software can be changed for different aircraft, "on the modeling side the difference between a Cessna and a 747, the model itself, the equations are actually fairly similar," Karbowski says.

Modeling aircraft also requires building more underlying models compared to what's necessary in the automotive world. But the engineers discovered that the modeling language in Autonomie and the way in which the software models the performance of cars and trucks was similar enough that they could more or less reuse it. "Of course, we need to adapt these things that are unique to aircraft, but generally speaking, the physics stay similar," Karbowski says.

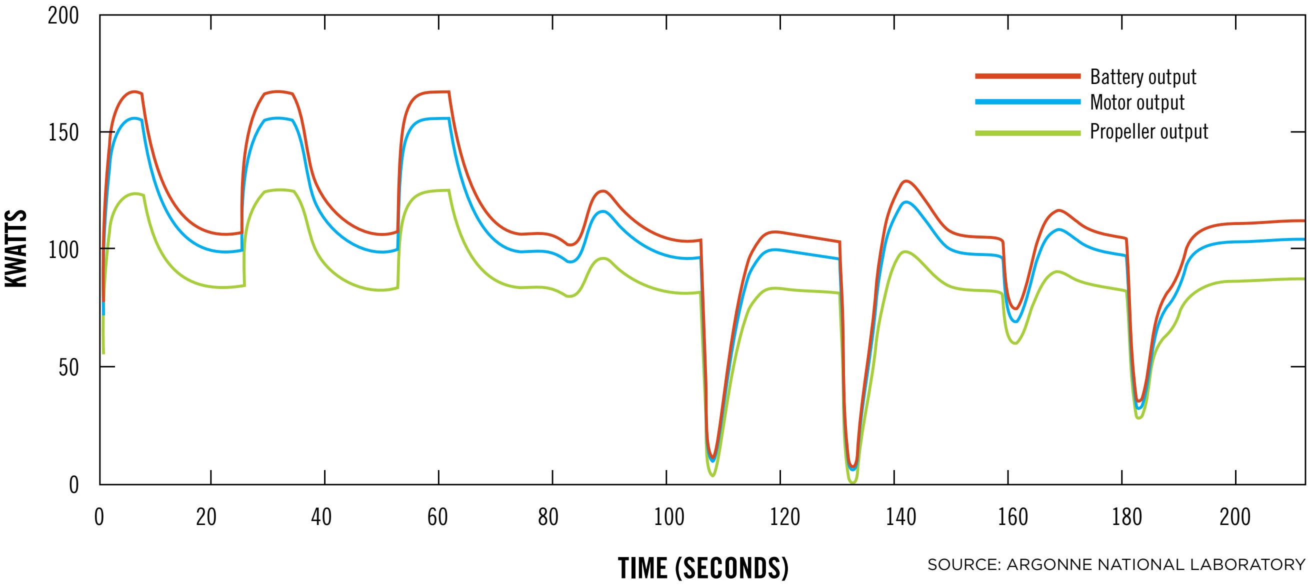
Making sure the model incorporates the correct data for its parameters, such as speed and the amount of lift generated, is critical. "That's where all the challenges come in," Karbowski says. The equations and formulas within the model could incorporate a broad range of theoretical parameters, but their output wouldn't make sense without the correct parameters.

Make it real

The engineers validated Aeronomie's generic model by checking it against real-life data, which presented another challenge: finding aircraft with extensive published data. They started with older aircraft like the RQ-2A Pioneer drone, which debuted in the 1980s and had publicly available data on extensive wind-tunnel testing. They also collaborated with Pipistrel, a Slovenian electric airplane manufacturer, to model their planes and compare the

Simulation takes flight

A graph generated by an early version of the Aeronomie software depicts the kilowatts of power consumption for the battery, motor and propeller of a Ryan Navion airplane during a simulated test flight over 210 seconds. Each increase in power consumption corresponds with a portion of the flight in which the plane is climbing.



SOURCE: ARGONNE NATIONAL LABORATORY

models' performance to real-life flight data.

Aeronomie won't be open source software, but the model will be accessible and easy to modify by the aerospace engineers who use it, Karbowski says. The team plans to offer software licenses to Aeronomie starting with a limited library of data on different types of airplanes and components. Engine manufacturers or plane designers or aircraft fleet operators will be able to incorporate their own data into the models to run simulations tailored to their own aircraft. The software will be able to incorporate computational fluid dynamics programs that compute the aerodynamics of specific airframes, for example.

The team is building the piece of the software that will communicate between the model and the graphical user interface, meaning the screen the user sees. The engineers will reuse much of interface from Autonomie for the aircraft version.

Running the simulation

Users will input parameters for their simulation, such as payload, drag coefficient, lift, motor energy efficiency, battery size and propeller size. Then they'll outline the mission: the flight distance, cruising altitude, points of landing and taking off, and whether payload will be dropped off, for example. If all goes as planned, the simulation run time will be 20 to 100 times faster than the actual flight — a 60-minute hexacopter mission takes about three minutes. The simulation runs through submodels that simulate environmental factors such as air density and wind gusts at certain altitudes, aircraft control over the flight route, the selected engine or motor generating thrust for the aircraft, aerodynamic forces during the flight, and the motion and positions of the aircraft during the flight.

Then the results of the simulation will be displayed according to what the user is seeking: graphs showing the speed, thrust, trajectory, power use, peak battery demand, electric current and overall energy consumption throughout the flight time, for example, or measurements of how certain components performed or an aggregate of thousands of simulation results for a fleet scenario.

The first beta version of the Aeronomie software is expected to be finished by July 2021. The goal is to build up a library of aircraft types and components, like with Autonomie and automobiles, so that the user can select an aircraft, parameters and mission and run the simulation with just a few mouse clicks.

The tool will be geared toward engineers with no computer programming knowledge. "Once you're a natural with what the tool does, you can run a lot of simulations easily," Karbowski says. "We're providing ways to do that without having to actually do any coding."

For Karbowski, his teenage self envisioned that he would one day become a professional pilot, but bad eyesight squelched that aspiration. Still, he says, his Flight Simulator experience taught him basic flight principles, which were useful as he built his own aircraft simulator, and just maybe enough to be a pilot of last resort: "I guess if I were in this movie where you have to pilot the plane because there's no more pilot, maybe I could do something." ★

CYBER FOCUS: SPACE

The GPS constellation, communications satellites, the rockets that launch them, and the ranges and networks that control them have something in common. Under U.S. cybersecurity policy, they do not amount to a specific sector of critical infrastructure. The Trump administration may change this. Debra Werner finds out why.

BY DEBRA WERNER | werner.debra@gmail.com

It's been 12 years since the U.S. Department of Homeland Security designated a new critical infrastructure sector. Then-Homeland Security Secretary Michael Chertoff declared the U.S. manufacturing base as its own sector of critical infrastructure, encompassing everything from production of appliances to motor vehicles to aerospace parts and more. The declaration signaled that manufacturing was vital to U.S. national and economic security and, therefore, government agencies should be legally required to work together to safeguard it.

Now the Trump administration is considering whether space technology, equipment and facilities should receive the same critical infrastructure designation as 16 other sectors. The case for doing so is not as obvious as it might sound. Many satellites and rockets already receive the heightened attention afforded to critical infrastructure, though indirectly. Satellites that transmit phone calls, videos and data fall under the communications sector, and military satellites plus the rockets to launch them are part of the defense industrial base sector.

Even so, U.S. reliance on space infrastructure continues to grow, and some in the Trump administration think the risks warrant additional security scrutiny.

Nothing has been decided yet. The Department of Homeland Security's Cybersecurity and Infrastructure Security Agency, or CISA, is evaluating various "courses of action to make sure that space infrastructure is getting the attention it needs from a national security and cybersecurity perspective," says CISA Assistant Director Bob Kolasky, who leads CISA's National Risk Management Center, an organization established in 2018 to pinpoint and address the most serious threats to critical infrastructure.

A Trump administration official made the case to me for such a declaration in an email approved by a spokesperson on the condition of anonymity: "In significant ways, the makeup of space-based infrastructure, the growth of industries surrounding such infrastructure, and the increasing complexity and dependency of the industry have changed the national risk landscape," this official said.

The conversation about better protecting space technology was prompted by the National Cyber Strategy of the United States of America. The document, signed in 2018 by President Donald Trump, calls for greater collaboration among U.S. government agencies, U.S. space companies, international government agencies and nonprofits in the face of "growing cyber-related threats to space assets and supporting infrastructure," noting their importance in "positioning, navigation, and timing" — a reference to GPS –– "intelligence, surveillance, and reconnaissance; satellite communications; and weather monitoring."

Now, it's up to Acting Homeland Security Secretary Chad Wolf to determine whether adding space technology to the critical infrastructure list will promote that collaboration. The DHS secretary's authority to designate critical infrastructure stems from the Critical Infrastructure Information Act, part of the Homeland Security Act of 2002, signed by President George W. Bush after the Sept. 11, 2001, terrorist attacks when officials worried that the next big assault might not begin as a physical one. U.S. law defines critical infrastructure as physical and cyber entities so vital that their incapacity or destruction "would have a debilitating impact on security, national economic security, national public health or safety."

Whether or not space technology is added to the critical infrastructure list, the Trump administration is well aware of its significance.

"For over a decade, national security strategies have recognized that space systems are essential to our prosperity, security and way of life," says the Trump administration official. "The expansion of commercial space interests demands closer coor-

▲ **Rocket engines** and their factories could become part of the U.S. critical infrastructure, a designation that could result in greater protection from cyber and physical threats because of their roles in launching national security satellites. Here, nozzles for Blue Origin's BE-4 at its factory.

Blue Origin

▶ **United Launch** Alliance's Atlas V Centaur upper stages, one of which is shown in ULA's Alabama factory, could soon begin launching astronauts for NASA. Declaring space technology as a critical infrastructure could improve their cybersecurity, some experts say.

United Launch Alliance

dination among critical infrastructure partners collectively to identify priorities to achieve security and resilience in space, not purely from the perspective of national defense, but also from the perspective of industry and commercial resilience in space and on the ground."

The GPS satellites, NASA scientific research missions and rocket launch sites are critical to U.S. national and economic security, says Kolasky, the risk center director. "The conversation right now is: Does it make sense to cleave off a space-focused critical infrastructure sector?"

Creating a new sector

If DHS decides it does, the agency would have to determine exactly what to include in the category. The easy calls would be satellite and rocket manufacturing facilities, launch sites and ground stations that send commands to satellites and retrieve data. But what about component and subcomponent suppliers or thermal vacuum chambers for satellite instrument testing?

Once the sector is defined, DHS would designate a sector-specific agency, meaning a government agency to act as an intermediary between sector representatives and other government agencies like the FBI that are on the lookout for physical or cyber threats. The sector-specific agency would then work closely with owners and operators of space technology, facilities and networks to establish standards, identify vulnerabilities and respond to cybersecu-

rity incidents, meaning any attempt to breech a network whether or not it succeeds.

The Treasury Department, for example, is the sector-specific agency for financial services. Treasury coordinates the work of local, state and federal government agencies in safeguarding private-sector banking and finance operations. It shares information with allies about threats through membership in the Financial Services Information Sharing and Analysis Center, or ISAC, which is based in Virginia with offices in the United Kingdom and Singapore.

"Banks and insurance companies are very competitive, but their top cybersecurity executives get together and share information," says Steve Lee, AIAA aerospace cybersecurity manager. "Because guess what, if Bank of America gets hacked or gets a ransomware attack, it's probably also happening to Chase Bank and Wells Fargo."

The space sector, though not viewed under U.S. policy as a category of critical infrastructure, does now have an ISAC associated with it. The Space ISAC was established last year at the National Cybersecurity Center in Colorado Springs, Colorado. Establishing this ISAC, however, was not necessarily a precursor to declaring space as a category of critical infrastructure. Aviation, for instance, has had its own ISAC since 2014 even though it falls under the transportation critical infrastructure sector.

Before the pandemic, Space ISAC members met repeatedly with DHS representatives and endorsed the idea of the designation. They pointed out the implications of a serious attack on "emergency

▲ **Spaceport America,** the commercial spaceport in New Mexico. The facility's cyber and physical security would receive additional U.S. government scrutiny if space were designated critical infrastructure.

Spaceport America

▶ **The security of the** GPS network is of special concern due to its role in banking, communications and more. GPS III satellites are shown at Lockheed Martin's processing center in Colorado.

Lockheed Martin

response, critical communications, weather, business operations and global and national security," Erin Miller, Space ISAC vice president of operations, explained in an email.

If the Trump administration were to designate space as critical infrastructure, companies would be freer to communicate with each other and with government agencies.

"Antitrust laws define the way companies are allowed to work together within a sector to prevent monopoly control," says Frank Backes, who leads the federal space and cybersecurity business units for Kratos Defense and Security Solutions, a government contractor and Space ISAC founding member based in San Diego. Once a sector is identified as critical infrastructure, the laws allow greater coordination to counter threats, adds Backes, Space ISAC board chair and president.

Sam Visner, a cybersecurity expert at MITRE Corp., one of the founding members of the Space ISAC, sees a broader impact. "Once something is regarded as critical infrastructure in this country, it provides sort of an ever-growing connective tissue for sharing threat intelligence and for sharing best practices," he says.

Rules governing critical infrastructure also afford companies flexibility in sharing information with government agencies on threats or incidents without incurring fines or penalties for any regulatory infractions.

"It's a structure that is pretty tried and true for ongoing collaboration between industry and government that sits outside of the general structure of where industry and government traditionally work together, which is a more heavily bureaucratic process," Kolasky adds. "This enables tight collaboration in some sectors on an almost daily basis."

Space industry executives told me they would welcome additional government collaboration and attention.

Government agencies devote considerable time and attention to investigating cyber and physical threats to critical infrastructure and enhancing defenses. Although some space assets fall within

U.S. critical infrastructure sectors

Critical infrastructure means "systems and assets, whether physical or virtual, so vital to the United States that the incapacitation or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters," according to the Critical Infrastructure Protection Act of 2001.

Here is the current list:

- Chemical
- Commercial facilities
- Communications
- Critical manufacturing
- Dams
- Defense industrial base
- Emergency services
- Energy
- Financial services
- Food and agriculture
- Government facilities
- Healthcare and public health
- Information technology
- Nuclear reactors, materials and waste
- Transportation systems
- Water and wastewater systems

existing critical infrastructure categories, GPS doesn't fit well in any of the categories.

Even satellite communications, which falls within the communications category, does not get as much attention as it would in a space-focused sector. "There's a lot of expertise in cybersecurity work done on terrestrial networks," Backes says. "There is much less focus on space communications networks."

Tangible and intangible benefits

If the declaration were made, the sector-specific agency would work with companies and agencies like the U.S. National Institute of Standards and Technology to adopt formal security rules.

"Creating standards and processes and procedures to protect space assets from adversaries or natural disasters would be a good thing," says Chris Bogdan, senior vice president for the aerospace business at Booz Allen Hamilton, another Space ISAC founding member. He notes, though, that some space companies may oppose the adoption of standards out of concern about the cost and time required to implement and maintain them.

Some arguments in favor of adding space to the critical infrastructure list are less tangible.

Declaring space a critical infrastructure would increase the stature and visibility of the sector, says Bogdan, a retired U.S. Air Force lieutenant general. "That's important because eventually we're going to have to invest a lot more on the federal, civil and commercial sides to protect it," he adds.

When a sector is designated critical infrastructure, the move has international implications as well. Adversaries recognize that the United States considers an attack on its critical infrastructure a significant attack, Kolasky says.

Allies, meanwhile, tend to join efforts to safeguard sectors declared critical infrastructure in the United States.

"I've had conversations with Germany, France, Japan and several other countries about space being identified as U.S. critical infrastructure," Backes says.

Moreover, the new label would highlight the growing importance of the commercial space sector and could prompt security steps akin to those the U.S. government takes to protect its satellites and space infrastructure. Designating something as critical infrastructure "benefits, first and foremost, the private sector which owns most of our nation's critical infrastructure," Visner says. A declaration like that "makes all of us take as seriously as we need to the job of defending it and making sure it operates safely." ★

▲ **The anechoic test** chamber at Lockheed Martin's GPS III Processing Facility in Colorado, where the company builds GPS satellites.

Lockheed Martin

COVER STORY

TAKING THE FIGHT TO THE NIGHT

The devasting wildfires that ended earlier this year in Australia have energized those in the United States who have long believed that optionally piloted helicopters should be the next great weapon against wildfires. Jan Tegler tells the story.

BY JAN TEGLER | wingsorb@aol.com

Battling a wildfire from the air is a dangerous business, but never more so than at night. Too often, aerial firefighting must be suspended after sunset due to poor visibility that could lead to a collision with other aircraft or terrain. That spells a lost opportunity, because the lighter winds and lower temperatures common at night are better for dousing flames and cordoning off fires with retardant. Even once the sun rises, morning fog and smoke can keep planes grounded until 10:00 a.m.

In the United States, some would like to fill the void with a coming breed of optionally piloted helicopters that still face regulatory hurdles. Others argue that, at least at night, the focus should be on equipping aircrews with night-vision goggles.

Each view has its passionate supporters.

"A drone the size of a Skycrane? I don't get it," says Wayne Coulson, founder of the British Columbia-based firefighting company Coulson Aviation and one of the leaders of the night-vision goggles camp. He is referring to the famous heavy-lift Sikorsky S-64 helicopters whose crews of two drop water or retardant.

Authorities hire Coulson's company to battle fires with a mix of conventionally piloted fixed-wing aircraft and helicopters, whose crews sometimes don goggles and venture into the night.

Among those in the other camp are two of the most innovative rotorcraft companies in the United States.

Kaman Corp., the pioneering helicopter company based in Connecticut, is in the process of installing a package of control equipment and software into one of its conventionally piloted K-MAX heavy-lift helicopters as a step toward creating a class of optionally piloted helos, or OPHs for short. Plans call for a series of uncrewed test flights of this K-MAX UAS aircraft with a safety pilot aboard in November at Kaman's Bloomfield plant. For about $3 million, a K-MAX UAS kit of cameras, datalinks, software and more can turn a K-MAX into an OPH capable of being flown autonomously or with a pilot either aboard or in a ground control station.

Not to be outdone, Lockheed Martin's Sikorsky Aviation company, also based in Connecticut, in 2022 plans to test fly an aerial firefighting helicopter with its own kit of cameras and software and more called Matrix. The business model is distinct from Kaman's in that just about any helicopter could be turned into an OPH, or any fixed-wing plane into an optionally piloted one. The company would not provide a cost figure for Matrix, saying it varies, but a potential customer who follows the market says the prices would be similar to Kaman's.

Matrix provides an aircraft "adjustable levels of autonomy," says Igor Cherepinsky who directs autonomy programs at Sikorsky. In a crewed configuration, it automates some flight control functions as a "digital copilot" to reduce pilot workload. Or Matrix can fly an aircraft autonomously without a pilot aboard.

One of Coulson's competitors, Erickson Inc. of Oregon, which flies Skycranes against wildfires under the brand name Air-Crane, reached a development agreement with Sikorsky in January to jointly install and test fly Matrix on an Air-Crane.

The first of those flights will be an "augmented" one, meaning Matrix will assist the safety pilots aboard, Cherepinsky says. Sikorsky also plans to conduct flights of a Sikorsky S-70 at an FAA UAS test site without pilots and only Matrix aboard. If all goes well, Sikorsky and Erickson will retrofit kits on its fleet of 18 Air-Cranes to transform them into optionally piloted S-64s, says Jeff Baxter, Erickson's director of research and development.

"OPTIONALLY PILOTED HELICOPTERS COULD GIVE US THE CAPABILITY TO FLY INITIAL ATTACK" — THE FIRST OPPORTUNITY TO DROP RETARDANT OR WATER — "DURING THE 16 HOURS WE DON'T FLY NOW."

— **Mark Bathrick**, U.S. Department of the Interior

Turning point

Support for flying drones, and by extension OPHs, against fires dates back to 2006 at the U.S. Department of the Interior's Office of Aviation Services. A turning point seemed at hand in 2014 and 2015, when OAS carried out demonstrations of aerial firefighting with an uncrewed K-MAX like the two that delivered cargo at night to U.S. Marines at remote outposts in Afghanistan. The K-MAX flew at the New York state FAA UAS test site and Lucky Peak Helibase in Idaho.

Nothing came of those flights. The Interior Department, the Forest Service, the U.S. Department of Homeland Security's U.S. Fire Administration and local and state agencies "prioritized available resources" toward integrating existing uncrewed aircraft, such as 3D Robotics' small camera-carrying Solo drone, into firefighting ahead of optionally piloted helicopters, explains Mark Bathrick, the OAS director.

Even so, OPHs are going to be a "game-changer," he predicts, and not just at night. The first hours of daylight can be marked by fog, haze and smoke that make conventionally piloted flights too hazardous

▼ **An uncrewed Kaman** K-MAX drops water on a fire during a demonstration in New York state. The company plans test flights of its uncrewed aircraft in November.
Lockheed Martin

as well. All told, piloted flight can typically be conducted for only about eight hours a day, Bathrick says. If a fire were to break out overnight, that can mean a late start. "Optionally piloted helicopters could give us the capability to fly initial attack" — the first opportunity to drop retardant or water — "during the 16 hours we don't fly now," Bathrick says.

Bathrick adds that crewed or uncrewed OPH could employ their on-board infrared navigation and targeting cameras to provide the "first-ever" real-time measure of the effectiveness of water and retardant drops on wildfires. "The first water drop on a wildfire was done in 1930, and we still can't measure drop effectiveness," Bathrick notes.

Those measurements also would permit authorities to decrease the number of aircraft over a fire, Bathrick says. Crewed aircraft or UAS flown strictly for fire monitoring or mapping could be eliminated from the mix of aerial operations.

Jake Sjolund, the tactical air chief at the California Department of Forestry and Fire Protection, or Cal Fire, likes this concept, but he says the agency has no plans to buy OPHs in the near future. According to Cal Fire, it operates the largest department-owned aerial firefighting fleet in the world, with 50 aircraft, including 12 UH-1H Super Huey initial attack helicopters.

Cal Fire is in the process of replacing those Super Hueys with 12 Sikorsky S-70i Firehawks, the newest aerial firefighting version of the company's UH-60/S-70 medium-lift helicopter. Each UH-60/S-70 can transport firefighters or drop somewhat more suppressant or retardant than a K-MAX but far less than an Air-Crane. Specifically, it releases 3,875 liters — a quarter the volume of a small tank truck — from its external tank, compared to 10,031 liters for the Air-Crane and or 2,290 liters for the K-MAX.

In several years, when OPH technology is proven, affordable and certified, the state agency will "pick up the technology and help take it to the next level," Sjolund says.

Owning the night

Coulson says the benefits of fighting fire at night can be realized sooner by equipping crews with night-vision goggles, or NVGs for short, and that his company has in fact conducted about 60 such missions so far. After years of training flights, the state of Victoria in Australia contracted Coulson in 2017 and 2018 to carry out NVG flights, and the next year Coulson flew NVG missions for the Orange County Fire Authority in Southern California. Each mission requires two helicopters. A three-person crew flies a Sikorsky S-76 at about 2,000 feet in a supervisory role. An air attack officer seated next to the pilot tells the camera operator seated behind them where to point the infrared device mounted on the aircraft's nose. Once the attack officer, who views the blaze on a 36-centimeter TV screen, decides which part of the fire to target, the camera operator designates the target with a laser. Nearby is an S-61 helicopter, whose two crew members see this laser show up brightly on their NVGs. The S-61 crew follows the beam and drops up to 4,000 liters of water to douse the flames or retardant to block the fire's path.

▲ **Lockheed Martin's** Sikorsky Aviation company says its kit of Matrix software and cameras would give almost any aircraft "adjustable levels of autonomy." The company plans to test fly in 2022 an aerial firefighting helicopter outfitted with Matrix.
Lockheed Martin

"It takes practice and experience, but it's effective," Coulson says.

Bathrick strikes a less upbeat tone about NVGs than Coulson. "Given the expensive, lengthy and graduated training regimen required to safely employ NVGs, they offer a limited return on a significant and recurring investment," he says.

NVGs also cannot address a broader problem: Half of the present coverage gap in aerial firefighting occurs during daylight when thick smoke over fires cuts visibility. The resulting darkness might seem like night, but in reality, "NVGs are useless during daylight, even in smoke," Bathrick cautions.

Origins and cost

K-MAX UAS and Matrix have roots that go back more than a decade. Sikorsky, which was purchased by Lockheed Martin in 2015, began developing and testing autonomous technology sometime before 2010. Kaman developed software and hardware for uncrewed K-MAX flights in the late 1990s. Together, the two companies equipped the two K-MAX helicopters that in Afghanistan delivered 2 million kilograms of cargo to Marines at remote outposts.

Those flights provided inspiration and confidence, if not technical solutions, for the rival designs to come. Romin Dasmalchi, Kaman's UAS business development lead, describes K-MAX UAS as a "clean sheet design" developed solely by Kaman. He describes the technology as the "next logical step" for operators, an OPH based on the combat-proven K-MAX.

Sikorsky's Matrix technology was pioneered in part under DARPA's Aircrew Labor In-Cockpit Automation System program, an effort to develop a tailorable kit to add a high level of automation to existing military aircraft, decreasing pilot workload and enabling operation with reduced crew. In 2013, Sikorsky began flying all components of the Matrix hardware and software architecture on board a modified S-76B it dubbed the Sikorsky Autonomy Research Aircraft or SARA, according to Cherepinsky. In 2018 and 2019, U.S. Army pilots flying SARA executed autonomous takeoff, transit and landing, obstacle avoidance, automatic landing zone selection and low altitude ground contour flight, employing Matrix's lidar and infrared cameras. The current version is scheduled to fly aboard an Erickson Air-Crane in 2022.

Also, Cherepinsky says that Matrix autonomy will be integrated into the SB-1 Defiant and S-97 Raider helicopters the company is offering for the U.S. Army's Future Vertical Lift program. A large buy like that could reduce the unit cost of Matrix.

"We're quite aware that unfortunately the funding for fire folks is tiny," Cherepinsky notes. "We are trying to get to economies of scale."

Getting costs down for Matrix and K-MAX UAS could be critical for these technologies to gain traction in firefighting.

Some authorities do not have large fleets of aircraft of their own, so they rely on the Forest Service and Interior Department to hire companies such as Coulson and Erickson to help them battle fires. Funds for doing so appear to be dwindling. Records on the GovTribe.com website show that the total value of contract awards fell from $575 million in 2017 to $125 million in 2020.

At this rate, "no one's going to be able to afford to retrofit an S-64 or K-MAX," says Steve Athanas of Swanson Group Aviation in Oregon, which flies helicopters for firefighting and other needs.

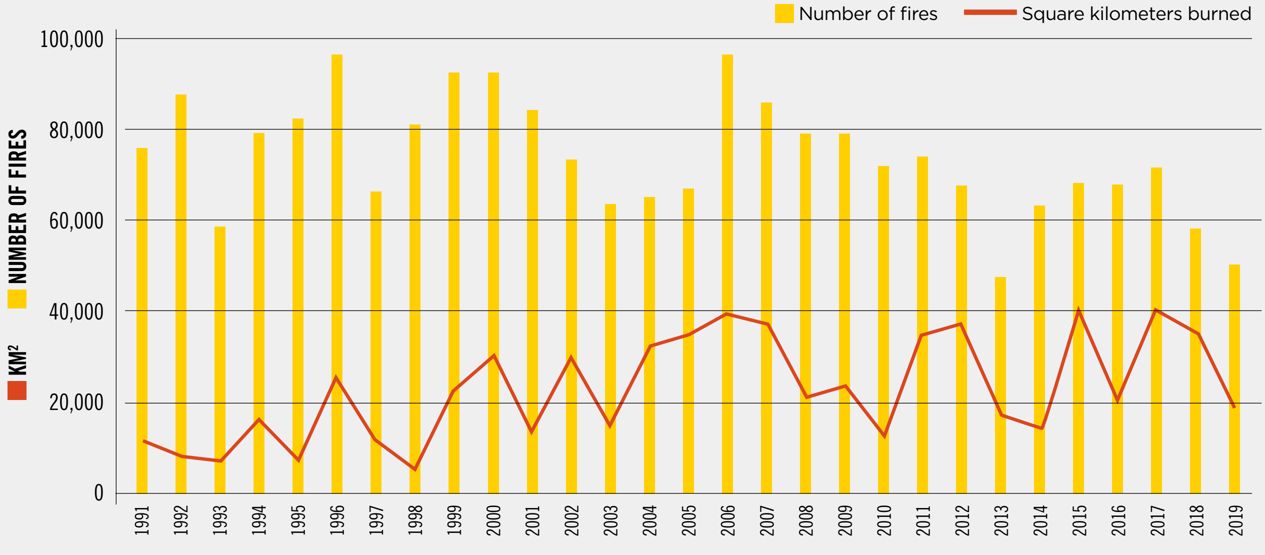
Swanson hopes this will change, and the company has decided to spend roughly $5 million, possibly before the end of the year to convert its two

"A DRONE THE SIZE OF A SKYCRANE? I DON'T GET IT."

— Wayne Coulson, Coulson Aviation

Fire data — explained

In the United States, fewer wildfires are burning more land, according to data compiled annually by the National Interagency Coordination Center in Idaho. Scientists are still exploring the phenomenon, but researchers from five universities have a possible explanation, at least for fire-prone California. Records show a link between the size of fires and expanding periods of low humidity. A dryer atmosphere whisks moisture more quickly from plants, creating "a recipe for larger fires that burn hotter and are more destructive," said John Abatzoglou, one of the authors of the 2019 study.



Source: National Interagency Coordination Center existing K-MAXs into K-MAS UAS aircraft. Athanas says his contract with Kaman Aerospace gives him the option of delaying the purchase "dependent on what the FAA rules as far as certification."

So how will Erickson, the inaugural Matrix customer, afford equipping its 18 S-64s with the kits? Although "Matrix will be an expensive, long program," says Baxter, the company expects the cost of operating OPH to fall below the cost of flying crewed helicopters over the long term.

"If I were to step back and say, 'What's the cheapest way I can fight fire at night now?' I'd go put night-vision goggles on and risk a crew in a lead plane and a crew in a helicopter at night in bad environments and I'd make money," he says. "But NVGs definitely don't have a long-term advantage because I'll be able to launch the same mission with nobody on board an S-64."

Bathrick of the Interior Department says contractors could make up for the cost of OPH kits through a higher operating tempo. "They'd benefit greatly from being able to triple the amount of time their helicopters could be used on wildfires," he says.

Regulatory hurdle

As far as the technology is concerned, Athanas is enthusiastic about OPH, preferring the potential of flying uncrewed K-MAX UAS at night to the safety risks of routinely flying with NVGs.

The question has been the disposition of FAA regarding OPH. Some OPH flights could be conducted by the Interior Department or Forest Service without FAA certification, if FAA were to establish a TFR, or temporary flight restriction, zone during a fire. Only particular aircraft, OPH in this case, would be permitted to fly in the TFR. Still, OPH backers want the larger market that FAA certification would bring. It's unclear to them whether that certification will be forthcoming. FAA has no timeline for approving certification of "operations of unmanned aircraft fighting fires presently," says Victor Wicklund, deputy director of FAA's aircraft certification service policy and innovation division.

Such a certification would include guidance about flying conditions. "Unmanned is going to be the way to go if the FAA would just come through with its guidelines," Athanas says.

He worries that when or if the guidelines do come, they "could be stifling." The FAA could, for example, stipulate that "you may conduct night unmanned firefighting missions as long as there are no ground personnel within 2,000 feet of the vehicle's flight path. In that case the mission would be impractical due to the presence of ground firefighting personnel," he says.

Despite this uncertainty, preparations for the OPH demonstration flights continue. Baxter of Erickson says uncrewed demonstration flights will begin in 2024 and "there is no technical reason" that uncrewed operations "couldn't start that same year."

▲ **An Erickson S-64** making a water drop.
Michael Pereckas/Flickr

Cybersecurity and insurance

Managers are increasingly concerned about the cybersecurity of uncrewed flights, whether by aircraft designed from the start to fly uncrewed or by helicopters equipped with the Matrix or K-MAX UAS equipment.

In late January, U.S. Secretary of the Interior David Bernhardt signed an order of "temporary cessation of non-emergency unmanned aircraft systems fleet operations," given that Interior had been flying small uncrewed aircraft in its firefighting efforts. The order cited cybersecurity concerns and the use of foreign-made drones.

Drones can still be flown in fire emergencies, at least for now, but the pioneers in the field know that this issue must be addressed. Sikorsky says it takes "cybersecurity seriously to ensure all our systems — mature and developmental — are protected." Kaman says its K-MAX UAS are well protected against cybersecurity threats, noting that the uncrewed K-MAXs it flew in Afghanistan were never compromised.

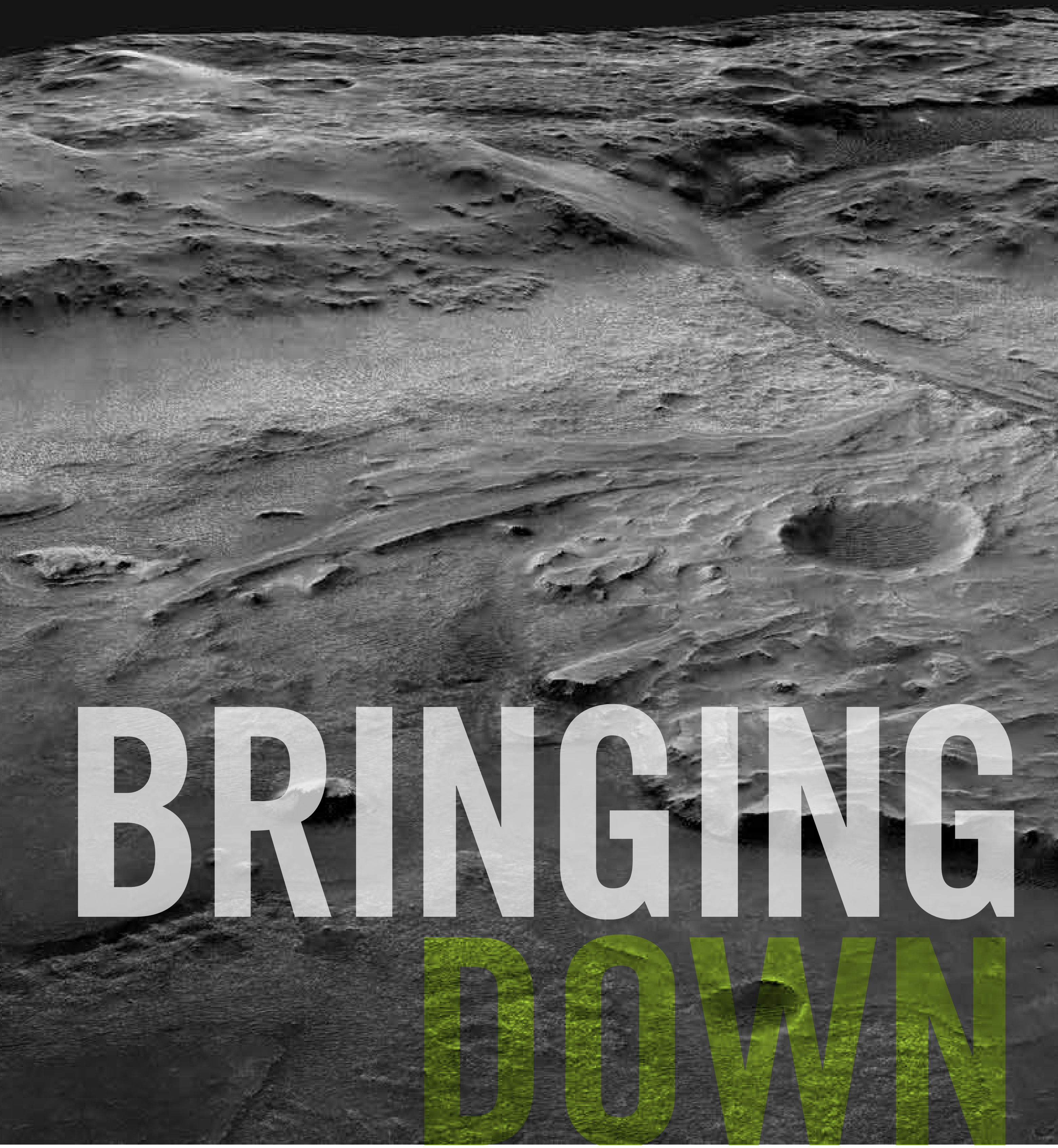
Insurance is another issue. Until the safety of flying OPH uncrewed is demonstrated at the intersection where wildfires are most urgently fought — where they threaten people and property — K-MAX UAS and Matrix won't be operated.

"Right now, no company is going to insure a 20,000-pound helicopter with no pilots aboard flying over people's heads, houses or buildings to go fight a fire at night," Coulson says. "Aerial firefighting with OPH is a good number of years away."

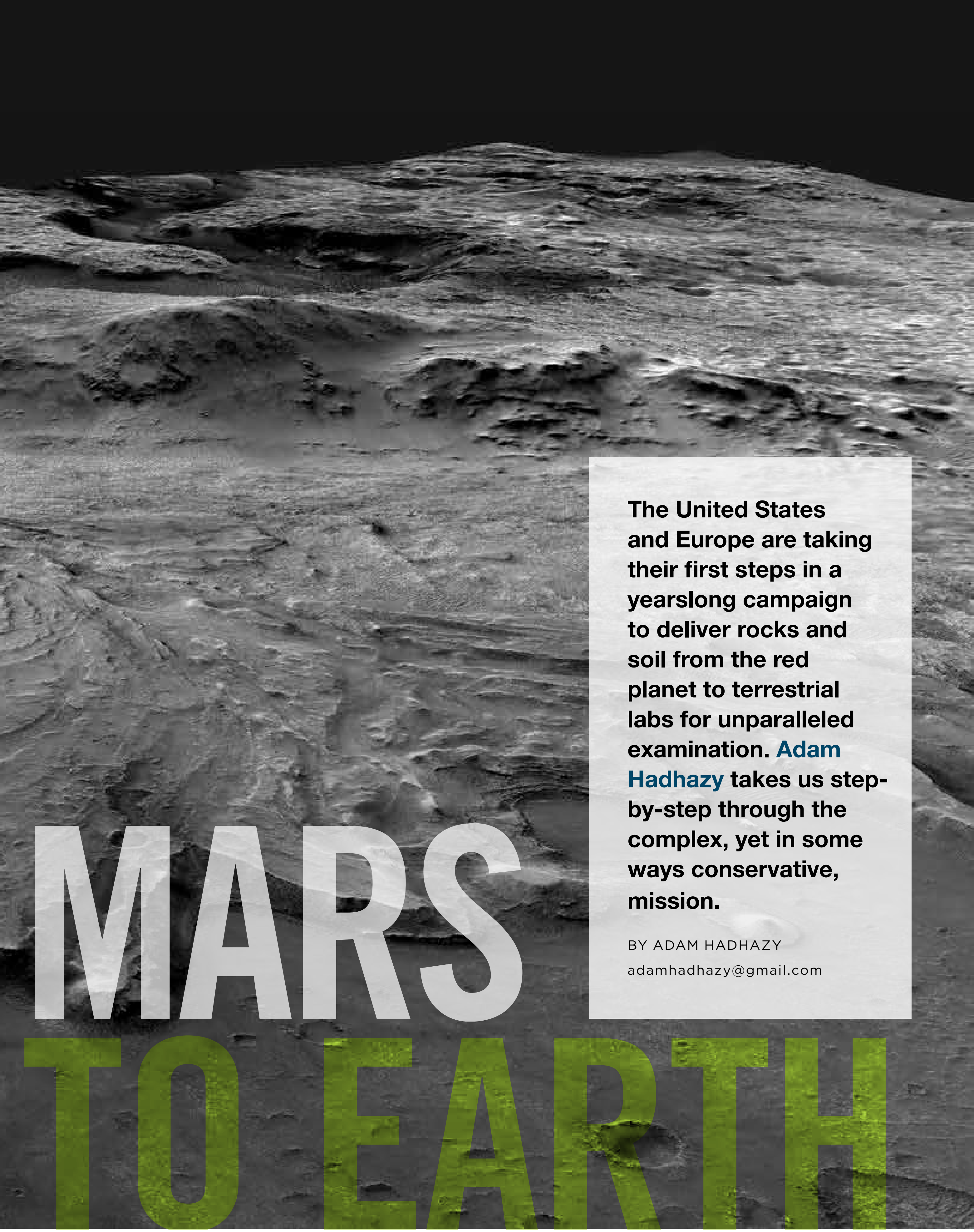
In Cherepinsky's view, "We have fly-by-wire aircraft flying over our heads every day and we're OK with it because certain standards exist. The same amount of rigor gets put into the Matrix system and all of its sensors. We can do this."

And so, the debate continues. ★

A view inside Jezero Crater. Scientists believe the shallow valley cutting through the crater's rim (top left) was once a river that fed a lake via a fan-shaped delta. The terrain may hold evidence of ancient microbial life. The crater on the delta has a diameter of 1 kilometer. The image is a mosaic of scenes from a camera on NASA's Mars Reconnaissance Orbiter.
NASA



BRINGING DOWN



MARS TO EARTH

The United States and Europe are taking their first steps in a yearslong campaign to deliver rocks and soil from the red planet to terrestrial labs for unparalleled examination. Adam Hadhazy takes us step-by-step through the complex, yet in some ways conservative, mission.

BY ADAM HADHAZY
adamhadhazy@gmail.com

Think of it as an interplanetary "Ocean's Eleven." This time, the target is not a casino but a Martian crater holding precious material that could tell scientists whether the red planet once harbored microbes or other lifeforms. Spiriting away a valuable half-kilogram of this rock and soil will require assembling a team of — yes, 11 — crewless rockets and spacecraft, including the Perseverance rover now on its way to Mars. The team members must all work in concert and in sequence, like the thieves in the 2001 film.

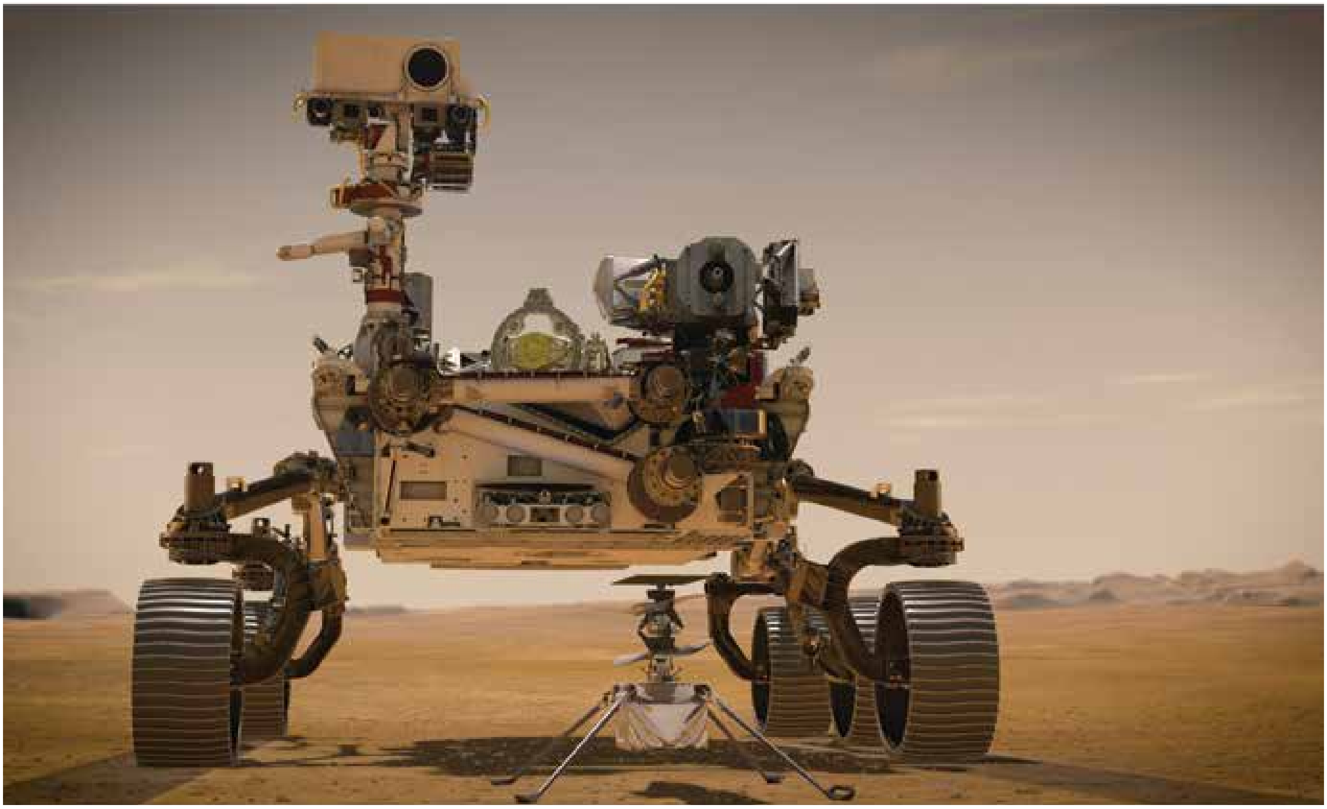
Luckily, NASA and the European Space Agency have more time and budget than George Clooney's Danny Ocean did. The $7 billion Mars Sample Return campaign will unfold over a decade rather than 24 hours. Success would fulfill a long-held dream of scientists to analyze Martian rocks and dirt in their laboratories. Engineers are improving spaceborne instruments with each successive generation, but even the most sophisticated rover cannot perform the sort of detailed microscopy, imaging and chemical analyses that a scientist can do in a lab, where there are far fewer constraints on size, weight and power.

Pulling off this groundbreaking heist, ironically, will require a highly conservative approach in which technical risk is avoided except where there are no alternatives.

Those in charge of various aspects of the campaign are banking that what has proved its mettle before will do so again. Spacecraft sent to Mars in the past by NASA and ESA were "as complex and capable as the individual pieces of this campaign. So now what we need to do is things we've largely done before, but string them together," says Chris Salvo, the Mars Sample Return systems engineering manager at the NASA-funded Jet Prolusion Laboratory in California.

The overall mission outline is as follows: The first leg began with the July 30 launch of Perseverance (formerly the Mars 2020 rover). After it lands next February, Perseverance will set out to collect and seal samples of rock and soil in tubes and leave them on the surface. Meanwhile, in 2026, a conjoined NASA lander and ESA rover will be launched to arrive at Mars in 2028. This Sample Fetch Rover will roll away, navigate to the samples, pick them up and carry them back to an ascent vehicle positioned atop the lander. Come 2029, the ascent vehicle will boost a container full of the samples into Martian orbit and then jettison it. Next, an ESA-built orbiter — having been launched separately in 2026 — will capture the container via a NASA-provided payload and stow it in a reentry vehicle. The orbiter will fly by Earth in 2031 and release this sturdy vehicle to intentionally crash-land in the Utah desert. Throughout it all, strict planetary protection measures must be followed to ensure that

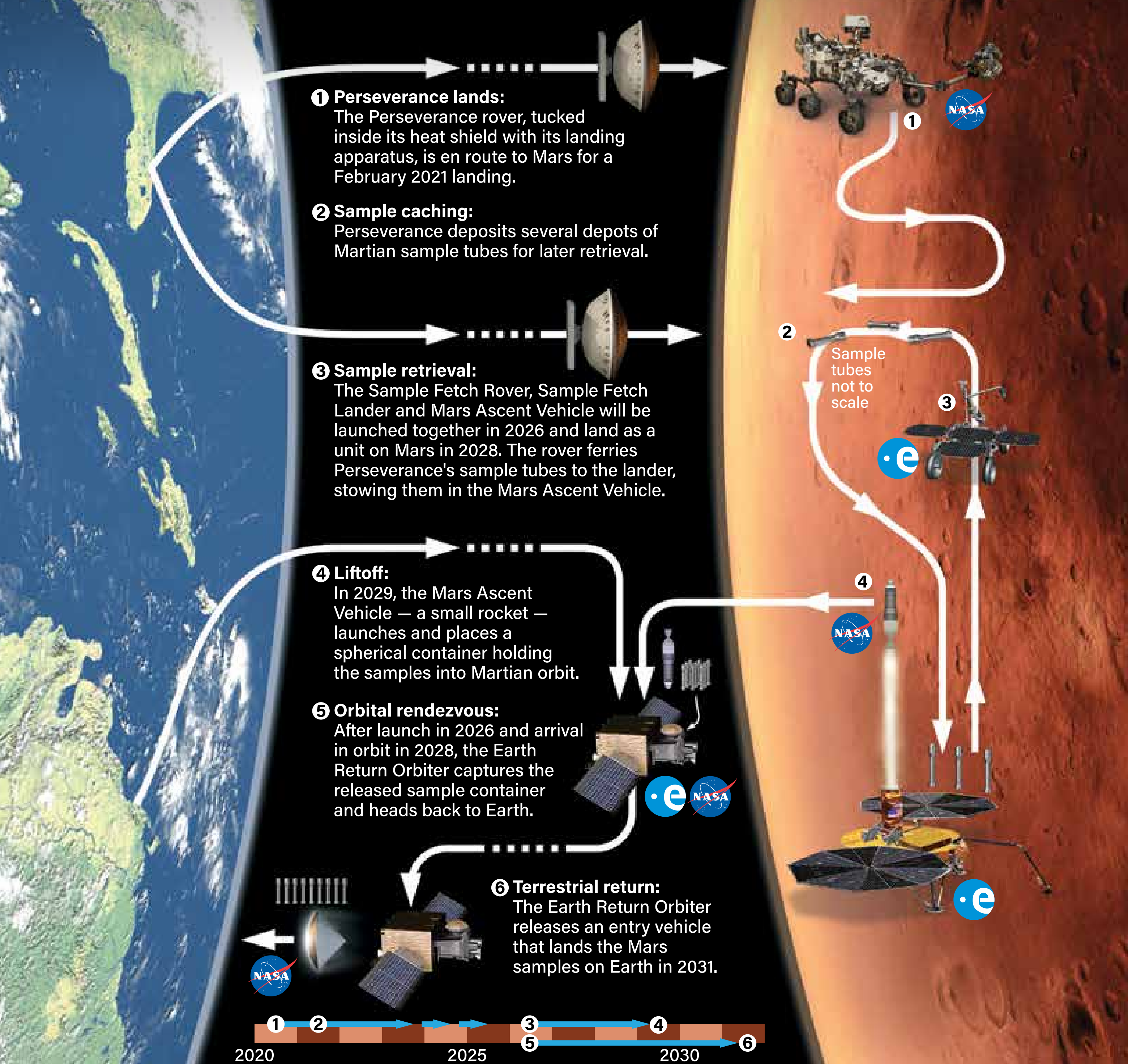
▼ **NASA's Perseverance** rover and Ingenuity helicopter scheduled to touch down on Mars in February 2021.
NASA



Complex campaign

Sending home 500 grams of Martian soil and rocks will require NASA and European collaboration, timely space launches, coordination between two rovers, the first-ever rocket launch from the surface of another planet and crash-landing a capsule in the Utah desert.

Graphic by John Bretschneider based on NASA sources.



▼ **A technician points** a smartphone camera (top center) at NASA's Perseverance rover so mission engineers watching from their home offices in Southern California can inspect NASA's Perseverance rover at the Kennedy Space Center in Florida. Covid-19 restrictions prevented the engineers from traveling to Florida. NASA

Earthly microbes do not contaminate the sample-gathering equipment on Mars or (albeit far less likely) that Martian life forms contaminate Earth.

It's a bold mission, no doubt. And it does call for a few "firsts," such as the first-ever rocket launch from the surface of Mars. "Heritage technology" is the mantra elsewhere.

Like Danny Ocean, managers also must arm themselves with ideas for what to do when events inevitably unfold less than perfectly.

Ain't broke, don't fix it

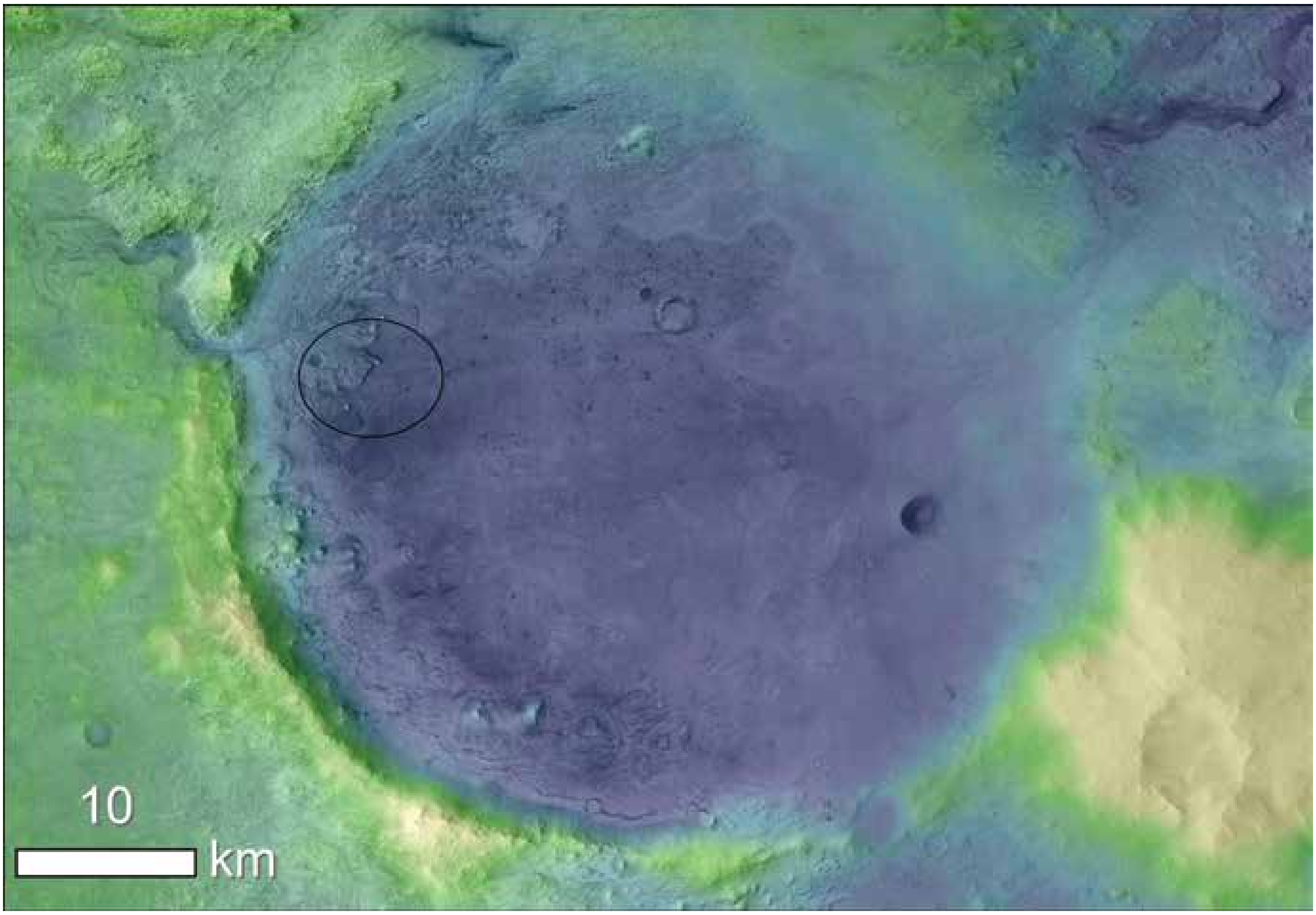
The conservative approach is evident in the first leg, starring Perseverance. Unlike previous new generations of Martian rovers, Perseverance is nearly identical in size and mechanics to its immediate predecessor, Curiosity, which landed on Mars in 2012. An exception would be its wheels, which are made of a stronger aluminum and have a gently curved tread pattern versus Curiosity's chevrons. These new wheels should grip just as well as Curiosity's but better withstand the pressure of rocks that led to the holes and tears experienced by Curiosity. Naturally, Perseverance also packs improved instruments, plus a minihelicopter, dubbed Ingenuity. Perseverance's engineers at JPL made liberal use of spare parts and components left over from Curiosity's construction, including its descent stage and avionics, as well as sticking with the sky crane touchdown system which, although highly innovative and unproven on its first go-round for Curiosity, was a thorough success.

Perseverance's destination — and thus the site where return samples will be collected — is Jezero Crater. It's an appealing destination, with orbital imaging revealing that a river once flowed over the crater's rim and formed a lake, creating a once-potentially habitable environment for microbes or other simple organisms. As Perseverance roams the region, scientists at JPL and various universities will look through the rover's mechanical eyes and select compelling sites for sample collection. These sites would, for instance, include those holding minerals, such as clays, that can only form in the presence of water, plus rocks that might preserve chemical markers of life that existed eons ago.

Careful, deliberative gathering of samples will establish geological context for the rocks, meaning where they formed or deposited, and in what conditions, which is key for scientifically evaluating the information the rocks contain. "Geologists want to know, 'What's the story here?'" says Salvo. "That's why geological context is so important."

That critical context is in contrast to the random bits of the red planet that have already made their way to Earth as meteorites. Such skyfalls will never rival the scientific value of targeted samples brought back to Earth. Meteorites often typically spend millions of years being irradiated in space — and that's before they go through the fiery crucible of atmospheric entry and ground impact; hardly an ideal journey for preserving delicate traces of life.

As Perseverance rolls along, the science team will look for rocks or regolith — meaning broken-up rocks and dirt — that look worn by ancient water. If the target is a rock, Perseverance can scrape it to reveal what's below or drill into it to extract and preserve a 15-gram core sample in a sample tube. This coring and collecting is different from Curiosity, which instead pulverizes rock with its drill. The coring process begins when a mechanical carousel on Perseverance's belly rotates to put a drill bit and pen-sized titanium



sampling tube within reach of T. Rex, the nickname for the short sample handling arm on the rover's belly. This arm installs the tube and bit into the drill on the end of Perseverance's main robotic arm, which bores as deeply as 5 centimeters. T. Rex returns the filled tube and bit to the carousel, which rotates to deliver the tube to inspection and sealing stations. The rover will carry a series of such hermetically sealed tubes of samples on a rack until the scientists identify a safe location to deposit them on the surface, where starting in 2026 they will be picked up by the Sample Fetch Rover. Plans as of now call for establishing several of these depots to cache a total of 30 samples of rocks and soil.

Fetch, rover, fetch

The fetch rover, whose first parts should be in production by Airbus before 2021, will draw heavily from the specs for ESA's ExoMars Rosalind Franklin rover, slated for launch in 2022, but at 230 kilograms, it will be about half Franklin's mass and not quite a quarter of the mass of Perseverance.

"The fetch rover is just fetching," says Ludovic Duvet, a senior system and technology engineer at ESA who led the Sample Fetch Rover's development. "It's purely a courier." In fact, it won't have science instruments, but the black-and-white cameras on board, including a camera at the end of the robotic arm, will gather a substantial amount of ground-surface imagery, which could help show local changes to environments where Perseverance has roamed just a few years prior. The locomotion system's readings of wheel-ground interactions should also be an interesting source of geological information, says Duvet, when correlated with in-situ and orbital images. As for those wheels, the fetch rover will ride on four, 7-cm-diameter, mesh-like wheels designed by NASA's Glenn Research Center in Ohio that are adaptable to uneven terrain and lightweight for their large size.

A solar panel will power the rover, giving it about a six-month window to receive precise location information recorded by Perseverance and Mars orbiters for the sample tubes before the Martian winter sets in and starves the rover of light, putting an end to its fetching days. Salvo compares the rover's quest to a treasure hunt, where an "X" marks the spot of each tube. To enable recovery, the rover will rely on its cameras to autonomously detect tubes by their shape and contours, determining their orientation for subsequent pickup by its robotic arm and gripper that will load them into a storage rack onboard.

Should the Sample Fetch Rover not reach Mars or break down on its way to the samples, Perseverance will also be able to retrieve its own dropped samples. "It's just one more way to build robustness into the mission," says JPL's Salvo.

▲ **NASA wants to land** its Perseverance rover within the oval shown in this elevation map of the 45-kilometer-wide Jezero Crater. Purple tones depict lower elevations. The image was produced by combining laser altimeter readings from NASA's Mars Global Surveyor with spectral imagery from the Mars Reconnaissance Orbiter and high-resolution images from the European Space Agency's Mars Express probe.
NASA/ESA

▲ **Perseverance in its** protective aeroshell just before it was encased in the payload fairing of the United Launch Alliance Atlas V that launched it toward Mars.
NASA

But if all goes as planned, the fetch rover will return the maximum 30 samples to the lander, which will be a scaled-up version of prior landers. Design cues have been borrowed from NASA's InSight probe, which arrived on Mars in 2019, and which itself was based largely on the Phoenix lander that alit in Mars' north polar region in 2008. Further harking back to those landers, the entry, descent, and landing of the sample fetch vehicles will involve the tried-and-true method of a heat-shielded aeroshell plowing through the atmosphere, followed by the deployment of a parachute and jettisoning of the heat shield, culminating in a final thruster burn to soften the touchdown. Because of their smaller size and mass compared to Curiosity and Perseverance, the fetcher and lander won't have to descend to the surface on a tether via the sky crane technique. "It's all based directly on what we've done before," says Salvo.

Rendezvous in space

Upon return to the lander base, the fetch rover's robotic arm will lift a door to the sample container, ensconced as a payload within the Mars Ascent Vehicle atop the lander. The rover will place the tubes in slots inside the container, with the number of slots giving the interior a honeycomb-like appearance. Once loaded, the container will close shut, and the Sample Fetch Rover will back off to a safe distance from the lander to video the subsequent launch. In case of a mission-dooming launch failure, the filming would serve as a means of diagnosing what went wrong. But more optimistically, the filming will instead capture humanity's historic first rocket launch from another planet. "That will be a nice moment for everyone," says Duvet.

As currently conceived, says Salvo, the Mars Ascent Vehicle will be a two-stage rocket fueled by an industry-standard, solid propellant that can lay idle for years and withstand the temperatures in the Jezero Crater region. To fit inside the lander, the launcher must be small — no taller than three meters — but given that the gravity on Mars is just 38% of Earth's, a model-rocket-like device will suffice. In April, NASA announced its intention to procure the launcher's solid rocket motors from Northrop Grumman.

Once in orbit, the ascent vehicle will spit out the

▲ **A concept model** of NASA's orbiting sample container, which will hold tubes of Martian rock and soil as they are returned to Earth. At bottom is a model of the sample-holding tube. The sample container will help keep contents at less than about 30 degrees Celsius to help preserve the Mars material in its most natural state.

sample container, which will be roughly spherical and about the size of a basketball. Shortly after, a NASA-provided payload on ESA's Earth Return Orbiter will open a flap-like door and engulf the container in a slow, steady maneuver. "Basically, the canister will swallow the ball, like a giant fish," says Salvo.

In the event that the orbiter, already in construction by Airbus and Thales Alenia Space, cannot rendezvous with the container, the container can remain in Martian orbit for years to await another attempt.

For all this to go smoothly, the launches and transits must be carefully orchestrated. Plans call for a new European launcher, the Ariane 64, to launch the orbiter shortly after the lander goes up in 2026 on an as-yet-unspecified U.S. rocket. The orbiter would overtake the lander en route to arrive first and serve as a communications relay for the surface elements of the mission. This is a necessary precaution, given that there is no guarantee that today's Mars orbiters that serve that function will still be alive and kicking as the 2020s wear on.

The orbiter will have a hybrid propulsion system consisting of an electric propulsion system, like that which propelled a prior Airbus spacecraft built for ESA, the BepiColombo probe to Mercury, as well as a conventional chemical engine to do a big burn for orbit insertion upon Mars arrival, plus the usual maneuvering thrusters. The orbiter will also come equipped with a precision guidance, navigation and control system as well as optical sensors, all working in concert to enable visual acquisition and a rendezvous with the orbital sample container. If that sounds rather tricky, Kelly Geelen, the ESA Earth Return Orbiter systems engineering team leader, assures it is in hand, with many technology demonstrations already completed. "We feel comfortable," Geelen says. "The vast majority of the equipment is at a high technology readiness level."

Earth for Earthlings, Mars for Martians

Mission planners must guard against any possible backward contamination of Earth from life forms on Mars.

"While we don't think there's a strong chance that the samples we get from the top couple inches on Mars are going to have anything viably biologically active in them," says Salvo, "out of an abundance of caution, the position that NASA, and really the world, has taken is to be prudent."

Within the lander on Mars, the sample container will incur some degree of contact with Martian air and dust. So even though the container will be subjected to the vacuum and radiation of space after ejection into orbit by the ascent vehicle, the container will still be treated as "dirty," says Salvo. Accordingly, once it is engulfed by the orbiter's canister, the surrounding volume will be considered a dirty zone, and the sample container must somehow be transferred into a sterilized zone. NASA is still working out some of the details for how to do this, but the general concept calls for shunting the container

REVIEW BOARD TO EXAMINE MISSION

NASA in mid-August announced the creation of an independent review board, or IRB, to examine whether the Mars Sample Return is feasible within the budget and timeframe. The IRB, which will be led by former Orbital ATK President David Thompson, will spend eight weeks in discussion with the European Space Agency and NASA about the mission, then submit a final report and recommendations to NASA. Recommendations from similar review boards have prompted changes to individual missions before construction begins in earnest. A review of the Nancy Grace Roman Space Telescope (formerly the Wide Field Infrared Survey Telescope or WFIRST) completed in 2017 led NASA to reclassify the coronagraph instrument as a technology demonstration in an effort to reduce the amount of testing needed and total cost.

—Cat Hofacker

into a sealing vessel, with its exterior possibly heat-treated in the process. That vessel then will be shunted into another sealing container as it moves into the Earth Entry Vehicle, the flying-saucer-shaped vehicle that will crash-land in Utah. ESA's Duvet compares these multiple levels of containment to Russian nesting dolls, with the result being that multiple layers isolate the samples from eventual contact with the external, terrestrial world. "We are taking very careful steps to break the chain of contact with Martian surface materials," adds Salvo.

Once safely stowed, the samples will be ferried from Mars back to Earth by the return orbiter. The orbiter will conduct an Earth flyby to release the entry vehicle and then perform an abort-style maneuver to get out of the way of Earth, Geelen says, and enter a heliocentric orbit that will avoid any repass of our world for a century, thus providing another level of planetary protection.

The entry vehicle will scream through Earth's

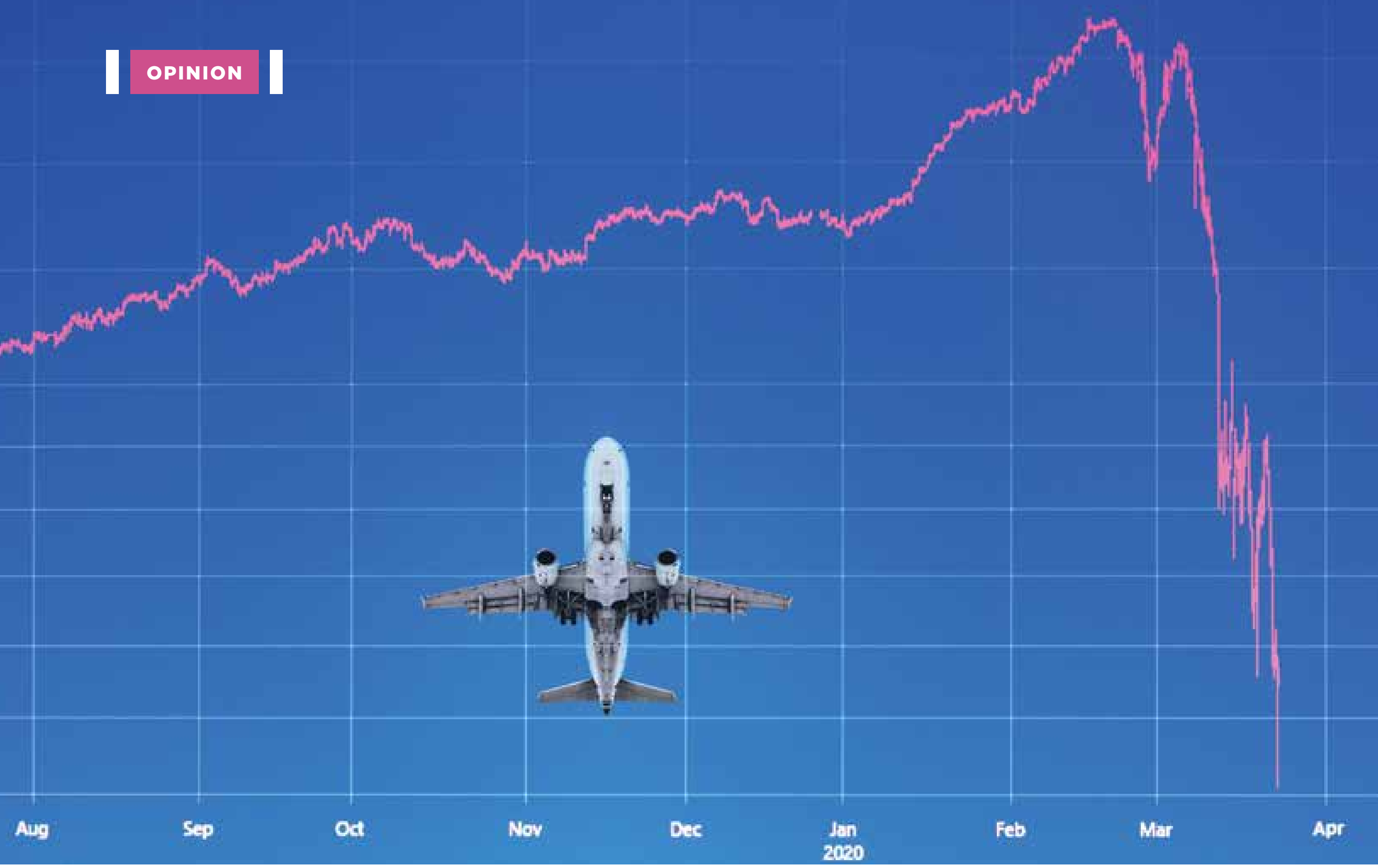
▼ **The rover's cruise** stage is on top of the bell-shaped back of the aeroshell, which covers the rover and its descent stage. The brass-colored heat shield at bottom was attached to the back of the aeroshell before all were encased in the fairing.
NASA

> **"While we don't think there's a strong chance that the samples we get from the top couple inches on Mars are going to have anything viably biologically active in them, out of an abundance of caution, the position that NASA, and really the world, has taken is to be prudent."**
>
> — **Chris Salvo**, NASA-funded Jet Propulsion Laboratory

atmosphere, destined for a controlled hard landing on the Utah Test and Training Range. This vast, dry lakebed 130 kilometers west of Salt Lake City is the same landing zone where NASA's Stardust probe came down with its cometary and stellar dust in 2006 and where the OSIRIS-REx container should arrive in September 2023 with its material from the asteroid Bennu. Both those missions, though, relied and will rely on a parachute to slow the entry vehicle's descent. This time around, because of planetary protection concerns, not to mention possible damage to the samples, designers decided that the capsule must be ready to withstand a parachute failure that, consequently, eliminated any need for a parachute to begin with, Salvo says. Accordingly, the entry vehicle will intentionally plow into the ground. Like modern cars, the vehicle is being designed with crumple zones — areas of its structure meant to shock-absorbingly compress — that will protect the precious red planet cargo.

Then the hands-on science begins. In much the same way that significant science is still being squeezed out of the moon samples snatched by Apollo astronauts half a century ago, the Mars samples would be the scientific gifts that keep on giving as engineers continue to advance Earthly instrumentation and analysis techniques.

"With sample return, you're not constrained to those instruments you can carry on your back to Mars, and you're not constrained in that moment [of time]," says Salvo. "That's why this mission is so compelling." ★



Covid-19 proves importance of resilience planning

The pandemic has shown us just how fragile air travel is, but diseases are far from the only potential disrupters in our future, and air travel is far from the only aerospace infrastructure at risk. Business management expert Amir S. Gohardani says covid-19 has things to teach us about domino effects and resilience.

BY AMIR S. GOHARDANI

As the covid-19 pandemic unfolds, resulting in deaths and major financial burdens for many airlines in addition to industrywide project delays, furloughs and layoffs, the aerospace and defense sector needs to recognize and address the resulting disruptive forces, and prepare to be resilient against future disruptions caused by the next disease or other tumultuous event.

Consider an analogy from a field adjacent to aerospace technology: Specialists in computer security and related fields of cybersecurity and information technology security often log network disruptions caused, for example, by cyberattacks. Such disruptions can mean loss of revenue for a company or an organization. Other kinds of cyberattacks can involve data breaches or theft of intellectual property that play out without obvious disruption, but in the longer term these can tarnish a brand's reputation and, at times, even threaten the very survival of a business or an organization. In 2018, the White House Council of Economic Advisers published a report estimating that malicious cyber activity cost the U.S. economy between $57 billion and $109 billion in 2016. Knowing the potential impacts of cyberattacks, wise organizations establish backup plans that detail the process for recovering information or getting systems operating again. Furthermore, a disaster recovery cost curve assists the stakeholders to identify an optimal disruption recovery plan in terms of cost and time. Organizations create business continuity plans, often utilizing a planning suite detailed in public forums by the Department of Homeland Security. Developed by DHS and the Federal Emergency Management Agency, the Business Continuity Planning Suite software is intended for any business with the need to create, improve or update its business continuity plan. In short, in the face of attacks or disruptions, everyone seeks resilience.

The aerospace and defense sector can learn from these insights. Both kinds of disruptions trigger other events that can have negative consequences but sometimes positive ones too. High-profile cyber incidents have prompted the software industry to develop smart learning systems for cyberattack detection. That's good, but on the other hand, such attacks can result in theft of intellectual property that can jeopardize U.S. national security objectives. Regarding the pandemic, here in the United States the flood of patients has exposed the dangers of relying on foreign suppliers for ventilators, masks and other equipment.

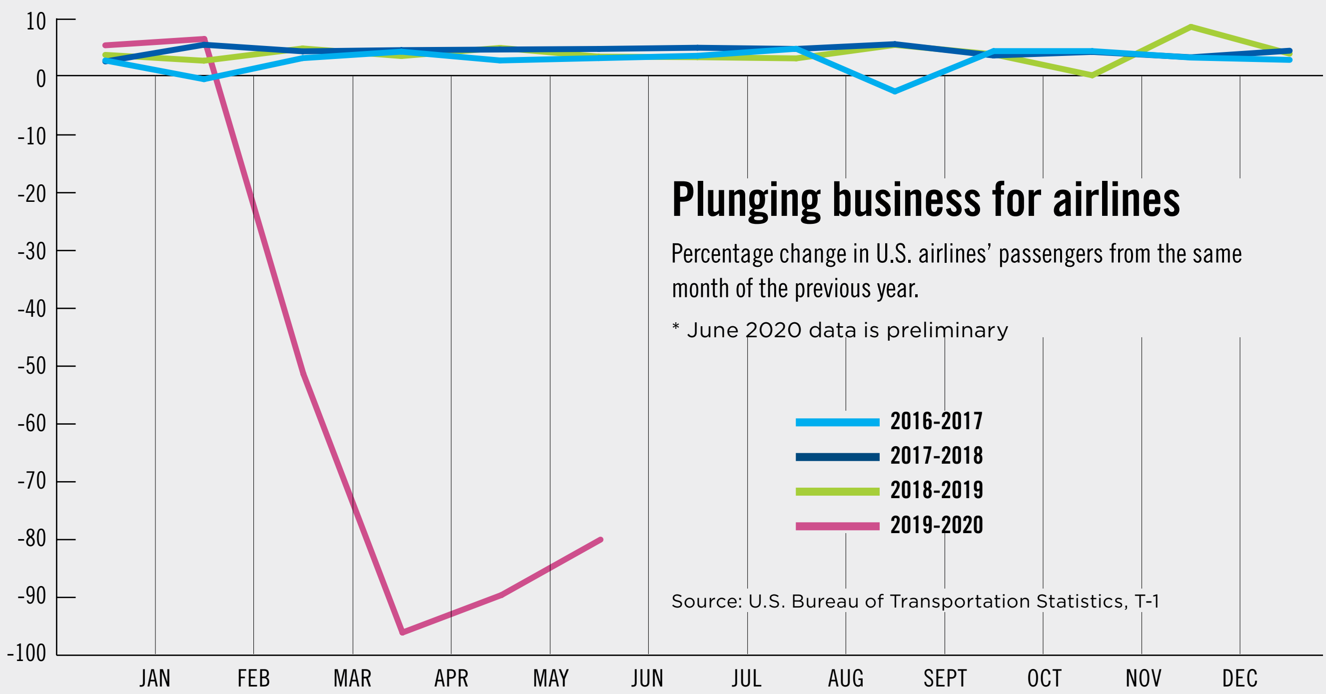
By having the lessons learned of aerospace history in mind and by embracing resilience with more rigor, corporations, government entities, policymakers and legislators can better prepare themselves for future disruptions with minimized losses in terms of human capital, financial capital and intellectual capital. In this context, loss reduction must be enabled through crafted methods and lines of action similar to the business continuity plans we see in the cyber sector. Such plans could also entail rerouting resources, products or services for optimized results under such dire circumstances.

Resilience planning could have helped authorities and the airlines make better use of aircraft, for instance. Many times during the pandemic, nearly empty planes have flown between destinations. The passengers were mainly health professionals embarking on their noble objective of saving lives, but flying a 200-passenger aircraft with a handful of passengers for these purposes was inefficient for all. Perhaps another arrangement could have been considered.

Another important concept is system resilience, the ability of a system to absorb changes and disturbances in the environment and maintain system functionality. A twin-engine aircraft with a skilled pilot aboard can, for example, experience an engine-out, and the pilot can land safely despite this disruption. Aviation authorities achieved this resilience in part by establishing ETOPS, short for the Extended-range Twin-engine Operational Performance Standards certification process, which specifies the maximum distance in minutes an

▼ **Lufthansa Technik** converted four Airbus A330-300 passenger aircraft to transport cargo after passenger travel was largely shut down because of the pandemic.

Lufthansa Technik



Amir S. Gohardani, has a doctorate in aerospace engineering and teaches business management and strategy courses in Orange County, California. He is a co-founder of Springs of Dreams Corp., a nonprofit educational organization. An AIAA associate fellow, he is the chair of the institute's Society and Aerospace Technology Outreach Committee.

aircraft of a particular design should be permitted to fly from the nearest airport, thus ensuring that a one-engine emergency landing is always feasible.

Just as a twin-engine aircraft can be engineered for resilience, so can a complex socio-technical system. Resilience is a promising discipline for potentially identifying domino effects through a holistic lens and overcoming them with minimal harm. This discipline broadly includes dependencies among four key capabilities: responding, monitoring, learning and anticipating.

When the 1973 oil crisis hit, aeronautical researchers looked for technical solutions to offset the spikes in fuel prices. NASA researchers gained momentum in their research studies. Also, the Hamilton Standard division of United Technologies patented the propfan concept in 1979, while General Electric worked on unducted fans. Researchers explored a propfan concept that would offer the fuel economy of a turboprop with the speed and technical performance of a turbofan. Unducted fans and open rotor engines are variations of this concept. In short, a wealth of technical knowledge was surveyed and generated. This instance marked a positive domino effect and illustrates that the aerospace sector already has the knowledge base and capabilities associated with resilience engineering. But today, there is still room for improvement and out-of-the-box thinking.

Looking at air travel during the pandemic, in pace with growing health concerns, the global slowdown consistently has caused a market surplus of air passenger services. Interestingly, despite the global economic slowdown prompted by the pandemic and air freight volume plunging by almost 28% earlier this year, air cargo demand soared for personal protective equipment and other items manufactured in Asia for delivery in Europe and North America. Some airlines repurposed sections of their air fleets by removing the passenger seats and transformed passenger aircraft into air freighters. This example shows that organizations can address disruptions through planning and resilience. Though it would be impossible to predict every possible scenario or the exact impact of the pandemic, airlines can employ applied data analytics to a larger extent than before to consider alternative cases for optimal operations. Similarly, the aerospace and defense sector should work more rigorously to predict adverse domino effects by employing additional resources and engaging in greater information sharing across U.S. government entities to minimize adverse effects. The defense side of the sector sometimes does this in military simulations, more commonly known as war games. The pandemic should further be a wakeup call to instill resilience in light of two threats in particular: a collision in space that knocks out communications, GPS or other satellite-based services, and the advent of drones, potentially swarms of drones, and their threat as bioweapons.

Although it is debatable if history repeats itself, in terms of pandemics, at least exemplified by the 1918 flu pandemic, this is true. Treating each event against a historical backdrop can at times remain a reasonable method for getting prepared. In the words of Mark Twain: "A favorite theory of mine is that no occurrence is sole and solitary, but is merely a repetition of a thing which has happened before, and perhaps often." ★

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Addresses for Technical Committees and Section Chairs can be found on the AIAA website at aiaa.org.

Other Important Numbers: Aerospace America / Karen Small, ext. 7569 • AIAA Bulletin / Christine Williams, ext. 7575 • AIAA Foundation / Merrie Scott, ext. 7530 • Book Sales / 800.682.AIAA or 703.661.1595, Dept. 415 • Communications / Michele McDonald, ext. 7542 • Continuing Education / Jason Cole, ext. 7596 • Corporate Programs / Nancy Hilliard, ext. 7509 • Editorial, Books and Journals / Heather Brennan, ext. 7568 • Exhibits and Sponsorship / Chris Semon, ext. 7510 • Honors and Awards / Patricia Carr, ext. 7523 • Integration and Outreach Committees / Nancy Hilliard, ext. 7509 • Journal Subscriptions, Member / 800.639.AIAA • Journal Subscriptions, Institutional / Online Archive Subscriptions / Michele Dominiak, ext. 7531 • K–12 Programs / Sha'Niece Simmons, ext. 7590 • Media Relations / Michele McDonald, ext. 7542 • Engage Online Community / Luci Blodgett, ext. 7537 • Public Policy / Steve Sidorek, ext. 7541 • Section Activities / Lindsay Mitchell, ext. 7502 • Standards, Domestic / Hilary Woehrle, ext. 7546 • Standards, International / Nick Tongson, ext. 7515 • Technical Committees / Angie Lander, ext. 7577 • University Programs / Michael Lagana, ext. 7503 • Young Professionals Programs / Alex D'Imperio, ext. 7536

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

FEATURED EVENT

ASCEND

16–18 NOVEMBER 2020

Online Event

ASCEND is the most forward-thinking space event in the world. It's the center of gravity for the space community—bringing technical and business leaders together to solve problems that affect our entire planet and beyond. Join us at ASCEND to build the future of space in cyberspace.

www.ascend.events

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2020			
9 Sep–9 Oct	Hypersonic Flight Vehicle Design and Performance Analysis Course	Online (aiaa.org/events-learning/online-education)	
12 Sep–26 Sep	Fundamentals of Python Programming with Libraries for Aerospace Engineers	Online (aiaa.org/events-learning/online-education)	
15–16 Oct	Young Professionals, Students, and Educators Conference	VIRTUAL EVENT (aiaaypse.com)	25 Sep 20
15 Sep–15 Oct	Liquid Rocket Engines: Emerging Technologies in Liquid Propulsion Course	Online (aiaa.org/events-learning/online-education)	
24 Sep–12 Nov	Design and Operation of Composite Overwrapped Pressure Vessels Course	Online (aiaa.org/events-learning/online-education)	
11–15 Oct*	39th Digital Avionics Systems Conference (DASC)	VIRTUAL EVENT (https://2020.dasconline.org/)	
12–14 Oct*	71st International Astronautical Congress (The CyberSpace Edition)	(iac2020.org)	
7 & 9 Oct	Sustainable Aviation	Online (aiaa.org/events-learning/online-education)	
14 Oct–11 Nov	Electrified Aircraft Propulsion Technologies: Powering the Future of Air Transportation	Online (aiaa.org/events-learning/online-education)	
19–28 Oct	Design for Advanced Manufacturing: Aviation Lightweighting Course	Online (aiaa.org/events-learning/online-education)	
20 Oct–12 Nov	Taking the Next Steps in Your Aerospace Career Course	Online (aiaa.org/events-learning/online-education)	
16–18 Nov	ASCEND Powered by AIAA	VIRTUAL EVENT	31 Mar 20
25–26 Nov	AIAA Region VII/Sydney Section Student Conference	Sydney, NSW, Australia	6 Oct 20

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.).

2021			
TBD Jan	1st AIAA CFD Transition Modeling Prediction Workshop	VIRTUAL EVENT	
TBD Jan	1st AIAA Stability and Control Prediction Workshop	VIRTUAL EVENT	
9–10 Jan	5th AIAA Propulsion Aerodynamics Workshop (PAW05)	VIRTUAL EVENT	
11–15 Jan	AIAA SciTech Forum	VIRTUAL EVENT	8 Jun 20
28 Jan–4 Feb*	43rd Scientific Assembly of the Committee on Space Research and Associated Events	Sydney, Australia (cospar2020.org)	14 Feb 20
31 Jan–4 Feb*	31st AAS/AIAA Space Flight Mechanics Meeting	Charlotte, NC (http://space-flight.org)	
6–13 Mar*	2021 IEEE Aerospace Conference	Big Sky, MT (www.aeroconf.org)	
3–4 Apr	AIAA Region VI Student Conference	Long Beach, CA	
8–9 Apr	AIAA Region II Student Conference	Tuscaloosa, AL	
12–14 Apr*	55th 3AF Conference on Applied Aerodynamics (AERO2020+1)	Poitiers, France (http://3af-aerodynamics2020.com)	
15–18 Apr	AIAA Design/Build/Fly Competition	Tucson, AZ	
20–22 Apr	AIAA DEFENSE Forum	Laurel, MD	17 Sep 20
5–7 May*	6th CEAS Conference on Guidance Navigation and Control (2021 EuroGNC)	Berlin, Germany (https://eurognc2021.dglr.de)	
31 May–2 Jun*	28th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (elektropribor.spb.ru/en)	
6 Jun	2nd AIAA Workshop for Multifidelity Modeling in Support of Design & Uncertainty Quantification	Washington, DC	
7–11 Jun	AIAA AVIATION Forum	Washington, DC	10 Nov 20
22–25 Jun*	ICNPAA 2021: Mathematical Problems in Engineering, Aerospace and Sciences	Prague, Czech Republic (icnpaa.com)	
9–11 Aug	AIAA Propulsion and Energy Forum	Denver, CO	
6–10 Sep*	POSTPONED FROM 2020: 32nd Congress of the International Council of the Aeronautical Sciences	Shanghai, China (icas.org)	15 Jul 19
27–30 Sep*	POSTPONED FROM 2020: 37th International Communications Satellite Systems Conference (ICSSC 2020)	Okinawa, Japan (kaconf.org)	15 May 19
25–29 Oct*	72nd International Astronautical Congress	Dubai, UAE	
15–17 Nov	ASCEND Powered by AIAA	Las Vegas, NV	

● AIAA Continuing Education offerings

**Meetings cosponsored by AIAA. Cosponsorship forms can be found at aiaa.org/Co-SponsorshipOpportunities.*

Call for Papers for the 31st AAS/AIAA Space Flight Mechanics Meeting

The 31st AAS/AIAA Space Flight Mechanics Meeting will be held 31 January–4 February 2021 at the Sheraton Charlotte in Charlotte, NC. Manuscripts are solicited on topics related to space-flight mechanics and astrodynamics, including but not limited to:

- Space robotics and autonomous space operations
- Earth orbital and planetary mission studies
- Asteroid and non-Earth orbiting missions
- Trajectory / mission / maneuver design and optimization
- Orbital dynamics, perturbations, and stability
- Rendezvous, relative motion, proximity missions, and formation flying
- Satellite constellations
- Dynamical systems theory applied to space flight problems
- Reusable launch vehicle design, dynamics, guidance, and control
- Machine learning, artificial intelligence, applied math applied to space flight problems
- Orbital debris and space environment
- Space Situational Awareness (SSA), Conjunction Analysis (CA), and collision avoidance
- Orbit determination and space-surveillance tracking
- Spacecraft guidance, navigation and control (GNC)
- Attitude dynamics, determination and control
- Ground-based sensors for space applications and payload-sensors
- Atmospheric re-entry guidance and control
- Dynamics and control of large space structures and tethers

The abstract deadline is 5 October 2020. More information can be found at http://space-flight.org/docs/2021_winter/2021_winter.html.

AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award

CALL FOR NOMINATIONS

Nominations are currently being accepted for the 2020 **AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award**. The recipient will receive a certificate and a $7,500 honorarium.

This award honors individuals who have made significant improvements in the relationships between airports and/or heliports and the surrounding environment, specifically by creating best-in-class practices that can be replicated elsewhere. Such enhancements might be in airport land use, airport noise reduction, protection of environmental critical resources, architecture, landscaping, or other design considerations to improve the compatibility of airports and their communities.

For nomination forms, please visit **aiaa.org/SpeasAward**. Presentation of the award will be made at the AAAE/ACC Planning, Design, and Construction Symposium, scheduled for February 2021.

DEADLINE: 1 November 2020
CONTACT: AIAA Honors and Awards Program at awards@aiaa.org

aiaa.org/SpeasAward

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

AIAA SHAPING THE FUTURE OF AEROSPACE
AAAE
ACC AIRPORT CONSULTANTS COUNCIL

ASCENDxSeries

The world is changing and so is ASCEND. AIAA's new space event was originally imagined as an in-person experience for reshaping the conversation around the space ecosystem and driving the space economy forward. This year's ASCEND (ascend.events) has transformed into a fully online event 16-18 November, and we have introduced new opportunities to shake up the conversation.

The ASCENDxSeries (ascend.events/experience/events) is a collection of online events happening now through November, which will feature curated webinars, collaborative workshops, and comprehensive summits for space experts, entrepreneurs, and enthusiasts. These three types of events each has a distinct purpose and format that allows for different types of engagement.

ASCENDxWebinars explore specific topics like diversity and inclusion in the aerospace workforce or the technologies, design, and ethics of building off-world civilizations. Most importantly, attendees get a chance to ask subject-matter experts the tough or top-of-mind questions in real time.

ASCENDxCo-Labs allow participants to connect and collaborate directly with each other through facilitated conversations that enable knowledge capture and result in tangible outcomes for the community.

ASCENDxSummits are multitrack, interdisciplinary events, each centered around a broad theme. Each summit, held monthly through November, features compelling keynote presentations, high-level panels, and in-depth workshops that provide inspiration and information.

The ASCENDxSeries events don't stop when the online meeting ends – each recording is available to watch on demand and many will lead to actionable outcomes. The ASCENDxCo-Lab on 29 July is leading to a collaborative report in response to NASA's "Plan for Sustained Lunar Exploration and Development." The ASCENDxWebinars on 17 and 21 July, which focused on diversity, equity, and inclusion, have already generated new partnerships across the aerospace community. The ASCENDxSummit in August connected aerospace professionals to the broader community of industries and individuals beginning to invest in space.

Each ASCENDxSeries event adds to the conversations we will be having in November at ASCEND that will shape the future for all who look to the stars and see the worlds of possibility. Join us!

San Martin Wins Brill Lectureship in Aerospace Engineering

AIAA and the National Academy of Engineering (NAE) have selected **Dr. Alejandro Miguel San Martin**, Guidance & Control Section Chief Engineer at NASA Jet Propulsion Laboratory (JPL) as the recipient of the fourth Yvonne C. Brill Lectureship in Aerospace Engineering. San Martin will present his lecture, "From Airbags to Wheels: The Evolution of GN&C for Entry, Descent, and Landing" on 7 October, 1100–1200 hrs ET, in conjunction with the virtual NAE Annual Meeting.

Early in his career at JPL, San Martin participated in the Magellan mission to Venus and the Cassini mission to Saturn. He was later named Chief Engineer for the Guidance, Navigation, and Control system for the Pathfinder mission. He assumed the same role for the mission that landed the robotic vehicles Spirit and Opportunity on Mars in 2004. Most recently, he was the Chief Engineer for Guidance, Navigation, and Control for the Mars Science Laboratory, which landed Curiosity on the surface of Mars in

2012. He was a co-architect of Curiosity's innovative SkyCrane landing architecture and also served as its Deputy Chief for Entry, Descent, and Landing. Throughout his career, San Martin has served as a panel consultant for various missions including Topex, Mars Polar Lander, Deep Impact, and Phoenix. San Martin has a B.S. in Electrical Engineering from Syracuse University and an M.S. from MIT in Aeronautics and Astronautics Engineering with a specialization in Guidance, Navigation, and Control for interplanetary space exploration.

AIAA, with the participation and support of NAE, created the Yvonne C. Brill Lectureship in Aerospace Engineering to honor the memory of the late, pioneering rocket scientist, AIAA Honorary Fellow and NAE Member, Yvonne C. Brill. The lecture emphasizes research or engineering issues for space travel and exploration, aerospace education of students and the public, and other aerospace issues such as ensuring a diverse and robust engineering community.

FREE LECTURE: Register at: www.nae.edu/238584/2020-Yvonne-C-Brill-Lectureship-in-Aerospace-Engineering.

MAKING AN IMPACT

Scholarship and Graduate Award Winners

Each year, AIAA distributes over $70,000 in scholarships and graduate awards to undergraduate and graduate students studying aerospace engineering at accredited colleges and universities throughout the United States. In 2020, AIAA scholarship and graduate award winners came from all corners of the aerospace industry and are studying a variety of topics from digital avionics to hypersonics. Below, we profile this year's 22 scholarship and graduate award winners who are shaping the future of aerospace.

AIAA Graduate Award Winners

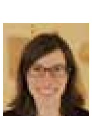
Neil Armstrong Graduate Award

Kathrine Bretl
University of Colorado Boulder (Boulder, CO)
Amount of Award: $5,000

Kathrine is in her final year of her Ph.D. at the University of Colorado Boulder, studying Aerospace Engineering with a focus in Bioastronautics. She completed a Bachelor of Science in Aeronautics and Astronautics with a minor in Political Science at MIT, then a dual-Masters in Aerospace Engineering Sciences and Engineering Management at CU. She has previously worked at SpaceX, several NASA centers across the country, and most recently, is collaborating with ESA/DLR. With a passion for both human spaceflight and space policy, she hopes to become an integral part of program management and policy development to continue to advance human space exploration.

"Human spaceflight is inherently challenging, and that challenge is what drew me to the field — using a multi-disciplinary approach to solve problems that promote and ensure safe and productive crewed flight. I look forward to opportunities for continued contributions to the field of Bioastronautics, and I am honored to be supported in these endeavors by AIAA through the Neil Armstrong Graduate Award."

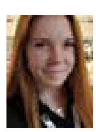
Orville & Wilbur Wright Graduate Awards



Elizabeth Benitez
Purdue University (West Lafayette, IN)
Amount of Award: $5,000

Elizabeth is a Ph.D. candidate at Purdue University studying travelling instabilities in Mach 6 flow with an axisymmetric separation bubble. Previously, she was a research engineer with Georgia Tech Research Institute for nearly five years, working with the Air Force in Dayton, OH. Elizabeth received a Masters in Aerospace Engineering from Georgia Tech in 2015, and a Bachelors in Aerospace Engineering with Information Technology from MIT in 2013.

"I am honored to have been selected to receive the Orville and Wilbur Wright Graduate Award from AIAA. Since I started my PhD, I have enjoyed participating in AIAA conferences and events. I am happy to be recognized by such a central organization to my field, and to be chosen from among students across the world. Having AIAA as a partner to fund my research is a great privilege, and this award is truly appreciated."



Julia Mihalyov
Johns Hopkins University (Baltimore, MD)
Amount of Award: $5,000

Julia is a first-generation Bulgarian-American as well as the first of her family to attend college in the United States. Julia graduated from Embry-Riddle Aeronautical University's Prescott campus with a B.S. in Aerospace Engineering with a focus in Astronautics. As an undergraduate student, Julia worked on a research and coding project in association with NASA Jet Propulsion Laboratory (JPL) where she aided in developing an ephemeris reader in the Julia Language as an additional tool for use in trajectory design, interplanetary travel, and other astrodynamics implementations. In 2018, Julia worked at The Aerospace Corporation in the Modeling and Simulation Department as a Brooke Owens Fellow. Following graduation, Julia worked as an intern at JPL supporting Psyche, a mission to analyze a metal asteroid appearing to exist as a core of a planet. Following her internship, Julia began her M.S. studies at Johns Hopkins University for Space Systems Engineering and is now working as a Systems Engineer at JPL supporting Europa Clipper, a mission dedicated to search for the habitability of life on Jupiter's icy moon Europa.

"This graduate scholarship award from AIAA will greatly support me in completing my higher education and obtaining my M.S. from Johns Hopkins, advancing towards my ultimate life goal to lead prominent space missions to success."

Dr. Hassan A. Hassan Graduate Awards in Aerospace Engineering

Andrew Navratil
North Carolina State University (Raleigh, NC)
Amount of Award: $5,000

Andrew is a graduate student at North Carolina State University pursuing a Ph.D. in CFD looking at turbulent combustion in high speed flows. He graduated Summa Cum Laude with a second B.S. in Aerospace Engineering from NC State University in spring 2020, and got his first B.S. from the University of New Hampshire in Mathematics with Computer Science. Andrew is originally from Albany, NY, is the oldest of seven, and an avid mountain biker.

"Dr. Hassan A. Hassan was a mainstay in the NCSU aero program from the early 1960s until his untimely death in 2019. I am honored to continue my education and contribute to research in aerospace engineering at NCSU under Dr. Jack Edwards, who worked closely with Dr. Hassan. I will strive to uphold the values this award signified and I am grateful for the financial support it provides as I continue to work hard at making a contribution with my research in CFD."

Elizabeth Blenk
North Carolina State University (Raleigh, NC)
Amount of Award: $5,000

Elizabeth completed her undergraduate degree in Aerospace Engineering from NC State University and will enter the Aerospace Engineering Graduate Program at NC State University in fall 2020. After completing her graduate degree, she hopes to secure a position in a company that allows her to continue challenging herself and expanding her education.

"This award will allow me to focus my efforts on my academics and on my involvement in AIAA. It is my hope to help those who are still trying to figure out what they want to achieve with their education. I have had the opportunity to explore various career paths and now that I've chosen my path, this scholarship will allow me to help others explore."

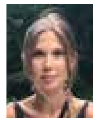
Luis de Florez Graduate Award

Julie Duetsch-Patel
Virginia Polytechnic Institute and State University (Blacksburg, VA)
Amount of Award: $3,500

Julie is a second-year Aerospace Engineering Ph.D. student at Virginia Tech, concentrating in Aero/Hydrodynamics. Her research focuses on the turbulent separated flow over a bump model, collecting and analyzing detailed experimental data to be used for CF validation studies. Julie graduated with her B.S. in Aerospace Engineering from Virginia Tech in 2019 as the departmentally-recognized outstanding senior. During her undergraduate studies, she was president of the AIAA Virginia Tech Student Branch for two years and served on the executive board of the Virginia Tech Society of Women Engineers student chapter.

"I am so grateful and honored to receive this award. This award will give me greater freedom to focus on my classes, my research, and my development as a graduate student by reducing financial concerns and strains that would otherwise distract. From the essential work I must do to develop myself. As an engineer. I am very fortunate to have found a field that challenges me and helps me to grow every day, and I am thankful to everyone who has helped support me as I pursue my passion."

Guidance, Navigation, and Control Graduate Award

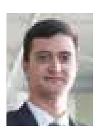


Maria Del Mar Cols-Margenet
University of Colorado Boulder (Boulder, CO)
Amount of Award: $2,500

Originally from Spain, Maria moved to the United States in 2015 to pursue a Ph.D. in aerospace engineering sciences at the University of Colorado Boulder. During these years, she has researched end-to-end flight software development strategies while collaborating on an interplanetary spacecraft mission with the Laboratory for Atmospheric and Space Physics (LASP).

"Receiving the AIAA GN&C graduate award, almost at the end of my PhD degree, is a magnificent way of closing up a very stimulating stage of my life. I am certain that, now and in the future, this recognition will help me on the quest for jobs as an aerospace flight software engineer"

John Leland Atwood Graduate Award



Alejandro Trujillo
Massachusetts Institute of Technology (Cambridge, MA)
Amount of Award: $1,250

Alejandro was born and raised in Miami, FL, to parents who immigrated to the United States from Cuba. He attended Georgia Tech from 2012 to 2016 and graduated with highest honors with a bachelor's degree in Aerospace Engineering. He then chose to attend MIT to pursue a Masters and Ph.D. in Space Systems Engineering; he received his Masters in 2018 and hopes to complete his Ph.D. by 2021. Throughout his academic career, he has also explored the space industry with internships in a variety of places, including Draper, NASA Marshall Space Flight Center, SpaceX, and most recently, The Aerospace Corporation. His career goals are to play a part in the return of human spaceflight to the moon and to Mars and beyond.

"Receiving the John Leland Atwood Graduate Award from AIAA will allow me to cover travel costs and other expenses for the academic and industry conferences in which I have papers being presented. These conferences are crucial to advancing my professional development and, as such, this award contributes directly to my growth as an engineer and industry member."

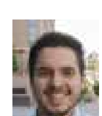
Martin Summerfield Propellants and Combustion Graduate Award

Umesh Unnikrishnan
Georgia Institute of Technology (Atlanta, GA)
Amount of Award: $1,250

Umesh is a graduate student working toward his doctoral degree in Aerospace Engineering at Georgia Tech. His research interests are centered around computational modeling and simulation of turbulent combustion. His doctoral thesis focuses on understanding turbulence and combustion processes at supercritical conditions and developing advanced subrigid scale modeling approaches to enable high-fidelity large eddy simulation of supercritical combustion in liquid rocket and other high pressure combustion devices.

"I consider being presented the AIAA Foundation Summerfield Graduate Award as a prestigious recognition of my academic diligence and research contributions to the field of aerospace propulsion and combustion. The award provides an inspiration and morale boost to continue to strive towards academic excellence in this field. It also serves as an endorsement of the significance and rigor of my research endeavor, and provides the impetus and support to advance my research work."

Gordon C. Oates Air Breathing Propulsion Graduate Award



Andres Adam
University of California, Irvine (Irvine, CA)
Amount of Award: $1,000

Andres was born in Caracas, Venezuela, and grew up in Barcelona, Spain. He obtained a bachelor's degree in Aerospace Technologies at the Polytechnic University of Catalonia (UPC) in 2015. In 2016, he was awarded the Balsells fellowship to pursue a Ph.D. in aerospace engineering at the University of California, Irvine (UCI). In 2018, he completed a program for double Master's degrees in aerospace engineering at UPC and UCI. Andres is currently a Ph.D. candidate at UCI whose research focuses on the noise modeling of turbulent jets.

"We live in times of change and uncertainty. We, as individuals, need to ask ourselves how our work is helping the world change for the better. This award will help me in my research towards reducing noise pollution from turbine engines, thus bringing air travel closer to the community It also serves as motivation for my future work and professional career."

William T. Piper Sr. General Aviation Systems Graduate Award

Mayank Bendarkar
Georgia Institute of Technology (Atlanta, GA)
Amount of Award: $1,000

Mayank is a Ph.D. candidate in the Aerospace Systems Design Lab at Georgia Tech. His Ph.D. research focuses on incorporating certification, system reliability, and safety considerations in the preliminary design stage for novel aircraft configurations and technologies. He completed his undergraduate education at the Indian Institute of Technology, Bombay. In his free time, he likes to go on hikes, play board games, or play table (Indian drums).

"AIAA has played an enriching role in my student and professional life and I am grateful to be award the William T. Piper Sr. General Aviation Systems Graduate Award. I intend to use it to attend future AIAA conference and events and stay-up-to-date with the state of the art in aerospace engineering."

AIAA Undergraduate Scholarship Winners

Daedalus 88 Scholarship

Niloy Gupta
University of Maryland, College Park (College Park, MD)
Amount of Scholarship: $10,000

Niloy is a senior double majoring in aerospace engineering and mathematics at the University of Maryland. He was on the ex-ABC research project, where he developed the flight systems for a novel, fixed-pitched, electric, coaxial helicopter. He currently conducts research on active flow control devices in addition to being heavily involved in the college's Design/Build/Fly team and the Tau Beta Pi and Sigma Gamma Tau engineering honor societies. He plans to pursue a Ph.D. in hypersonic aerodynamics before working in industry.

"This scholarship will allow me to spend more time on my schoolwork, research, and professional societies as I will not have to work part time to cover some of my expenses."

David and Catherine Thompson Space Technology Undergraduate Scholarship

Linyi Hou
University of Illinois at Urbana-Champaign (Champaign, IL)
Amount of Scholarship: $10,000

Linyi is a senior in aerospace engineering with a minor in computer engineering. Currently, his research focuses on velocity-based orbit determination and Neptune aerocapture. He wishes to pursue a career in space mission design and optimization to the outer planets and asteroids. In his spare time, Linyi is heavily involved in a student organization called the Illinois Space Society, and he also enjoys soccer, cooking, and playing the guitar.

"This scholarship helps me complete my undergraduate education at the University of Illinois, and brings me closer to my goal of earning a doctoral degree in aerospace. Knowing that my efforts have been recognized by the scholarship committee is a strong motivator for me to work more diligently in the years to come."

Vicki and George Muellner Scholarship for Aerospace Engineering

Matthew Mullin
Stony Brook University (Stony Brook, NY)
Amount of Scholarship: $5,000

Matthew Mullin is a rising senior mechanical engineering major at Stony Brook University and an active member of the AIAA Student Branch at Stony Brook University, serving as Vice-President and Design/Build/Fly propulsion lead. Matthew's interests lie in propulsion, sustainability, renewable energy, and their intersection. He is currently working on a high-altitude balloon startup, and was fortunate enough to win 1^{st} place in the 2020 SBDC Stony Brook Entrepreneur's Challenge and 3^{rd} in the NYBPC Business Competition in the energy/environment category.

"I am incredibly grateful to receive the Vicki and George Muellner Scholarship. I'll be able to take extra classes during the winter, which will better prepare me for my graduate studies where I intend to pursue alternative propulsion and applications of renewable energies."

Wernher von Braun Undergraduate Scholarship

Rachel Cueva
University of Maryland, College Park (College Park, MD)
Amount of Scholarship: $5,000

Rachel is a rising senior in the University of Maryland's Department of Aerospace Engineering. She is a part of the Gemstone Honors College and Aerospace Engineering Honors Program, as well as a Pathways Engineering Student Trainee at NASA Goddard Space Flight Center contributing to the Nancy Grace Roman Space Telescope. Her ultimate goal is to become a NASA astronaut and contribute to future missions to the moon and Mars.

"This scholarship will help me to achieve my educational goals by reducing student debt for continued education, and will enable me to pursue my dream of becoming a NASA Astronaut."

Liquid Propulsion Scholarship

Kiseuk Ahn
Bellevue College (Bellevue, WA)
Amount of Scholarship: $2,000

Kiseuk is a sophomore at Bellevue College studying Mechanical Engineering with a passion for research and development in the aerospace industry. Kiseuk hopes to continue gaining scientific knowledge and skills through classes, extracurriculars, internships, and jobs to obtain an advanced degree with the goal to become a research scientist working for a sustainable future.

"The AIAA Liquid Propulsion Scholarship has encouraged me to keep pursuing challenging endeavors to achieve my goals of helping the world to become a better place."

Cary Spitzer Digital Avionics Scholarship

Isaiah Fleischer
University of Michigan (Ann Arbor, MI)
Amount of Scholarship: $2,000

Isaiah is a rising senior pursuing a BSE in Aerospace Engineering at the University of Michigan. He is on the Social Committee of Michigan's AIAA Student Branch and plays an active role in Michigan's WOAA chapter. Additionally, he serves as the Internal Operations Director of M-Fly, Michigan's SAE Aero Design Team. Isaiah plans to pursue a career in Systems Engineering, with a focus in Operations Analysis. Outside of aerospace, he has a passion for skiing, rock climbing, and photography.

"This scholarship will help me finish my undergraduate degree so I can continue on to a Master's in Space Engineering at Michigan. The combination of my BSE and M.Eng will prepare me to tackle challenges in my career and hit the ground running as a Systems Engineer."

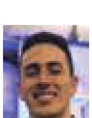
Dr. Amy R. Prichett Digital Avionics Scholarship

Laura Morejon-Ramirez
University of California, San Diego (San Diego, CA)
Amount of Scholarship: $2,000

Laura is a Senior at the University of California, San Diego and has served as the chairperson of her school's AIAA student branch for a year, and has been involved with the organization during her whole college career. She is very grateful for the opportunities AIAA has provided her, from professional connections, to technical skills, to lifelong friendships.

"Thanks to the Dr. Amy R. Prichett Digital Avionics Scholarship, I will be able to pursue my dream of becoming a successful Aerospace Engineer. I am thankful for having been chosen for this award and can't wait to keep gaining technical and soft skills in aerospace."

Dr. James Rankin Digital Avionics Scholarship



Carson Schubert
University of Texas at Austin (Austin, TX)
Amount of Scholarship: $2,000

Carson's academic focus is wireless communications, and he has called Texas "home" for his entire life. From an early age, Carson was hooked on anything space related, and knew that he wanted to devote his life to enabling the next generation of exploration and discovery. This dream has taken him to NASA Glenn Research Center, where he worked on cognitive communications; NASA Jet Propulsion Laboratory, where he worked on the Europa Clipper mission planning team; and most recently Blue Origin and New Glenn Communications, where Carson worked on avionics research and communications respectively. Back at university, Carson does research with the Texas Spacecraft Lab. Whenever geography allows, you can find Carson hiking and backpacking in the mountains.

"I hope to inspire all humanity by engaging the nation, and the world in the incredible journey that is space exploration. To do that I must obtain an education that takes me to the forefront of space technology and scientific discovery. This scholarship from AIAA is invaluable in the pursuit of this future, and will allow me to focus on my studies rather than my finances."

Ellis F. Hitt Digital Avionics Scholarship

Sean Dungan
Florida Institute of Technology (Melbourne, FL)
Amount of Scholarship: $2,000

Hailing from Middletown, Rhode Island, Sean Dungan is a hungry Aerospace Engineer in the making. Sean hopes to contribute greatly to the field of aerospace and set his sights on CFD and modeling techniques. When he is not at his desk, one can find Sean in the ocean or at the golf course.

"This very generous scholarship will help me finish paying for my undergraduate studies and help me apply to graduate school. It will also help shift the deciding factor from economic to academic reasons when choosing the best graduate program for me."

Space Transportation Scholarship

Mark Magnante
University of Missouri (Columbia, MO)
Amount of Scholarship: $1,500

Mark is a senior at the University of Missouri – Columbia, majoring in Mechanical Engineering and minoring in Aerospace Engineering and Mathematics. Mark has served as Vice Chair of Mizzou's AIAA Student Branch in the 2019-2020 academic year and is the propulsion lead for rocket projects in the coming fall semester. Mark is originally from Newbury Park, CA.

"This AIAA scholarship is going to help me graduate from Mizzou debt-free while reducing the financial burden placed on my family as a whole. While my brother is a rising sophomore at Mizzou and with my parents having to deal with COVID in the classroom as high school teachers, this really means a lot."

Leatrice Gregory Pendray Scholarship

Kyra Warren
Trine University (Angola, IN)
Amount of Scholarship: $1,250

Kyra is in her third year at Trine University and is pursuing her studies in Aerospace Engineering. At Trine, Kyra serves as secretary of the AIAA Student Branch and ASME Chapter and competes on the women's triathlon team. The AIAA Student Branch and ASME Chapter Trine is growing each year and continuing to create more activities to involve the student body and expose elementary students to engineering. Kyra has interned at L3Harris Technologies for the past two summers and gained experience in making satellites and learning the structural analysis side of mechanical engineering. Outside of school, Kyra is an avid cello player and enjoys disc golf.

"This scholarship will help me continue to pursue my dream in becoming a successful mechanical engineer in the aerospace field."

Applications for the 2021 scholarships are being accepted from 1 October to 31 January (**aiaa.org/home/get-involved/students-educators/scholarships-graduate-awards**). For information about how to get involved with AIAA and make an impact on the next generation of aerospace engineers, please visit aiaa.org/get-involved or contact Merrie Scott, merries@aiaa.org or contact Michael Lagana at scholarships@aiaa.org.

News

SAT OC — A New Beginning

By Amir S. Gohardani, SAT OC Chair

Sierra Nevada owners, Fatih Ozmen and Eren Ozmen, on either side of Michelle Rouch with "Chasing Our Dreams." CREDIT: KIDDIE HAWK AIR ACADEMY

In these unique times, many changes have taken place, including to the name of our committee, which is now officially known as the Society and Aerospace Technology Outreach Committee (SAT OC) per the Integration and Outreach division for 2020-2021. Our committed members lead many of the committee's originally planned activities with diligence and in recognition of these tireless efforts, SAT OC's most recent activities are categorized into three separate sections: art activities, ongoing initiatives, and planned collaborations.

Art Activities

SAT OC prides itself on its involvement with the arts, and Michelle Rouch spearheads many such efforts. On 16 January, she attended an event to raise funds to inspire kids in aviation: the Living Legends of Aviation in Beverly Hills, CA. A piece of her artwork titled "Chasing Our Dreams," depicting Sierra Nevada Corporation's Dream Chaser approaching the International Space Station, was showcased. The artwork had been commissioned by nonprofit Kiddie Hawk Air Academy.

Ongoing Initiatives

As in previous years, SAT OC will host its Society and Aerospace Technology track at the 2021 AIAA SciTech Forum. Primarily led by Matthew Kuester, this track typically examines the societal benefits of aerospace technologies/ products, as well as the relationship between aerospace and society, culture, and art.

Planned Collaborations

In recent meetings with Kevin Burns (History Committee), Alex Straub (Women of Aeronautics and Astronautics), and I, we discussed potential venues for collaboration among the committees. SAT OC welcomes such efforts and is currently exploring potential opportunities to collaborate with the AIAA Cybersecurity Working Group, led by Sam Adhikari.

Finally, SAT OC would not have accomplished so many of its goals without its valued members. In anticipation of a brighter future, I am delighted to work with such a talented pool of individuals from different backgrounds and collectively explore new chapters in SAT OC's future.

Wichita AIAA/SETP/SFTE Distinguished Lecture

On 25 June, the AIAA Wichita Section teamed up with the local and regional sections of the Society of Experimental Test Pilots (SETP) and the Society of Flight Test Engineers (SFTE) to host a very fascinating and entertaining Zoom presentation by AIAA Distinguished Lecturer, SETP Fellow, and test pilot **James "JB" Brown**, who spoke on "Flying the Lockheed Stealth Fighters." Approximately 75 professionals participated live and learned of the design history and of flight testing the F-117A and F-22 stealth fighters. Zoom worked particularly well, with JB able to demonstrate concepts as if in person (see photo) and show and describe slides and videos with high clarity. The presentation was followed by a question/answer period and then an informal, online social among the meeting participants.

As a bonus, participants at home were able to invite their family members, particularly their children, to follow along with the presentation. This was a great way to promote STEM careers and spark children's interest as they heard from a test pilot on the cutting edge of the aerospace profession.

How Far Do You See In 50 Years?

SSTC 2020 Middle School Essay Contest

Chrislaina Anderson Lucas Anderson

The AIAA Space Systems Technical Committee's (SSTC) Annual Middle School Essay Contest continues to improve its commitment to directly inspire students and local sections. Each year, additional sections start parallel contests to feed into selection of national winners awarded by the SSTC.

The 2020 essay topic was "How advanced can you envision space technology and exploration through the next 50 years? What do we need to do NOW to achieve that?" Seventh and eighth grade students were asked to participate. This year, 15 sections submitted official entries to the contest, including Antelope Valley, Cape Canaveral, Connecticut, Greater Huntsville, Hampton Roads, Houston, Long Island, Los Angeles-Las Vegas, Mid-Atlantic, Palm Beach, Rocky Mountain, San Francisco, Southwest Texas, St Louis, and Vandenberg. For each grade, there were first-, second-, and third-place winners, which included $125, $75, and $50 awards for the students, respectively. The six students also received a one-year student membership with AIAA.

The first-place winner for 8th grade is Lucas Anderson from Colorado Spring, CO (Rocky Mountain Section). The second-place winner for 8th grade is Alexander Goetz from Fenton, MO (St. Louis Section). The third-place winner for 8th grade is William Mayville Jr. from Palm Beach Gardens, FL (Palm Beach Section). Emily Huynh from the San Francisco Section received an Honorable Mention for her essay.

The first-place winner for 7th grade is Chrislaina Anderson from Santa Maria, CA (Vandenberg Section). The second-place winner for 7th grade is Noah Stoumbaugh from Yorktown, VA (Hampton Roads Section). The third-place winner for 7th grade is Ksenia Apalkova from San Jose, CA (San Francisco Section). Ashley Wilson from the Long Island Section received an Honorable Mention for her essay.

All 2020 winning essays can be found on the *Aerospace America* website (**aerospaceamerica.aiaa.org/bulletin/september-2020-aiaa-bulletin**). The topic for 2021 is "Describe science experiments you can conduct on the lunar surface that is unique to our moon." If you, your school, or section are interested in participating in the 2021 contest, please contact Anthony Shao (ant.shao@gmail.com), Erica Rodgers (erica.rodgers@nasa.gov), or your local section for more details.

Waligora Honored with Jeffries Aerospace Medicine and Life Sciences Research Award

Although the 50th International Conference on Environmental Sciences (ICES) was cancelled in July, **James M. Waligora**, NASA Johnson Space Center (retired), was able to be recognized with the 2020 AIAA Jeffries Aerospace Medicine and Life Sciences Research Award in a special awards ceremony at his home with his family. Mr. Waligora received the award "for pioneering human performance studies and engineered countermeasures critical for safe and productive extravehicular activity on programs spanning Apollo to the International Space Station."

Obituaries

AIAA Senior Member Fickeisen Died in March

Frank C. Fickeisen passed away on 22 March.

In 1944, Fickeisen briefly attended classes at the University of Washington before enlisting in the U.S. Navy where he trained in radar. When he returned to Seattle he finished his B.S. and Masters in electrical engineering. He went to work for Boeing, and had a long and varied career working first with the BOMARC, a defense missile center, and then moving on to their commercial division, where he worked on the 707, 747, and 767. He worked to certify twin engine jets to fly longer worldwide routes as part of the ETOPS program and travelled the world helping airlines and governments adopt safety measures needed to safely operate these routes. Fickeisen was among the first group of Technical Fellows named by Boeing in 1989 . He retired in 1993, but continued to consult with numerous air safety agencies throughout the world for several more years.

AIAA Associate Fellow Rusak Died in May

Zvi Rusak, professor of mechanical, aerospace, and nuclear engineering at Rensselaer Polytechnic Institute, died on 29 May. He was 61.

Dr. Rusak served as a member of the Rensselaer faculty since 1991. He received three degrees from the Technion—Israel Institute of Technology: a bachelor's degree (1980) and a master's degree in Aeronautical Engineering (1982), and a doctorate in Aerospace Engineering (1989). He worked as an aeronautical engineer at the Israeli Air Force (1982–1988), where he headed the Aeroelasticity group (1987–1988). He spent 1989–1991 as a postdoctorate associate in the Department of Mathematical Sciences at Rensselaer, working with Professor Julian Cole, before joining the Rensselaer faculty.

Dr. Rusak was a stalwart in the field of theoretical and computational aerodynamics and fluid mechanics. His research has helped illuminate the vortex breakdown phenomenon, which occurs in vortex flows above airplanes and in swirling flows in pipes and nozzles of engines. In addition, his studies in transonic aerodynamics aimed to design aircraft wings to minimize their drag due to the appearance of shock waves. Other studies sought to improve the maximum lift of wings by modifying their shape to delay flow separation and stall.

Dr. Rusak published more than 250 papers and made significant contributions to the understanding of fluid flows, the science of liquids, and gases in motion. His research applies to both aeronautical and mechanical engineering systems, including the design of aircraft wings, helicopter blades, wind and hydroelectric turbines, and combustors. His publications include more than 80 archival journal papers, including the *ASME Journal of Fluids Engineering*, *Journal of Fluid Mechanics*, *Physics of Fluids*, and the *AIAA Journal*.

Dr. Rusak was not only a respected researcher, he was also a passionate teacher. His love for teaching was reflected in many positive comments from his students. He formerly served on the editorial board of the *ASME Journal of Fluids Engineering* and the *AIAA Journal*. He was a Fellow of the American Physical Society and the American Society of Mechanical Engineers, and an Associate Fellow of AIAA. He received multiple honors and recognitions.

AIAA Senior Member McVeigh Died in June

Michael Anthony "Tony" McVeigh, age 82, award-winning helicopter engineer, died on 28 June.

His childhood fascination with aircraft became a lifelong passion and marked a highly distinguished professional career. McVeigh graduated with honors from Queen's University Belfast, and then earned a Master's Degree in Aeronautical Engineering from Cranfield University in Bedfordshire, England. Prior to his recruitment by Boeing, McVeigh worked designing missiles at Short Brothers and Harland, Ltd. in Belfast. He immigrated to the United States in 1966 to begin his 46-year career with The Boeing Company, retiring at 78 in 2015, as a Senior Technical Fellow.

As part of the Boeing Vertol Aerodynamics Organization, McVeigh pursued the validation of advanced helicopter concepts. His knowledge and intuition went beyond helicopters, focusing on complex issues involved with the combination of fixed wing concepts with novel rotor and propeller configurations, such as tiltrotor and tiltwing aircraft.

His focus on the development, wind tunnel testing, and optimization of tiltrotor and tiltwing designs continued throughout his career. He was a major contributor to the first Boeing real-time piloted simulation math model for the Boeing M222 tiltrotor, and subsequently the XV-15 tiltrotor aircraft with hingeless rotors. He was also responsible for the aerodynamic design of the Boeing advanced composite replacement rotor blades for the Army-Bell XV-15 tiltrotor aircraft and contributed to the Model 360 helicopter technology demonstrator.

McVeigh's contributions for the JVX/V-22 went from nose to tail. He helped shape the nose of the aircraft with particular focus on the slope of the windshield, and placement of the air data system. He recognized the importance of the mid-wing area, and after much work, developed the mid-wing fairing that provided good aerodynamic flow around the wing stow mechanism. He augmented that area with some special vortex generators to help keep the flow attached through the flight envelope. In addition, McVeigh developed a spanwise set of vortex generators to help keep the flow attached across the wing and was instrumental in developing the flaps and flap schedule to help reduce download in hover. He engineered the wing/nacelle fairing to control flow through the transition from hover to airplane mode and researched the use of tip sails on the nacelles to help increase lift. McVeigh led the development and placement of the fuselage strakes to control flow and improved stability. A truly major achievement was his development and implementation of a forebody strake to solve a high angle-of-attack, high-speed tail buffet problem on the V-22.

In 2001, McVeigh received the American Helicopter Society's Paul E. Haueter Award for his outstanding technical contributions to the development of tiltwing and tiltrotor aircrafts. McVeigh was named a Senior Technical Fellow by The Boeing Company in 2003. In 2004, McVeigh was recognized as a Fellow by the Royal Aeronautical Society.

He authored/co-authored 25 published technical papers and held four patents. Under a NASA/industry program, McVeigh led the development of the patented "Butterfly" tilt-rotor download reduction device. McVeigh had leadership roles in many programs that included the DARPA/Boeing/Virginia Tech DiscRotor study with its rapidly evolving configurations, and in the application of active flow control devices that concluded with a flight test demonstration of the technology.

AIAA Senior Member Rae Died in July

William J. Rae, University of Buffalo, Distinguished Teaching Professor, passed away at the age of 90 on 15 July.

Accomplished in the fields of aerospace, flight dynamics, and fluid mechanics, Rae started his career at Cornell Aeronautical Laboratory as a mathematician in the Aerodynamics Department, but attended night school to get a second degree in engineering. He earned his Master's and Doctorate in Aerodynamics through a fellowship to Cornell and studied the effects of boundary layers on electron density distributions during reentry for the Apollo communications blackout problem. After 30 years of engineering, he went on to become a beloved professor in the SUNY-Buffalo Department of Mechanical and Aerospace Engineering.

Rae received the highest faculty rank in the SUNY system. His engineering research contributed to everything from

NASA's space exploration missions to road vehicle dynamics and efficiency, helical particle separation, and understanding the transonic flow through axial compressor blades.

In addition to inspiring generations of students, he made aerospace engineering courses exciting and fun. Rae received numerous awards during his long career at the University of Buffalo, among them the SUNY Chancellor's Award for Excellence in Teaching in 1993, the Most Helpful Teacher Award from the UB AIAA Student Branch and the Carl Naish Award from the Millard Fillmore College Student Association.

While teaching the fundamental properties of aerodynamic flight to students in his flight dynamics class in 1995, Rae began developing a theory that explains why a football doesn't fly like a missile or a bullet. His theory demonstrated that "the flight of a football is almost as complicated as the flight of an airplane."

Rae noted that while serious aerodynamic studies had been conducted on the flight of baseballs, soccer balls, golf balls and tennis balls, there had never been, to his knowledge, similar studies of footballs. Thus, for one course at UB, he taught the fundamental properties of aerodynamic flight by having his students "fly" a football using simulation software. He then validated the software simulation with wind tunnel studies using a highly instrumented football. This may have been the least of his aerospace research projects, but probably became the most enduring as news articles about his football studies were published in newspapers and sports magazines across the United States.

He was active in the AIAA Niagara Frontier Section for more than 40 years, including serving as chair, and over the course of his career Rae published in excess of 20 technical papers for AIAA journals and proceedings. In 2002 he retired from teaching and in 2016 he was inducted into the Niagara Frontier Aviation and Space Hall of Fame.

AIAA Associate Fellow Gionfriddo Died in July

Maurice P. Gionfriddo, 89, passed away on 18 July.

Gionfriddo had both a Bachelors and a Master's Degree from MIT. He served as a first lieutenant for the U.S. Air Force during the Korean Conflict.

Prior to retirement, Gionfriddo was employed as an aeronautical engineer at the U.S. Army Natick Laboratories. After retirement he started consulting and his current endeavor was founding the aeronautics company Logistic Gliders, Inc. Throughout his career he developed innovative products for the aerospace industry. He was also an active member of the Parachute Industry Association.

He was recognized with the Theodor W. Knacke Aeredynamic Decelerator Systems Award in 1990 and the AIAA Sustained Service Award in 2007. Gionfriddo also had a passion for creating and flying model airplanes.

1920

Sept. 3 The Martin MB-2 heavy bomber completes its first flight. Essentially an improved MB-1, the MB-2 is powered by two 410-horsepower Liberty V-12 engines, has a maximum bombload of 1,400 kilograms and has a maximum range of 900 kilometers. David Baker, **Flight and Flying: A Chronology**, p. 134.

Sept. 8 The first transcontinental American airmail service is inaugurated by Randolph Page flying a de Havilland DH-4. The plane carries 181 kilograms of mail from New York and arrives in San Francisco on Sept. 11. The last leg of the route is opened between Omaha and Sacramento and covers 2,600 kilometers. The mail is dropped by parachute en route and then carried to its destinations by land transportation. **Flight**, Sept. 16, 1920, p. 992; **Aeronautics**, Sept. 16, 1920, p. 209.

During September 1920

•The Zeppelin-Staaken E. 4/20, 18-passenger transport undergoes its first flight tests. This four-engine, all-metal plane is the forerunner of later, modern all-metal aircraft. Charles H. Gibbs-Smith, **Aviation**, p. 248.

•The de Havilland Aircraft Co. Ltd. is created in Great Britain by Geoffrey de Havilland after the demise of Airco, where he worked as lead designer creating several important designs during World War I. David Baker, **Flight and Flying: A Chronology**, p. 134.

1945

Sept. 2 Japanese foreign minister Mamoru Shigemitsu, on behalf of his emperor and the Japanese government, signs Japan's surrender aboard the battleship USS Missouri, which is anchored in Tokyo Bay, thus ending World War II. David Baker, **Flight and Flying: A Chronology**, p. 305.

Sept. 5 The Douglas C-74 prototype, the massive Globemaster, makes its first test flight at the Douglas plant in Santa Monica, California. The Globemaster has a takeoff weight of 73,000 kilograms (162,000 pounds) and is powered by four Pratt & Whitney Wasp-Major engines. The 37-meter-long plane with a 52-meter wingspan can have as many as 72 seats. **The Aeroplane**, Sept. 14, 1945, p. 296.

Sept. 20 An experimental Gloster Meteor prototype, powered by two Rolls-Royce Trent turboprop engines, makes its first flight, with test pilot Eric Greenwood at the controls. David Baker, **Flight and Flying: A Chronology**, p. 305.

During September 1945

• A captured German Focke Achgelis Fa 223 Drache flies from Germany to Brockenhurst, England, becoming the first helicopter to cross the English Channel. J.R. Smith and A. Kay, **German Aircraft of the Second World War**, pp. 598-602.

• The first jet-propelled aircraft built in the U.S., the Bell XP-59 Airacomet, is placed on exhibit at the Smithsonian Institution in Washington, D.C. The Airacomet was never produced in large numbers and never went into action as it was no faster than conventional piston engine fighters. The Airacomet did provide the necessary flying experience for the new generation of jet pilots. The aircraft remains on display to this day in the National Air and Space Museum's Boeing Milestones of Flight Hall. **Flight**, Sept. 6, 1945, p. 251.

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1970

Sept. 1 Concorde 002, the British prototype of the British-French supersonic transport, reaches Mach 1.68 (1,770 kph) and creates a double sonic boom in a test flight over Oban, Scotland. This is the first time the British Concorde breaks the sound barrier in its current test series although no sonic boom damage is reported. **Washington Post**, Sept. 2, 1970.

Sept. 2 The United Kingdom's first attempt to launch a satellite with its own booster fails when the pressurization system in the three-stage Black Arrow rocket malfunctions. The vehicle was to have orbited an 82-kilogram satellite to study the upper atmosphere. Previous U.K. satellites were launched by NASA boosters. **Baltimore Sun**, Sept. 3, 1970.

Sept. 15 The Concorde 002 makes an unscheduled landing at London's Heathrow Airport. Chief test pilot Brian Trubshaw of British Aircraft Corp. chooses to land there — after flying over the Farnborough International Airshow — when thunderstorms and poor visibility close the Concorde test base at Fairford, Gloucestershire. **Aviation Week**, Sept. 21, 1970, p. 32.

Sept. 5 The name "tranquilite" is given to a mineral discovered in an Apollo 11 moon rock by scientists of the Max Planck Institute for Nuclear Physics at Heidelberg, West Germany, according to an announcement. Tranquilite is named for the Sea of Tranquility, the Apollo 11 landing site. **Baltimore Sun**, Sept. 5, 1970, p. A10.

Sept. 10 British aviation historian Charles Gibbs-Smith, reports The Times of London, has discovered in a Flemish manuscript dated about 1325 with a drawing of a toy helicopter that predates the design of a helicopter by Leonardo da Vinci by 150 years. Gibbs-Smith calls it the "earliest known illustration in history of a powered aircraft." Furthermore, it is believed the toy was in use before 1300. **New York Times**, Sept. 10, 1970, p. 30.

Sept. 12-24 The Soviet Union launches its Luna-16 uncrewed lunar probe from Baikonur to the moon. The spacecraft subsequently becomes the first probe to land on the moon and return a sample of lunar soil to Earth. Altogether, the spacecraft spends 26 hours, 25 minutes, on the lunar surface. The samples are obtained with an Earth-operated electric drill that penetrates 350 millimeters into the soil. **New York Times**, Sept. 13-25, 1970; **Aviation Week**, Sept. 28, 1970, p. 19, and Oct. 12, 1970, pp. 16-17.

Sept. 21 The discovery of a 2,500-year-old solar observatory at the ancient ceremonial center of Monte Alto near Esquinta, Guatemala, is reported by Harvard University anthropologist Edward Shook. It is believed the observatory was created as a means for recording days and the position of the sun to determine the best times to plant crops. **New York Times**, Sept. 21, 1970.

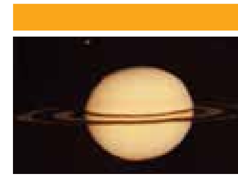
Sept. 25 A television-guided air-to-surface Condor missile is launched from a Grumman A-6 Intruder aircraft and scores a direct hit in the first test of the Condor. The test is conducted at the U.S. Naval Weapons Center in California. **United States Naval Aviation, 1910-1980**, p. 281; **Aviation Week**, Oct. 12, 1970, p. 15.

Sept. 25 The Soviet Union launches its Cosmos 365, described as a research satellite, and it is recovered after completing slightly less than one orbit of Earth. However, a few days later the U.S. Defense Department identifies this craft and its mission as the "latest test of a fractional orbit bombardment system (FOBS)." **Aviation Week**, Oct. 5, 1970, p. 23.

1995

Sept. 7 Space shuttle Endeavour is launched. Its crew deploys and retrieves two satellites. One is Wake Shield Facility-2, which is designed for growing semiconductor film. The other is Spartan 201, which gathers data about the sun and solar wind. NASA, **Astronautics and Aeronautics, 1991-1995**, p. 655.

Sept. 11 Pathfinder, a 270-kilogram uncrewed aircraft designed and built by AeroVironment, sets an altitude record for solar-powered aircraft of 50,500 feet. Pathfinder is part of a NASA-industry project to develop remotely piloted aircraft that can operate at altitudes up to 100,000 feet on environmental sampling missions lasting at least a week. NASA, **Astronautics and Aeronautics, 1991-1995**, p. 655.



Sept. 30 Pioneer 11 ceases operation after 22 years. It was the second spacecraft to explore Jupiter and the first to encounter Saturn, sending back images of both planets and Saturn's rings. NASA, **Astronautics and Aeronautics, 1991-1995**, p. 657.

CONTINUED FROM PAGE 64

is dependent on a set of uncertain model parameters. They also assume a prior belief, like the satellite's location, to be uncertain but this uncertainty is known. Herein lies the danger of assuming that we know exactly what is unknown, meaning there's no uncertainty about the uncertainty.

All orbital analysts assume that the true orbit lies within our measure of error uncertainty. The error is the difference between what is true and our belief. In space surveillance, most algorithms represent the error as random. A Frequentist considers randomness, also known as aleatory uncertainty, as irreducible. No further measuring will provide more information or ability to better predict an outcome. However, in practice, we see that as we gather more observations, we can learn more about the objects. The fact that we can learn more about something implies that our uncertainty wasn't all due to randomness but rather, ignorance.

Consider the uncertainty in the computation of PoC. The error uncertainty of the relative positions of two objects is modeled as a probability. As such, the PoC calculation tends toward zero as this error uncertainty grows larger, known as probability dilution, giving a false sense of risk. It makes no sense that the more ignorant we are of an event, the less probable it is to occur. Probabilities should model and represent randomness, not ignorance. We're unlikely to know for certain when our ignorance is equivalent to the randomness, so we should avoid using probabilities as such to quantify the collision risk. Instead, we should use a combination of the possibility of a collision occurrence via null hypothesis testing, in which we only remove hypotheses discarded by evidence, and consider the environmental consequences if the collision were to occur. To wit, instead of modeling our uncertainty as a probability we should model it as a possibility, meaning ultimately there is a yes or a no answer. We would then also take into account whether an operationally hazardous cloud of debris would result for decades, if the collision occurred.

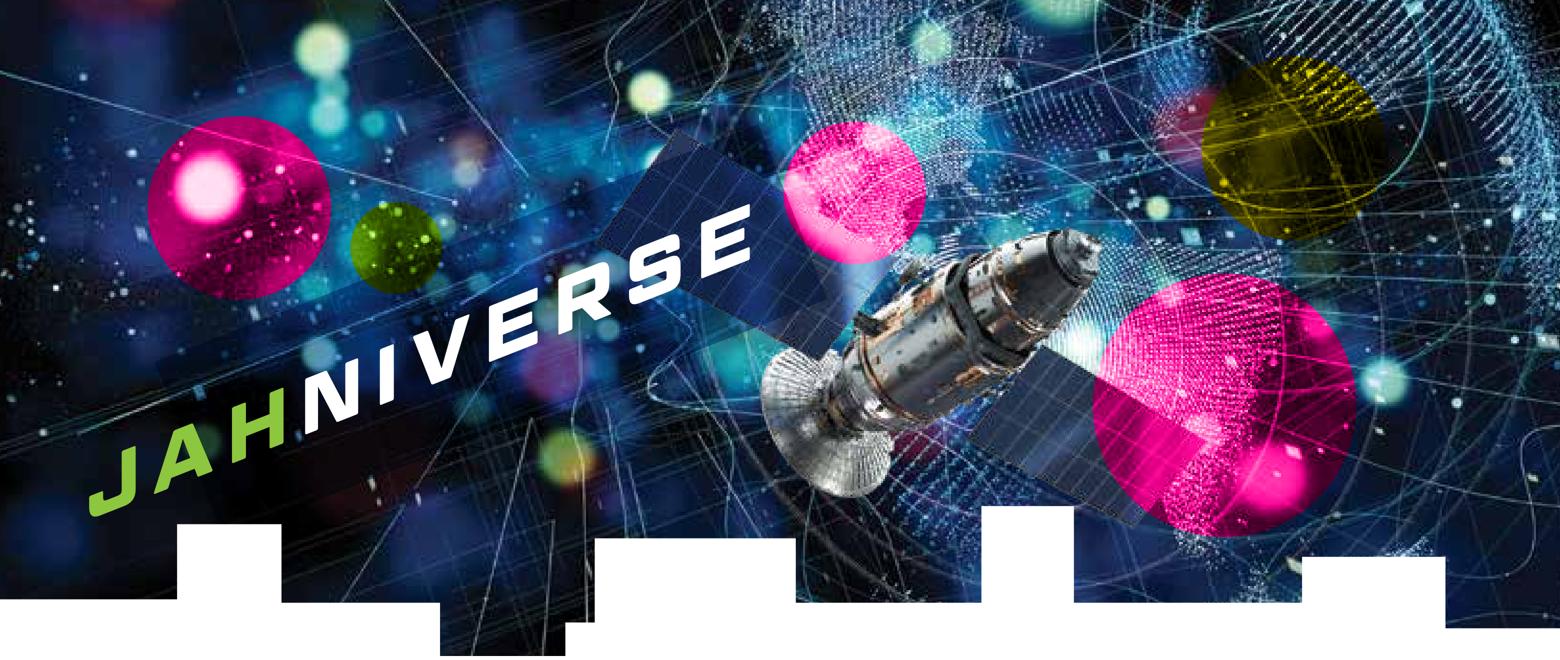
Pragmatically, we need some rules of thumb resulting in a default action that we take under certain conditions, once we predict a possible conjunction between a pair of objects, assuming at least one of them can have its trajectory intentionally altered. The criteria for the default action at the maneuver decision threshold are when:

- We have no further data.
- We have too few data.
- We have overwhelming evidence that our null hypothesis is true.

In fairness, there are times when PoC may be a meaningful measure of the risk, such as when there are sufficient quantities and qualities of measurement data for the inference process and our beliefs are sufficiently informed. However, we may be unable to find a prior belief that properly accommodates our actual ignorance. It is of no surprise that Rudolf Emil Kalman, a Hungarian-American expert in systems theory and estimation, was in search of a "prejudice free" inference method when he co-developed the Kalman Filter, a method of inferring model parameters from a given set of observations.

My recommended approach to minimizing collision risk in space would be to:

- Assume the uncertainty is epistemic, meaning there are systematic effects we are just ignorant of, and if a conjunction is predicted, evaluate the possibility of a collision.
- Determine the default action based upon the criteria previously provided and the predicted debris-generating consequences assuming the collision occurs (number of objects and/or contribution to the saturation level of the local orbital carrying capacity).
- Given the default action (maneuver or not), determine what the null hypothesis needs to be.
- Always perform the default action unless the collected evidence makes the null hypothesis look ridiculous. ★



Needed: Rules of thumb for avoiding collisions in space

BY MORIBA JAH

The International Space Station and thousands of anthropogenic space objects such as satellites and launch debris often pass uncomfortably close to each other. During the runup to one of these close approaches or conjunctions, one organization or another will invariably release a probability-of-collision figure to the media.

PoC is often the deciding factor about whether spacecraft operators should expend precious fuel maneuvering to avoid their craft becoming orbital wreckage. NASA, for instance, makes use of PoC for deciding whether or not to maneuver the International Space Station, which reportedly was maneuvered as recently as July 3 to avoid a potential conjunction with debris within hours.

The interest in potential collisions is understandable, given the stakes, but relying on PoC alone is the wrong measure of collision risk because its calculation is subjective. Two people with the same data will compute different PoCs just due to differing assumptions with how they treat the measurements and the underlying astrodynamics.

Before I suggest a better process, let's look at our sources of knowledge about the trajectories and characteristics of these objects. The information we have comes from radar and telescope measurements that are noisy and biased. Determining and predicting the trajectories of the entire population of objects would be impossible, so instead we must invoke statistical inference. Here, the analysts are divided into two philosophical camps: Frequentists and Bayesianists.

Frequentists believe that probabilities represent the frequency of an outcome based on how often that outcome has occurred in the past, such as how often specific satellites have been predicted to come close to each other. They assume that the observed data are partly the product of a random process but also dependent upon some fixed, deterministic, model parameters such as a satellite's location. Frequentists try to choose a hypothesis that minimizes wrong decisions given a set of hypothetically repeated trials.

Bayesianists, by contrast, assume that probabilities represent the degree to which a hypothesis is believed to be true. They assume that the observed data are a realization of a random variable which itself

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Moriba Jah is an astrodynamicist and space environmentalist living in Austin, Texas, where he's an associate professor of aerospace engineering and engineering mechanics at the University of Texas at Austin. He holds the Mrs. Pearlie Dashiell Henderson Centennial Fellowship in Engineering and is an AIAA fellow.