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On the cover: Illustration of Airbus' hydrogen-powered blended-wing-body concept aircraft

Image credit: Airbus

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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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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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Aviation's overdue embrace of bold innovation

Walking the exhibit halls of the Paris Air Show back in 2015, I had a hankering to write a story about what it would take to build a totally climate-friendly airliner, one with roughly the passenger capacity and ranges of conventional hydrocarbon versions. I assumed that meant one powered by electricity, like Airbus Group's tiny, piloted E-Fan plane, then grabbing headlines. In front of me were booths filled with executives and researchers from all the world's leading aerospace companies. This should be easy, I thought, but I was wrong. If there was an integrated strategic communications plan on the topic, I did not stumble on it. I got the piece done after scouring deeply for presentations and sources at the small booths of research and development companies and agencies.

Most people wanted to talk about open rotor designs and larger front fans to produce higher bypass ratios and better fuel efficiency. All are important innovations, but not the revolutionary kind I was after. When I pressed to learn about electricity and hydrogen, one executive told a small audience that he did not expect to climb aboard such an aircraft in his lifetime, and "probably my kids will not" either. References were made to superconductivity and hydrogen fuel cell technology as promising, but many years off.

What a difference six years makes. Now Airbus wants to make a hydrogen-powered design a reality by 2025, plenty of time for that executive's children to board clean airliners by 2035. Maybe most notably, I no longer hear the excuse that air travel comprises just a few percent of the human influences thought to be warming the planet, so therefore nothing needs to be done. That argument always reminded me of people who say they don't vote because one vote doesn't matter. In reality, votes and carbon emissions add up, and we're all better off when more people vote and each sector works hard to reduce or eliminate its carbon emissions.

As our cover story shows, we're witnessing a clash of titans over how the sector should do its part, not whether it should do its part. Boeing is conducting hydrogen research too, but places much greater emphasis on sustainable aviation fuels as the most impactful carbon-reduction technology for the foreseeable future.

I would not venture to guess who has the stronger case. What I'm sure of is that the debate has supercharged today's engineering students, graduates and a host of startups to do their part to revolutionize air travel. ★

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

Going to the moon to protect Earth

Michael Nord's article "Walking on rocket propellant" [April 2021] offers hope that the moon will have resources that all may share. In particular, if oxygen is generally available and makes up 89% of the mass for an H_2O rocket exhaust, then the burden of shipping rocket propellant or water to the moon is greatly reduced. This would alleviate competition among space-faring nations for those special locations (e.g., poles) that already have water.

It has been suggested that fusion-powered rockets, using the moon's helium-3, could provide the necessary delta-v's of 10s of kilometers per second (over the Earth's orbital speed of 30 km/s), to reach out quickly to defend the Earth from comets and asteroids. Such rockets would carry nuclear warheads whose flash could deflect the incoming object by means of sudden surface ablation. The very small cross-section for fusion reactions, however, means the size of a fusion rocket would totally dwarf the rather compact nuclear warhead. An alternative approach, based on so-called mass driver technology, could electromagnetically accelerate the nuclear payload to adequate intercept speeds but requires driver lengths of upward of 10 kilometers; big, but not impossible. It has the advantage of multiple shots for a single investment in mass but needs to be sited where the rotation of the moon provides an adequate sweep of the potential angles required for intercept.

This returns us to the need for planning the use of lunar real estate, even if finding and extracting water is not the compelling goal. Such planning in order to protect the Earth can be an international effort. It would be a truly exceptional engineering project, but one for which all the physical and engineering requirements are well-understood.

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Turchi is a fellow of both AIAA and IEEE and former president of the Electric Rocket Propulsion Society.

Giants in their fields

When they asked Isaac Newton how he could see so far, he replied, "I was standing on the shoulders of giants," referring to Galileo Galilei. I read the article by Amanda Miller about the new satellite directed by Dr. Martin Weisskopf ["Building a new astronomy tool," April 2021] and it reminded me of Newton's reply. Dr. Weisskopf is building a wonderful instrument to investigate the universe following the properties of X-ray astronomy started by MIT professor Bruno Rossi. Interestingly enough Dr. Weisskopf and Dr. Harvey Tenenbaum received the Bruno Rossi Prize for astronomy in 2004.

I appreciate the thorough reporting Aerospace America produces to keep me informed and up to date on the developments in space science. Keep up the good work!

Giuseppe Aurilio, AIAA senior member
Arlington, Massachusetts
Aurilio assisted with the mechanical design of the Chandra X-ray Observatory at the Harvard-Smithsonian Center for Astrophysics in Massachusetts.

Another rocket plane design

The article "Why it's time to reach for full reusability" grabbed my attention [May 2021]. It was very well-written and illuminated the practical and economic parameters of commercial launch operations.

The 2-stage (2-1/2 stage?) rocket plane design that seems optimal reminded me of DLR's SpaceLiner program, spearheaded by Dr. Martin Sippel there. That program has roots in the Sanger design but has been continuously studied and refined for many years — for the purpose of closing a case for an economical, commercial, viable space transportation system.

Allan Lockheed, AIAA senior member
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"Doom and gloom" commentaries

Regarding the April 2021 Aerospace America issue, I found the commentaries ["Our role in assuring a cleaner, greener future," and "Decarbonizing by 2050: optimists, pessimists and realists"] frustrating. I have studied this subject area for decades and clearly realize how this subject is being used to advance a political agenda not based on solid, real science. It's perfectly fine for AIAA members to explore alternative energy solutions, but it needs to be for the right reasons and not from some hysterical doom and gloom. Your commentaries give credence to this gloom and doom and don't help anyone.

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FLIGHT PATH

Building Our Off-World Future Faster

The ASCEND community is accelerating the conversation around building our off-world future. Building on the momentum of our successful launch, 2021 ASCEND has taken off with a heightened awareness of our opportunity, indeed, our mission, to build on-ramps to space for everyone. ASCEND is focused on big challenges, pathways to success, the application of innovation, and the exponential value of interdisciplinary collaboration in space.

The whole space ecosystem is gravitating to us to strengthen the relationships that will make the future of space happen. In 2020, we introduced ASCEND as the first international community specifically envisioned to work on expanding the space economy. The pandemic postponed our live event, but accelerated our transformation to virtual events, allowing us to engage more people online. The inaugural ASCEND main event last November hosted over 3,000 participants online from 33 countries, 1,300+ organizations including 125 universities. Thousands more attended smaller-scaled, single-topic ASCENDx Summits, Webinars, and Workshops on the web throughout the year.

An Advocate for Interdisciplinary Collaboration

It's critical that ASCEND be a convening area for the entire off-world community. ASCEND is for core technical professionals from academia, commercial, and government space sectors who are already deeply involved in space projects.

ASCEND is also for the larger universe of students and professionals from adjacent industry sectors who are excited by the real opportunity to grow their business from and in space. We want to include construction, agriculture, hospitality, medical, and manufacturing. All of these industry sectors – and more – are needed to build a thriving space ecosystem. Our goal is to connect technical experts with business and government leaders from aerospace and adjacent industries to discuss, test, build, and solve problems together.

Welcome Support from NASA; Looking for "Space MacGyvers"

NASA has emerged as a strong supporter of ASCEND, both at the November 2020 event and since then. In February, NASA headlined a livestream event previewing the Perseverance arrival on Mars. NASA also helped lead the ASCEND webinar, "Maximizing Payload Success," in April, giving innovators insight into successful payload project planning so they can get their plans off the ground and into orbit. At our 15 June ASCENDxSummit, "Accelerating Pathways to Space," NASA will preview its upcoming Laser Communications Relay Demonstration, a revolutionary way of communicating data from space.

We've moved the discussion forward on who will be living and working in space. During the March ASCENDxSummit, "Accelerating the Next-Generation Workforce," we heard from Kara Cunzeman, Devin Liddell, and Margaret O'Mara – two futurists and a historian – who sparked all kinds of creative ideas about the intellectual, physical, and emotional skills future generations of space users will need to succeed.

Cunzeman shared research on the many possible futures, and how we can think about strategic foresight. "There are alternative futures that we can make happen, but we have to dream those," she said. Liddell had the room buzzing with his observation that "Interdisciplinary knowledge is the new superpower." To punctuate the point, he invoked the ultimate human Swiss army knife. "The off-world economy will offer bright futures for interdisciplinary thinkers like a space MacGyver who's capable of tackling many different jobs." And O'Mara encouraged, "Bring people into the room. Don't be constrained by who's done it before. Seize that opportunity to be inclusive."

We know living and working in off-world communities will require myriad talents beyond STEM literacy and a global ecosystem of support from government, industry, and academia. ASCEND's role in this dynamic is to put exceptional technical content in a larger context designed to attract a wider audience to our year-round conversation about living and working in space. ASCEND is on the flight path to help everyone see humanity's future in space, and to inspire more of them to pursue the challenge, excitement, and satisfaction of helping us realize our off-world future faster.

2021 Guiding Coalition Exemplifies the Community Spirit of Space

To maximize our reach and impact, we've enlisted a diverse advisory board of technology, science, business, and engineering leaders. The members of our 2021 ASCEND Guiding Coalition bring an accumulated wealth of experience – millions of miles and billions of dollars invested in space – to inform and inspire the ASCEND community. Meet them all online at **ascend.events**.

Attend the Annual Event in November

Live in Las Vegas and online everywhere, your experience at the 2021 ASCEND main event will be unique. The conversation in November will be facilitated by experts, featuring exceptional technical content in a larger context. 2021 ASCEND will offer the technical depth and breadth of an AIAA forum, along with senior leaders from the space community who will help drive the conversation.

As program planning continues, the ASCEND team's highest priority is ensuring attendees' safety, comfort, and access to the optimal ASCEND experience – live and virtual. Look for announcements on the program content coming out in June, with registration opening in July. Start plotting your trajectory to ASCEND today at **ascend.events**.

I invite you to join the ASCEND community now – because no one goes to space alone. ★

Rob Meyerson
ASCEND Executive Producer
Founder and CEO, Delalune Space

AERO PUZZLER

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

It's a matter of perspective

Q: Three marine scientists and a former space flight controller board a boat before dawn off Florida's east coast. "Whoa, look at that jellyfish!" the controller says. The marine scientists look down at the water, but the former controller points to the sky. The scientists are baffled and ask how there could be a jellyfish in the sky. What should the controller tell them?

Draft a response of no more than 250 words and email it by noon Eastern June 15 to aeropuzzler@aiaa.org for a chance to have it published in the July/August issue.

FROM THE APRIL ISSUE

CROSSING THE INTERPLANETARY DIVIDE: We asked whether it was true that travelers flying to Mars will pass a point after which they will no longer be in free fall toward Earth; they will be in free fall toward Mars. Astrophysicist and consultant Laura Forczyk reviewed your answers.

WINNER: For a spacecraft transiting from Earth to Mars, there are actually three major bodies that will influence the trajectory. For about the first 600,000 miles, Earth's gravity dominates; and the last 300,000 miles of the trip are governed by Mars's gravitational influence. However, the bulk of the journey takes place outside of those zones. During that intermediate part of the journey, the spacecraft is not "falling" toward either Earth or Mars — its trajectory is governed primarily by the sun! Gravitational force is governed by central body mass and distance from the central body; a "sphere of influence" calculation shows the distance where the planet's gravity has diminished to the point where the sun's gravity begins to take over.

Wes Dafler, an AIAA senior member, works on U.S. Navy projects as an air vehicle lead flight test engineer for Boeing Test and Evaluation.
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For a head start ... find the AeroPuzzler online on the first of each month at https://aerospaceamerica.aiaa.org/ and on Twitter @AeroAmMag.

▲ **NASA astronaut Shannon Walker** brushes patches of aircraft and spacecraft materials for a Boeing experiment to see whether a clear polymer coating sprayed on half the patches could one day be sprayed on surfaces such as passenger airline seats to guard against microbes, including the virus that causes covid-19. NASA

Killer coating

BY CAT HOFACKER | catherineh@aiaa.org

Every few days, the NASA astronauts aboard the International Space Station float through the U.S. Harmony module and brush their fingertips across a swatch of woven aircraft seat cloth, a seat buckle and other samples coated with a clear, proprietary polymer.

It's all part of a Boeing and University of Queensland experiment set to run through July to test the ability of this polymer to tear apart microbes, meaning viruses and bacteria, left by an airline passenger or a spacecraft crew member bound for Mars. Among the patches on the wall-mounted plaque are padding and other materials one would expect in the interior of a spacecraft. Any microbe is trapped by charged particles in the polymer, and the heat from the astronaut's fingertips changes the shape of the polymer "and tears the microbe apart to rupture it," says Jason Armstrong, head of the team of Boeing researchers at the Australian branch of the company's Research & Technology division.

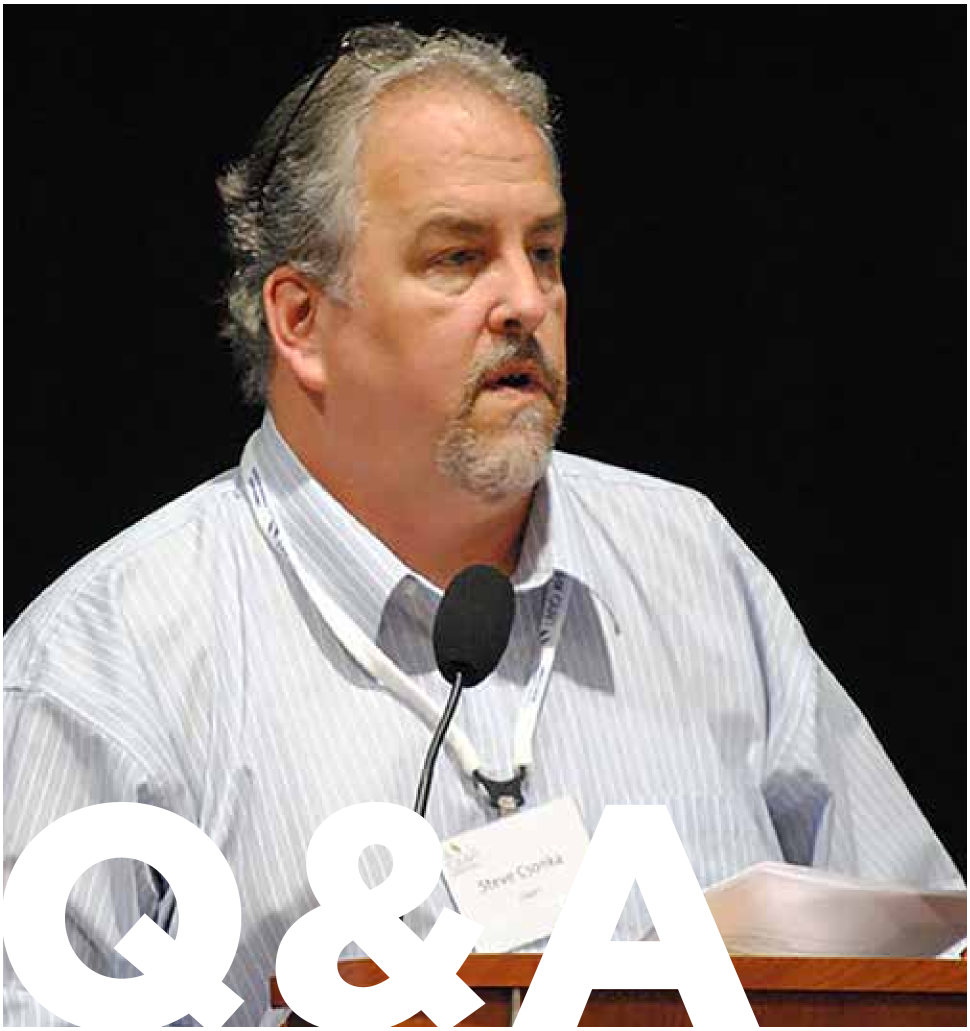
The researchers prepared two identical sets of patches, one of which was sprayed with the polymer coating before it was launched to the station in December aboard a SpaceX Dragon capsule. Once the patches are brought home, Boeing researchers at the company's Houston labs will swab both sets and look under a microscope to compare the number of intact microbes. The polymer-coated patches should show a 3-log, or thousand times, reduction in the number of intact microbes.

The researchers began developing the coating four years ago for future crewed missions to Mars — the goal being to protect astronauts from unknown pathogens while also preventing naturally occurring microbes on human skin from eroding spacecraft surfaces over the course of long-duration missions. But after the onset of the pandemic, they decided to modify the polymer to bind and destroy the SARS-CoV-2 virus that causes covid-19.

Early laboratory tests in Australia in which patches were coated with the polymer and then swabbed with samples of influenza viruses and salmonella bacteria showed "really promising" results, Armstrong says. The researchers decided to apply through the United States ISS National Lab process, and they won a coveted experiment spot.

Beyond human spaceflight and passenger air travel, Armstrong says the polymer coating could also be adapted for use in hospitals or other applications. Just dissolve the polymer in water and it could be "sprayed over anything that's already been manufactured, or it could be put into a manufacturing assembly line and sprayed there and then components are assembled somewhere else."

As for space applications, Armstrong says it's likely the polymer coating could win regulatory approval in time for early crewed missions under NASA's Artemis program, which plans to land two astronauts on the lunar surface in 2024. ★



Green-fuel guru

More online aerospaceamerica.aiaa.org

Steve Csonka will know he's succeeded when he works himself out of his job as head of the Commercial Aviation Alternative Fuels Initiative. This coalition of U.S. government agencies, air transport companies and fuel producers hosts workshops and directs research to accelerate the production and certification of SAFs, sustainable aviation fuels made from crop residue and other sources. Csonka is among those who believe SAFs represent aviation's best shot at achieving net-zero carbon dioxide emissions by 2050. Hurdles to this goal include the need to approve additional conversion methods, and policies that incentivize production of SAFs at the level the air transport industry will require — some 500 million tons annually by 2050, according to the Air Transport Action Group. If all goes as Csonka hopes, CAAFI (pronounced CAF-ee) "will likely be sunsetted," he says. I called him at his Cincinnati home to discuss the road ahead. Here's our conversation, condensed and edited.
— Cat Hofacker

STEVE CSONKA

POSITIONS: Since 2012, executive director of the U.S.-based Commercial Aviation Alternative Fuels Initiative, a 1,200-member coalition founded in 2006 and funded by FAA and four air transport industry groups; director of environmental strategy at GE Aviation, 2010-2012, one of several roles he held during his 13 years at the Ohio-based GE subsidiary; head of fleet planning at American Airlines, 1998-1999.

NOTABLE: Before assuming the executive director role, he helped set CAAFI's strategy and priorities between 2008 and 2012 as a member of the organization's Steering Group, similar to a board of directors. At GE Aviation, oversaw the design, development and production of the GEnx engine announced in 2004 that powers the Boeing 747 and 787 Dreamliner. He coined the name GEnx, which is now short for GE Next-generation but was initially an inside joke about the majority of the engineering team belonging to Generation X.

AGE: 59

RESIDENCE: Cincinnati

EDUCATION: Bachelor of Science in aerospace engineering, Parks College of St. Louis University, 1985; Master of Science in aerospace engineering, University of Cincinnati, 1992.

Q: "Sustainability" can mean so many things, so define what it means in the context of sustainable aviation fuels, or SAFs.

A: In general, we've been operating under a premise that sustainability refers to social, economic and environmental viability, fundamentally making a concept viable for ourselves and our future generations. Within those three categories, you can also differentiate several other different approaches, like, "What does it mean to be socially sustainable?" We're trying to make the world better for future generations from several aspects, and we really can't make something work in one area if it doesn't work in all of those areas. The big driver for the aviation industry since the 2006 timeframe has been addressing the greenhouse gas aspect of our emissions, or the CO_2 specifically, which is our primary greenhouse gas. Prior to that, we clearly had a focus on sustainability aspects from the perspective of lowering community noise, for instance.

Q: Speaking of the community's interests, feedstocks, or the raw materials for SAF, can't come from deforestation, for example, or land that would otherwise have been used to grow food crops.

A: When it comes down to looking at feedstocks, we look at issues of food versus fuel, yes, but we will also look at issues of food and fuel. We'll look at whether palm oil is acceptable because of its link to deforestation. We will also look at whether all palm is the African palm that people fear for deforestation in Southeast Asia. The bottom line is we are very much paying attention to those issues, but not from the perspective of "everything that comes from this category is bad" and "everything that comes from that category is good." It's not that way when you get down to the detailed level, and the aviation industry needs to look at that detailed level.

Q: Beyond the environmental benefits, SAFs also could represent economic sustainability for aviation by eliminating the reliance on crude oil.

A: Yes. We suffered through several years of extreme swings in fuel price driven by no fault of our own, but by supply shortages or cartels establishing production levels. We not only started down this path from the perspective of supply surety, but also with respect to price stability. Having more fuel sources provides some stability. I remember in one of those years where we had the worst price swing, the military was relegated to actually stopping training flights and stopping different kinds of missions because they were operating on a fixed budget from Congress, so when the price of the fuel skyrocketed and there was nobody to hand them more money, what option did they have? On the commercial side, it's a little bit different in that those price changes go immediately into ticket prices, and then you'll see the second-order effect of dampening travel demand. There's a lot of attributes associated with the development of these alternative fuels that are attractive, not least of which is potentially less money being exported from our country for the production of petroleum fuel and the development of significant jobs and economic activity, from a rural development perspective.

Q: Can SAF achieve aviation's portion of what's becoming a global pledge to achieve net-zero emissions by 2050?

A: It's not going to get us there alone. We still have inefficiencies with respect to operations and infrastructure, air traffic management. All of those issues need to continue to be addressed in order to get us to a net-zero kind of approach. We've got something like a 3% growth rate associated with carbon. We're trying to cap that level and then start our way on a trend toward reducing that to zero. Will we get there with SAF alone? I don't know. CAAFI has been charged with putting the fundamentals in place that'll allow that to happen, removing the technical obstacles. It's tough to envision a zero future when you're growing at 3%. What I can tell you today is that we understand the fundamentals of SAF and how much it can deliver. Looking at our other options for reducing emissions: When people talk about aggressive technology, they sometimes gravitate to electrified products or hydrogen-powered products, and

"I can say this with all seriousness and a lot of sincerity — society hasn't yet come to grips with what limiting warming between 1.5 or 2.5 degrees Celsius actually means with respect to the level of investments required, the level of curtailment of human activity."

what we know today is that those technologies don't work from an overall efficiency and cost perspective, nor will they likely for another two decades — at least in the large aircraft space, which is where all of our emissions come from.

Csonka later got back to me and clarified that he was referring to large cargo and passenger aircraft with ranges over 500 kilometers, which in 2018 generated 93% of aviation's carbon dioxide emissions, according to the World Economic Forum. — *CH*

Q: What about electric power?

A: Today's electric aircraft are small personal aircraft, two passengers, a couple of hundred miles. I expect to see that technology being brought into that small aircraft space, and over the next two decades, that this technology might mature to the point where we get the energy on a volume and weight basis that's coming close to what we get out of kerosene and turbine engines. We won't be there for quite some period of time, irrespective of the announcements that have been made. What I do know for sure is that if folks expect aviation to start on a sustainability journey today with respect to carbon, SAF is the solution. It needs to be the solution that starts today, that mitigates that long-term aggregated amount of CO_2 that we're producing, for our kids and grandkids in the future. That's why SAF development is so important and why we're focused on it today.

Q: SAFs are still hydrocarbon fuels that emit roughly the same amount of carbon as conventional fossil fuels when burned by jet engines, so where is the carbon reduction coming from?

A: What we're producing is a synthetic jet fuel, starting from a source different than petroleum crude being pulled out of the ground. The benefit is coming from the fact that when I fly an airplane and burn this fuel, I'm not having to reach into the ground and pull hydrocarbon molecules out of the ground and use those to produce a fuel that produces CO_2 that winds up in our biosphere. Instead, we're reaching into nature and pulling those hydrocarbons out. Plants take CO_2 molecules out of the air and put them into the form of a hydrocarbon precursor. We take those hydrocarbon precursors and turn them into jet fuel. So if I look at the full lifecycle of a recycled carbon versus pulling them out of the ground, I'm getting somewhere between 60% and 80% reduction in the total lifecycle addition of carbon to our atmosphere. It's not a 1-to-1 ratio because there's often carbon generated to harvest and transport the crops that were the feedstock for that fuel, convert the feedstock to fuel, and carbon generated by transporting that fuel to the airport, for instance. Nature hands us those hydrocarbon precursors in a couple of primary forms: first in fats and oils, secondly in starches and sugars, and thirdly in the lignocellulose itself, the body material that makes up plants and trees. A fourth general category that we're becoming more and more attuned to are the hydrogen and carbon resources that come from circular economy kinds of concepts: using the emissions that come off another process or using municipal solid waste or food waste that comes from our food production on a daily basis, or sludges that come out of water treatment facilities.

Q: Carbon isn't the only thing coming out of the tailpipe. How promising are SAFs for reducing some of aviation's other contributions to atmospheric warming, such as nitrogen oxides and contrails?

A: Jet fuel is a series of hydrocarbons, carbon chains with hydrogen attached to them. Hydrocarbons are a great source of energy because they like to burn. If they burned in pure oxygen, they would produce CO_2 and water. Since we burn them in air, we also get some nitrogen oxides, or NOx [pronounced nox] and some other things coming up. Within that family of hydrocarbons we have four families of molecules: paraffins, normal paraffins, cycloparaffins and aromatics content. Each of those families of molecules is different and there are several thousand variations of those molecules across that full range of fuels. The aromatic content, double-ringed carbon structures, don't burn real well. They're responsible for the production of particulate matter, and some other potentially hazardous air pollutants. Those are very odd molecules to start with, and they don't burn well as opposed to the other three structures that burn pretty well. Most of the synthetic fuels that are being produced today are more of the paraffinic variety. They burn really clean because they're these long chains and they break up really nicely. So we don't get much in the way of hazardous air pollutants or particulate matter precursors. We don't get a reduction in the production of NOx, which is a temperature-driven phenomenon more than anything. So in order to continue to get NOx reductions in our industry, we'll need to continue to refine combustion technology. Some of those other attributes associated with pollutants do get improved through the introduction of these synthetic fuels, and even going forward, our aromatics might not be the double-bonded structures that don't burn very well. We can envision a future where we have fully formulated 100% synthetic fuels that will burn more cleanly, give us the energy density that we need, freeze point, all the other attributes that are in the fuel spec. We're still in early stages, but the future continues to look bright to resolve the issues that we have with these fuels.

Q: The ASTM International standards body has only approved most SAFs to be blended 50-50 with conventional fuel. What's the path to approving 100% SAF?

A: The idea with SAFs being drop-in fuels is that there's no required modifications anywhere, either in the aircraft themselves, fuel distribution infrastructure, airports. We're trying to keep the concept of SAF and the concept of sustainability from burdening society more broadly. Today the industry has approved seven different manufacturing approaches, or pathways, to produce blending components for SAF. Each of those pathways individually doesn't produce that whole family of molecules found in jet fuel; the molecules are identical to what I find in jet fuel, but it's not the full suite of molecules. So ASTM established blending requirements to make sure that we don't deviate outside of the distribution of fuel molecules that we know and love and put a max blending limitation to make sure that we don't have an excursion of the overall fuel properties in a direction that we don't particularly appreciate. However, two of those pathways have a close approximation of the full suite of molecules. Pathway six, for instance, if you look at the details of that on a molecular basis, it really is a fully formulated jet fuel. We put in a 50% blending limitation on it because of our conservatism. We weren't ready yet to jump to higher max usage levels or full synthetics. But there's already been flights flown on that fuel in a 100% drop-in format during test flights — which are exempted from the 50-50 blend limit — so that pathway could go to 100% fairly quickly. We could see another approach we could take to our existing pathways and perhaps blend them together and produce something that looks more like a fully formulated fuel.

Q: Describe the pros and cons of governments incentivizing SAF production through means such as tax credits versus mandating that airlines blend a certain percentage of SAF into every flight.

A: Let me start off with this premise, because you'll get some pushback from purists who want to count on fundamentals of free-market economics: What I offer to those entities is that there is still room for policy in the world, even if you're a purist with respect to free-market economics, when the free market doesn't have a feedback mechanism that allows for societal involvement in the decision process. At least from an American perspective, that's the purpose of having policy, right? Policy provides some shifts in direction with respect to the free-market economy in a bunch of ways that we refer to as carrots and

▲ **Sustainable aviation** fuels make up less than 0.1% of total jet fuel burned even though the amount used by commercial aircraft rose 65% between 2019 and 2020, according to the International Air Transport Association.
Lufthansa

sticks: enticements or mandatory policy. The different mechanisms that are being used today or that some policymakers are considering are things like subsidies through the Renewable Fuel Standard tax treatment, whereby the IRS will give producers a reduced amount of tax that they have to pay on their profitability. On the other side, governments can say you've got to blend a certain amount of this low-carbon fuel with every gallon of jet fuel that's produced. That is less conducive to the way in America that we think about free-market economics and how you can incentivize an industry. But blending mandates can be effective, especially with respect to sending a market signal to new producers, right? New producers say, "Hey, there's a guaranteed market for me." My only input is that a mandate is sort of a blunt instrument that goes against some of the free-market economics. You need to be careful with whether there are long-term effects from forcing certain commercial kinds of activity and perhaps putting the power in the hands of the producers in the near term, instead of having a more balanced approach between the producer and the buyer of the fuel.

Q: Are industry commitments through the United Nations' International Civil Aviation Organization sufficient, or should governments mandate that the aviation industry must achieve certain milestones?

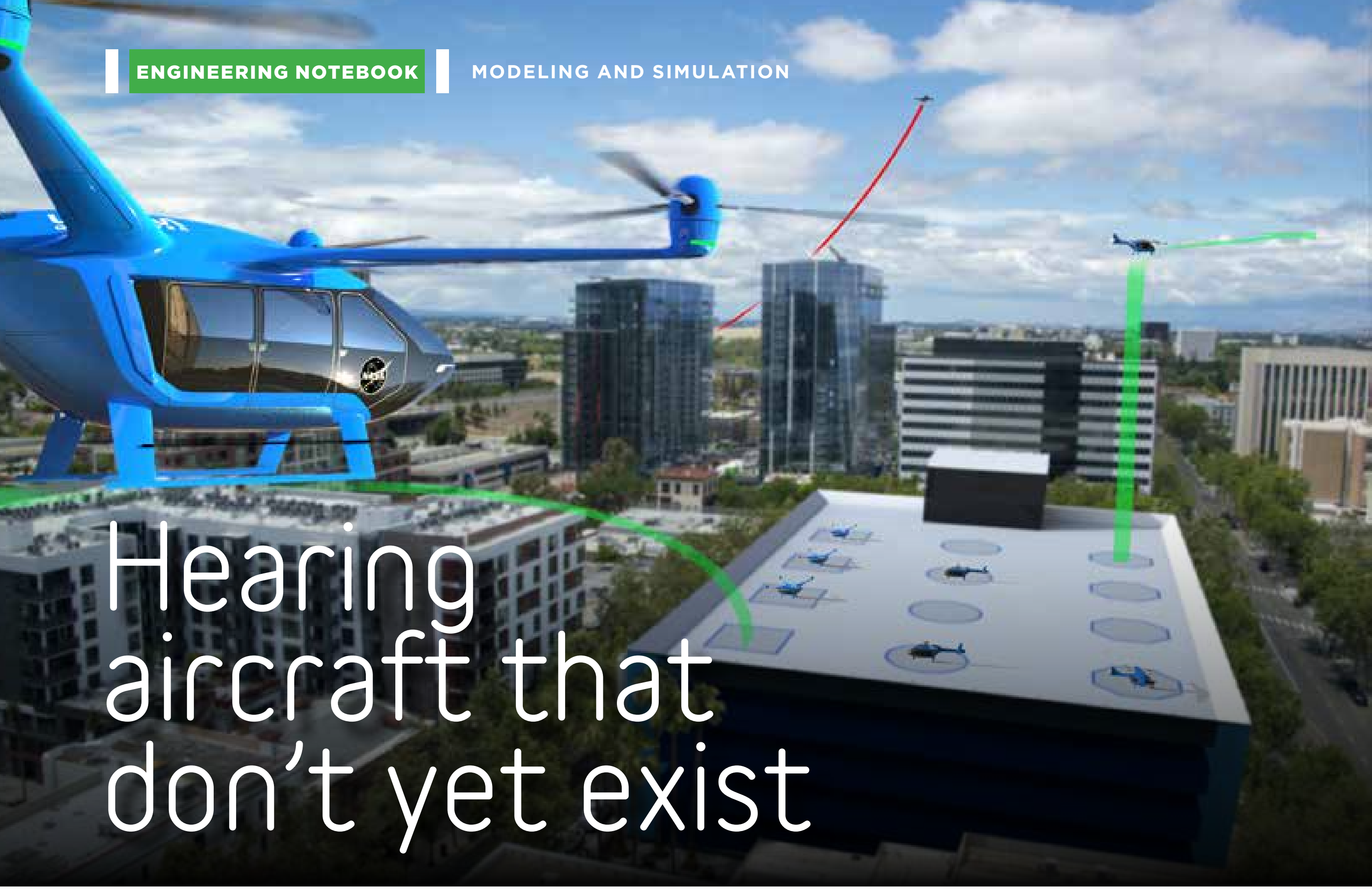
A: I don't see any single solitary mechanism really delivering the change that is needed at the end of the day, not just for aviation, for everyone. I think in general — and I can say this with all seriousness and a lot of sincerity — society hasn't yet come to grips with what limiting warming between 1.5 or 2.5 degrees Celsius actually means with respect to the level of investments required, the level of curtailment of human activity. We understand the goal and the need to get there, but the plans aren't all in place to actually do that or what some of those plans might mean with respect to the level of societal investments required, the need to modify human activity, including our use of various goods, and services. All I can say is that CAAFI has been working on the fundamentals that are our primary driver for allowing this to happen. We'll see how it plays out at the end of the day, but some more comprehensive agreed-to policy worldwide is probably necessary. CORSIA isn't going to get us there.

About 200 countries pledged to cap emissions from international flights at 2019 levels through the 2016 ICAO agreement CORSIA, short for Carbon Offsetting and Reduction Scheme for International Aviation. Airlines of participating countries will voluntarily purchase carbon offsets between 2021 and 2027, at which time CORSIA becomes mandatory for all countries. — *CH*

All of the governments of the world haven't signed up to that yet just like they haven't all signed onto the Paris Agreement. As we continue to build societal consensus, I think that will continue to change. The ICAO activities generally around aviation sustainability are consensus driven, and so when you have a consensus decision, it might not be as strong as you might expect because some countries aren't as progressive as others. What I can point people toward is accept this as the first stage of where we're going with respect to CORSIA. You can also go back and look at time over the last four decades and see what has happened with respect to those tailpipe emissions. We have had ratcheting stringency for four decades, and we've lived up to those increased stringencies and continue to improve environmental attributes for all of aviation: prospective noise, tailpipe emissions. Same thing is going to happen with respect to greenhouse gas requirements. So is aviation going to be able to advance and respond? Yes, we are, just like we always have. It is an attribute of societal existence that's unequaled from the perspective of the safe and efficient, timely transport of goods and services, and the importance associated with making societies connect and providing a lifeline to island nations and all of these other aspects. Aviation is an important aspect. We need to continue to make it more sustainable, and that's what we're all focused on.

Q: Net-zero doesn't necessarily mean zero carbon dioxide emissions, so what comes next after the 2050 goal to achieve zero carbon or zero emissions?

A: I do believe that we might someday have 30 pathways, or we might even have something that's a little bit better than that, a compositionally based specification that says: "Producers, you can make these synthetic molecules any way you want out of any feedstock that you want, as long as I wind up with this set of characteristics." We'll see how that plays out over the next couple of years. Another concept that's also out in that 10- to 20- to 30-year timeframe is making fully synthetic fuels, starting with hydrogen and carbon only: cracking the water or using it from other sources, capturing CO_2, and then recombining those into jet fuel. That's out in our multigenerational product plan. And those fuels by definition are designed to be zero-carbon fuels produced from renewable power. Those by definition will be zero-carbon index fuels or potentially even negative-carbon index fuels. And so you can see, with a series of SAF solutions, that you wind up with pretty deep success on achieving carbon reductions in the industry. It just remains to be seen how all the elements continue to mature, how they come together, how technology continues to play out. ★



Hearing aircraft that don't yet exist

Scientists and engineers are developing methods for predicting the noise generated by the aircraft that make up urban air mobility networks.
NASA

Designers and urban planners would love to know what the coming class of urban air mobility aircraft will sound like. The trouble has been that many of the designs are still at the digital blueprint stage. Keith Button tells the story of a NASA-developed software that's poised to solve the problem.

BY KEITH BUTTON | buttonkeith@gmail.com

It sounds like a new take on the age-old riddle about the tree that falls in the forest with no one around. If an aircraft exists only in digital form, can anyone hear it? For the coming breed of electric rotorcraft that would shuttle us around cities, the answer is about to be "yes."

Acoustics researchers and software engineers at NASA's Langley Research Center in Virginia have written software that, when connected to headphones or loudspeakers, produces the sound that an urban air mobility aircraft would make. The Langley group plans to release the program in June via the software.nasa.gov website for UAM developers, noise researchers or consultants who plan to make presentations to city planning boards about proposed vertiports for UAM aircraft.

This urban air mobility function will be an add-on to the existing NASA Auralization Framework, or NAF, a computer program developed in 2015 by a team of acoustics researchers and software engineers led by Stephen Rizzi, a senior aeroacoustics researcher at Langley. They wrote the first version of NAF based on an older NASA computer program that had outlived its usefulness: It didn't work well with other software, and it was focused on airliners, while the Langley group wanted to add the ability to auralize rotorcraft and propeller planes, later to include UAM designs. After all, most UAM designs or prototypes have rotors and/or propellers. NAF produces the sound of a complete aircraft by predicting and auralizing the sound of its components and structures to include its airframe, landing gear, if any, and its method of propulsion, whether gas turbine engines, propellers or rotors. With the addition of UAM, it will cover the sound of just about every type of aircraft except rocket-powered vehicles and sonic booms for supersonic planes.

The 300 or so companies that are developing UAM vehicles promise that their aircraft will be quieter than conventional helicopters, but those claims have been difficult to verify.

"People are trying to understand: 'Well, how much quieter, really? And will I be annoyed by it still or will I not notice it?'" says Ryan Biziorek, an acoustics consultant at Arup, a London-based engineering consulting firm, who created UAM noise simulations for a Los Angeles Department of Transportation project based partly on NASA auralization models. The setting also makes a difference. In downtown Chicago in the middle of a weekday, for example, UAM aircraft taking off and landing may be drowned out by car traffic noise.

No one can say for sure how the public will react to UAM rotorcraft, partly because of their unique sound quality. "It doesn't sound like a helicopter; it doesn't sound like a large commercial transport. What is it? Well, it's this other thing," Rizzi says.

The UAM sound has two distinct components: Irritating tones, which are equivalent to the "ddzzzz" sounds that a television in the old days would make at the end of the broadcasting day or perhaps now when a signal is interrupted. "You can listen to [that sound] for about three seconds before you hit the remote and turn it off," Rizzi says. There are also masking sounds that sound like white noise.

Auralizations will help aircraft designers weigh the noise benefit from a potential design change, such as to the landing gear, versus the price tag of that change.

Seeing sound

Traditionally, planners and regulators have struggled to represent aircraft noise levels in a format that the public can easily understand. Computer modeling of noise levels surrounding an airport, for example, might be projected as a contour map showing the different levels of accumulated noise exposure over a 24-hour period, says Biziorek, who contributed to community noise studies for a proposed expansion of London's Heathrow Airport.

"We're not able to easily talk about it because it's not something we can tangibly see," Biziorek says. "When we try to get people to talk about sound with these numbers and these graphical representations of it, it's very difficult for people to find a common language and a common understanding."

Aside from UAM designers and entrepreneurs, acoustic researchers stand to benefit in their efforts to explain why particular structures produce the sounds they do so they can make aircraft acceptable to the public. "There's a lot of information, even for us technologists, that helps us to understand the numbers that we're generating."

Thumps and wshhhes

A key component of the UAM auralization computer program was born from wind tunnel research that colleagues of Rizzi at Langley — whose offices were just down the hall from his — were conducting with a quadcopter drone in 2018. Rizzi and his team could hear a difference between their own computer-generated auralization of the flyover noise from the drone and the actual audio recording in the wind tunnel. Similarly, they could also see the difference between the two sets of numbers that described the auralized sound and the actual sound: Something was missing from the auralization.

They realized their software accurately predicted one part of the sound from the rotor blades: the "thump-thump-thump" caused by pressure fluctuations on the blade that change as it rotates and by the air displaced by the blade, called periodic blade loading and thickness noise. But they didn't have a model to predict the "wshhhwshhhwshhh" sound, generated by changing turbulence off the blade or airfoil, known as airfoil self-noise.

Rizzi and his team would need to put both elements together to accurately auralize the sound of UAM aircraft, most of which are similar to drones in that they are typically multirotor aircraft. Over two years, acoustics researchers developed the self-noise model, and software engineers turned that model into computer code to create sound that humans could hear. As a first step they needed to know the velocity of air from the wake of the spinning blades, the angle of attack and the geometry of the rotor blades as the aircraft was trimmed, so they obtained it from a comprehensive model of rotorcraft aerodynamics.

They also needed a computer program that could quickly compute the noise from each blade, so they took old code based on a 1989 NASA study of airfoil turbulence noise and rewrote it into a modern computer framework. They fed the data from the rotorcraft model into that framework, and the framework calculated the noise numbers for a rotating airfoil.

At the same time they were developing the computer code to predict the airfoil self-noise, they were writing the code that would turn that noise prediction into the sound that humans could hear if the rotors were flying overhead. For their model, they calculated noise predictions for every point on a hemisphere-shaped grid surrounding the rotating rotors in their model, like the bottom half of a globe. This represented what a listener would hear if positioned at any point on that grid.

To understand how their model represented the sound changing over time as the rotors passed overhead, picture the listener on the ground pointing up at the hemisphere grid under the rotors. The closest grid point to the listener would represent the initial sound heard. Then as the rotors and the hemisphere continued traveling, the listener on the ground would be oriented toward a different point on the grid, which would be the subsequent sound heard. Every 10 milliseconds the grid point and the sound heard by the listener on the ground would change slightly.

For the "thump-thump-thump" piece of the UAM auralization, meaning the periodic blade loading and thickness noise, the task was easier. They broke the noise into its two components: pressure on the blade that fluctuates as it rotates or the loading noise, and the air displaced by the blade, or thickness noise. Just as they had for the airfoil self-noise, they computed a noise prediction and auralization model for the periodic noise, wrote a NAF module for it and plugged in their blade loadings, motion and geometry data.

When the engineers had put together the computer models for predicting and auralizing the components of the blade noise, they ran it through another NAF tool that propagates the noise through the time and space between the source and the listener, accounting for factors that would change the sound. That would include the Doppler shift in frequency when an aircraft flies toward

or away from a listener, and also atmospheric absorption. In an AIAA SciTech paper published in January, "Prediction-Based Auralization of a Multirotor Urban Air Mobility Vehicle," Rizzi and his team demonstrated their prediction and auralization computer program with a six-passenger electric quadcopter design, combining the modeling for each of the four rotors on the design aircraft.

When the Langley group published the paper, its UAM model was a prototype: It worked but it "wasn't yet slick" and required a lot of manual labor, Rizzi says. "Now it's ready for prime time. We can put this in the hands of a user with the proper documentation, and they should be able to replicate the results."

Producing an auralization with the NAF isn't as simple as sitting down with the program and typing in some numbers, Rizzi says. An aircraft manufacturer or acoustics consultant, for example, would need the design of the aircraft that will fly, plus systems engineers to develop computer models of the aircraft with the right inputs for the NAF, plus systems analysis people and acousticians developing predictions and validating their predictions with experiments. Then they would need the people who produce the auralizations for test subjects and design the testing to gauge the responses.

Next step: annoyance levels

Within about two years, the Langley group hopes to take the next step in noise prediction: To produce a model that could predict annoyance levels without having to listen to an auralization. This would be based on the accumulated test results from a series of auralizations for a wide range of sounds with human test subjects. Those experiments would be conducted at the psychoacoustic test facility — an auditorium — at Langley. Listeners can rank noises by level of annoyance and provide other feedback that isn't captured by traditional numeric measurements, Rizzi says.

The idea would be to directly predict annoyance levels, based on past test results, for any new or existing aircraft design in various environments, Rizzi says.

Biziorek plans to apply the UAM tool to simulate aircraft noise in three dimensions, demonstrating how a particular type of aircraft sounds as it approaches or flies away or flies overhead. Auralizations are typically played for listeners in his company's dozen or so sound labs — specialized auditoriums. For a building developer proposing to build a vertiport rooftop UAM landing site, for example, Biziorek could layer in how the Doppler effect will change the sound's pitch, background noise, how the sound might reflect off or be absorbed by other nearby buildings, different aircraft types being considered for the vertiport, mock arrival or departure sequences, and how changing each factor would change the sound.

UAM manufacturers so far have been hesitant to share their noise signature data, Biziorek says, but he's hoping that more of them will start to use the NAF and reveal more "so that we can start to have more informed experiential conversations with city agencies and state agencies and communities that are going to be experiencing these vehicles daily." ★

▲ **NASA researchers** demonstrated their auralization computer program with this six-passenger electric quadcopter design, combining the modeling for each of the four rotors.

NASA

Simulating threats

Military strategists need to be sure they are sending pilots to battle with electronic warfare equipment that can spoof and evade enemy radars in a host of scenarios. Assessing EW performance once required many hours of costly and time-consuming flights, but today much of the work can be done on a laboratory bench or in a test chamber. Brad Frieden of Keysight Technologies describes how his company achieves this.

BY BRAD FRIEDEN

When military planners contemplate being in a battle, they must have confidence in their ability to control the electromagnetic spectrum as a means of protecting a war fighter on the ground, at sea or in the air. Take, for example, a pilot in an aircraft that's been painted by the targeting radar of another aircraft. Multiple antennas on the painted aircraft's wings or belly feed a radar warning receiver, or RWR, on board, which must detect this electromagnetic energy and display a warning on a cockpit screen or helmet-mounted display. This warning must identify the other plane and refresh the information at rapid intervals. Most likely the aircraft is a foe, and the pilot's electronic attack system must be ready to automatically jam the threat radar so the enemy can't fire a missile. Versions of this interplay can be seen in the ground and sea domains as well.

One option to test electronic warfare systems, such as the RWR or electronic attack radar jammer on an aircraft, is to take to the air with that equipment and perform flight tests, but those are expensive and may radiate signals that are sensitive and could be intercepted. That's why having a threat simulator, which can create the radio frequency signals that would be present in a battlefield scenario, is critically important to put such systems through their paces before they're needed in a real conflict. And there are benefits if such a threat simulator can be scalable, calibrated, accurate and quickly available. It's also desirable if it can have an open architecture, meaning it could accommodate a variety of software packages and standard interfaces. Such a system of software and signal generators would produce an RF and digital rendering of an actual electronic threat, such as a targeting radar, to test RWRs and jammers against the threat without having to fly the aircraft or operate ground vehicles or ships. We decided to make our threat simulator out of off-the-shelf building blocks, namely Keysight N5193A and N5194A UXG signal sources, which are benchtop instruments that can create radar/jammer RF pulses with fast-hopping frequencies for electronic warfare system testing. These can be assembled in a modular fashion to create a variety of system configurations, scalable from simple to complex.

This idea of threat simulation wasn't a new concept, since jammers had been tested in lab environments simulating the electromagnetic spectrum in battlefield scenarios for many decades. But for customers, acquiring such a system with all these new attributes would be something cutting edge. Keysight shipped its first threat simulator in 2018 and continues to improve upon it.

Converting an oscilloscope

As a primary element to augment a threat simulator's ability to create realistic EW signals, we converted a wideband oscilloscope, one normally used to measure the performance of high-speed digital communications devices, into an RF pulse analyzer. Imagine, for example, that designers needed to verify that an aircraft's jammer would react properly to being painted by a radar. They can now run an RF cable between the aircraft's jammer and our oscilloscope, and then

multiple RF cables from the threat simulator rack or racks to the RWR and to the jammer's input receiver. These cables deliver simulated radar signals as though the aircraft were being painted by an enemy radar. The oscilloscope readings would, for instance, show designers whether the jammer effectively achieves "pull off," in which electromagnetic pulses designed to look like radar reflections slowly pull the threat radar away from tracking the aircraft's location, deceiving it. With our oscilloscope and threat simulator, initial testing of a jammer and RWR can be done on a lab bench, with the threat simulator playing the role of an enemy radar. Designers can find performance issues early and fix them, long before any kind of validation in an anechoic chamber is attempted or a final flight test is conducted.

To create this technology, one challenge we faced was on the signal source side. Our simulated enemy radar signal might need to cover a range of frequencies from a few gigahertz to 40 GHz, sometimes hopping quickly between frequencies. In fact, multiple pulsed RF signals might need to be simulated simultaneously. This required sources that could switch from one frequency to another in mere hundreds of nanoseconds. At the same time, complex modulation schemes needed to be simulated with great accuracy to mimic a real threat. Keysight created a computing and hardware architecture to turn models of actual threats in an EW environment into digital representations of received threat signals and then into actual RF that could drive the RWR and jamming input receiver.

This goal for signal generation required us to digitally place modulation on top of a carrier signal. This placement occurs at an intermediate frequency of 1.8 GHz, with precise control of the modulation that rides on the pulses at a bandwidth of up to 1.6 GHz, just as is found in today's most advanced radar and jammer signals. The most accurate way of placing this modulation on top of this intermediate frequency carrier signal would be to do it digitally. Through a process of digital up-conversion, the baseband modulation signal gets placed on top of a 1.8-GHz carrier signal with great accuracy. Specifically, the integrated circuit achieves this modulation by applying the in-phase and quadrature phase, or I/Q, digital data technique, a method of modulation also used in ultra-high-speed digital communications.

In the real world, threat signals are analog, meaning these signals shift their amplitude smoothly over time. Therefore, we needed to smooth out the voltage steps in our intermediate frequency carrier signal, which we accomplished by incorporating a kind of analog circuitry known as a reconstruction, low-pass filter. This removed the step artifacts left over from digitization, leaving an analog signal.

This 1.8-GHz analog signal is upconverted to the final desired RF frequency, such as a simulated threat radar for the lab. In the real world, threat

▲ **In this game board view** from the Keysight Z9500 Simulation View application, the tracking radar on an enemy jet (Threat 1) paints a friendly aircraft equipped with a radar warning receiver, labeled SUT for system under test. Simulation View calculates the Threat 1 radar signals that the SUT would experience, and Keysight's N5194A signal generators create replicas of those radio frequencies. Two ground-based threat radars and their transmitted scanning antenna pattern beams are also shown.
Keysight Technologies

Painted by radar

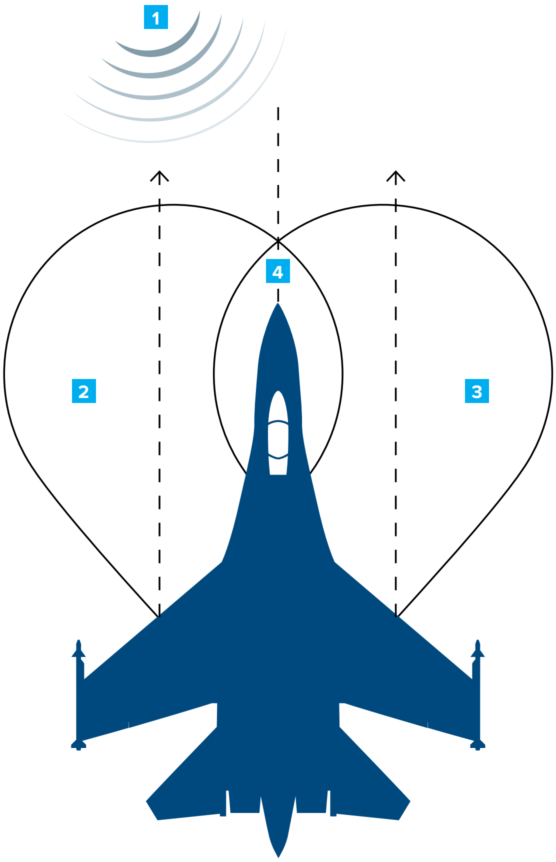
To display a threat location, an aircraft's radar warning receiver must deduce the location of the radar source by measuring the angle of the incoming radar. Here's how it works:

1 Enemy radar targets aircraft.

2 Radar wavefront enters receiving pattern of antenna on left side of aircraft.

3 Radar signal enters receiving pattern of antenna on right side of aircraft an instant later.

4 Radar warning receiver software deduces the angle of arrival from the measured phase difference and/or time difference between the signals captured by each antenna. The angle of arrival is relative to an axis straight ahead of the aircraft (the dashed line from the plane's nose called the boresight).



Source: Keysight Technologies

radars change amplitude of signals within a couple of hundred nanoseconds to try to outsmart a jammer, and it's common for an aircraft to face multiple threat signals.

Our architecture works off millions of pulse descriptor words, which are lists of parameters for each pulse specifying its start time, frequency, pulse width, amplitude and modulation on pulse. With this architecture we provide a real-time, pulse-descriptor-word-based tool that can be quickly delivered to customers and quickly reconfigured to address multiple threat configurations.

In war-fighters' hands

How do our customers use this architecture? Consider first a case in which a radar paints an aircraft from a particular direction. If the angle of the incoming radar can be deduced, then the position of the radar relative to the aircraft can be calculated and placed on the RWR display, and now a war fighter could elect to send a signal in that direction to spoof the radar. More often the war fighter depends on their jammer to do this automatically. To determine the incoming signal's direction, the RWR on the aircraft receives the signal on multiple antennas and from that determines the difference in phase characteristics of the arriving waves. From that, software calculates the azimuth (left to right angle relative to boresight of the vehicle) and elevation (up or down relative to the boresight of the vehicle) of the other aircraft. These phase differences in the signals are called the angle-of-arrival characteristics since they relate to the threat emitter's direction. Our architecture creates multiple signals with accurate angle-of-arrival phase characteristics to test that a radar warning receiver is properly displaying a threat's direction. If you don't get those angles right, you're not measuring the RWR's ability to locate the threat emitter.

Our signal generators get these angles right through proper multiport calibration combined with Simulation View, software that calculates in real time the expected signal phase differences between the antenna ports, and also provides a graphical game board that shows the simulated aircraft and threats. The team developed a process to synchronize multiple sources together while still maintaining phase coherency across multiple ports. It is imperative to calibrate ports in amplitude, delta phase and delta time to create signals with the proper angle-of-arrival characteristics. The result is multiport signal generation capable of testing an RWR that should sense the phase difference between signals received, so it can properly calculate the azimuth and elevation of the threat radar to know its location.

Commercial oscilloscope for RF pulse analysis

Another challenge, but this time related to signal analysis instead of signal creation, was that we had

With our oscilloscope and threat simulator, designers can find performance issues early and fix them, long before any kind of validation in an anechoic chamber is attempted or a final flight test is conducted.

to enhance our oscilloscope architecture so that it could serve as an RF pulse analyzer, capturing every received RF pulse into memory over seconds or tens of seconds. We combined two data processing techniques to achieve this. One technique was variable-length segmented capture, in which we capture the radar pulses when present and ignore the dead time between pulses. The other technique was real time digital down conversion, which allows us to strip off the modulation from the carrier and process and analyze only the modulation.

To understand the variable-length segmented capture and real-time digital down conversion techniques, imagine that you attended a weeklong virtual conference but only wanted to hear and take notes on the sessions with a certain author. The variable-length segmented capture is analogous to your filtering the conference sessions by the author's name so only those sessions are printed in your schedule. Then if audio from the sessions of interest were broadcast on a local FM station at 98.1 megahertz, and you had a radio in your room tuned to that frequency, you could hear the sessions because the radio performs the analog equivalent of the digital down conversion. The modulation arriving on the 98.1 MHz carrier radio frequency is converted into sonic frequencies of 20 hertz to 20 kilohertz that you hear. The real-time digital down conversion does a similar thing inside our oscilloscope but in that case, it pulls the signal modulation off a carrier through a purely digital process so you can analyze the radar and jammer pulses.

Various frequency bands often have to be analyzed for pulsed RF applications. Keysight's UXR has the capability of operating at 256 gigasamples per second, which allows the UXR oscilloscope to operate in bands up to 110 GHz. This sample rate and bandwidth performance allows users to measure signals with carrier-plus-modulation-frequency content up to 110 GHz.

The oscilloscope has to convert ultra-high sample rate data into to a much slower sample rate I/Q data format. For I/Q data format, the sample rate only has to be fast enough to support a bandwidth as wide as the modulation riding on the RF pulses. By doing this, the oscilloscope goes from being able to capture only a handful of milliseconds to potentially being able to have seconds of continuous capture, depending on how narrow the signal modulation bandwidth is.

The UXR real-time digital down conversion I and Q data on each channel drive an intermediate frequency trigger to sense when a pulsed RF radar/jammer signal, with a certain tuned frequency, is present, and only store the I and Q samples into oscilloscope memory for each channel when the signal is present. We call this variable-length segmented capture and it results in extremely efficient signal capture since samples are not wasted on simply capturing noise when no signal is present between the RF pulses. We designed the UXR so that with this capture mode there is zero trigger re-arm time between segment captures. Therefore, no matter how close together RF pulses may be, they can each be captured into variable-length memory segments.

An example application for the UXR oscilloscope would be to determine whether a range gate pull off jammer operates properly. A typical radar system transmits a signal toward a target and then measures a radar echo signal reflected back off the target and tracks each reflected pulse in time. The shorter the time for a radar pulse to return, the closer the target is to the radar. A range gate pull off jammer spoofs the radar by placing larger jammer pulses on top of the radar echo signals at first, and then slowly, over perhaps 10 seconds, moves the jammer pulses away from radar echo pulses up to perhaps 10 microseconds, causing the radar to track the jammer pulses instead of the radar reflection pulses, also causing the radar to believe a false target range. Then the jammer pulses disappear, leaving no signal present for the radar receiver, thus causing the radar to lose track of the target altogether and forcing it to have to reacquire track.

Let's look more specifically at how the range gate pull off test can be accomplished. The UXR oscilloscope, in a normal acquisition mode for a 30-GHz carrier frequency radar, must digitize the input signal at 128 gigasamples per second, which burns through oscilloscope memory quickly, and can only capture 12 microseconds of time, not nearly the 10 seconds of an entire range gate pull off cycle. With the variable-length segmented capture and real-time digital down conversion, the 30 GHz input signals are still digitized at 128 GSPS, but the samples do not go into oscilloscope memory; instead, they are processed by the UXR into 800 megasample per second I and Q data and stored into 800 megabytes of oscilloscope memory. They are then offloaded to the 89600-vector signal analysis software to conduct pulse analysis such as measuring the pull off times. Only I and Q data samples are sent to oscilloscope memory to when the RF pulses are present as sensed by the intermediate frequency trigger. This results in the ability to capture every radar echo and jammer pulse over nearly 50 seconds to see multiple RGPO cycles and prove proper jammer operation where the radar has 1-microsecond-wide RF pulses that repeat every millisecond.

Finally, we chose a software architecture that could both simulate moving platforms including aircraft, land vehicles or ships, and simulate the signals that receivers on friendly platforms would receive on their antennas, such as enemy radar signals, while setting up analysis test and measurement equipment to easily ensure that the proper signals were created. Key signal characteristics such as center frequency, modulation bandwidth, pulse repetition interval and antenna scan rates are turned into oscilloscope setup parameters. This can save engineers and technicians many hours or days of time through automating the measurements.

With our UXR oscilloscope used as an RF pulse analyzer, and multiple UXG signal sources used for RF pulse generation, important tests on EW systems can now be performed even more efficiently on the lab bench or in an anechoic chamber, thus saving time and money. The advances we've made in high-speed test solutions for commercial communications can be applied to the very stringent wideband pulsed RF characterization requirements for the war fighter. ★

Brad Frieden is a factory application engineer focused on radar/electronic warfare in the Aerospace and Defense group of Keysight Technologies in Colorado Springs, Colorado. He holds a Bachelor of Science degree in electrical engineering from Texas Tech University and a Master of Science in electrical engineering from the University of Texas at Austin.

COVER STORY

THE WAY TO NET ZERO

The world's top two commercial aircraft manufacturers have radically different visions for how best to curb the carbon footprint of air travel between now and 2050. Airbus' vision of developing hydrogen-powered aircraft for all but the longest routes has produced an air of excitement, while Boeing is more cautious about hydrogen, and is not shy about explaining why. Keith Button spoke to executives from both companies. Here is what he learned.

BY KEITH BUTTON | buttonkeith@gmail.com

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▲ **An Etihad Airways Boeing 777-300ER** is filled with a combination of traditional jet fuel and plant-based jet fuel. Boeing is part of the Sustainable Bioenergy Research Consortium, a nonprofit established in Abu Dhabi to develop technology to produce sustainable aviation fuel.
Boeing

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Taking the leap with hydrogen

Airbus hopes to offer airlines a hydrogen-powered passenger plane by 2035. Here are the four concepts that the company says it will seek to "evaluate" and possibly "validate" over the next four years.

	PASSENGERS	PROPULSION	ENGINES	EXHAUST	RANGE
Blended-wing body 	200	Hybrid turbofans driven by hydrogen combustion and electricity	2	Water vapor	3,700 km
Pod 	100-200	Thrust comes from removeable pods, each containing a hydrogen fuel cell, liquid hydrogen, cooling system and electric motor to turn an eight-bladed propeller	4 or 6	None or small amount of vented hydrogen	1,800 to 3,600 km
Turbofan 	200	Hybrid turbofans driven by hydrogen combustion and electricity	2	Water vapor	3,700 km
Turboprop 	100	Hybrid turbofans driven by hydrogen combustion and electricity	2	Water vapor	1,850 km

SOURCES: Airbus

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▲ **Researchers from DLR**, the German Aerospace Center, developed the four-seat Hy4, which first flew in 2016. DLR and its spinoff H2FLY plan to scale up the aircraft's hydrogen-electric propulsion technology into a 40-passenger aircraft by 2030.
DLR

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MEET THE PENTAGON'S SOFTWARE MODERNIZATION EVANGELIST

The U.S. Defense Department's process for updating weapon software is notoriously ponderous, and this threatens to put the country at a disadvantage, if it hasn't already. What if updates could be developed and dispatched almost continuously to all forces, perhaps even to aircraft in flight? Jan Tegler interviewed the man who wants to make it a reality.

BY JAN TEGLER | wingsorb@aol.com

▲ **The U.S. Air Force** is looking for information from companies that could work with C-130 prime contractor Lockheed Martin to move the aircraft to the DevSecOps method of developing software.
U.S. Army

News of Russia's alleged SolarWinds hacking of U.S. government computers has broken when I get on the phone with Nicolas Chaillan and his public affairs representative to discuss DevSecOps, short for development, security and operations, which is the U.S. Defense Department's initiative to modernize how military software is developed and delivered across the force to improve speed and security. For the Air Force, DevSecOps means in part ending the block approach to updating the software in its aircraft, ground facilities, missiles and satellites. Today, an entirely new version, or block, must be loaded to replace the existing one, and this can be done at best once or twice a year.

In March, the Government Accountability Office criticized the block process and the F-35 program's twice-a-year multi-increment software delivery process as being too slow to modernize the fighter.

"The goal is never to do massive updates," says Chaillan, the French-born software entrepreneur hired by the Defense Department in 2018 to co-lead DevSecOps with the department's chief information officer, currently John Sherman, an intelligence professional serving since January in an acting role. The Air Force, after some months, also made Chaillan its chief software officer, and specifically, the head of the movement toward more frequent updates that was begun by others. "You look at SpaceX," says Chaillan, "they upgrade software 17,000 times a day in a flow of small, incremental changes. Over months it compounds to a significant set of new features."

SpaceX did not respond to my attempts to verify that figure — but it's a colorful way for Chaillan to underscore the dramatic change that he is attempting to orchestrate, a change that has yet to fully take root. The idea is to bury the block approach in the coming years, including for the Air Force's thousands of aircraft, and even enable updates to aircraft in flight.

At stake for the Air Force and other services could well be the ability to stay ahead of adversaries on such critical functions as target recognition, com-

YouTube/Defense Acquisition University

Nicolas Chaillan

munications and data processing. That said, functions directly related to life and limb, meaning control of aircraft and the safeguarding of nuclear weapons, will be "decoupled" from the shift, Chaillan notes.

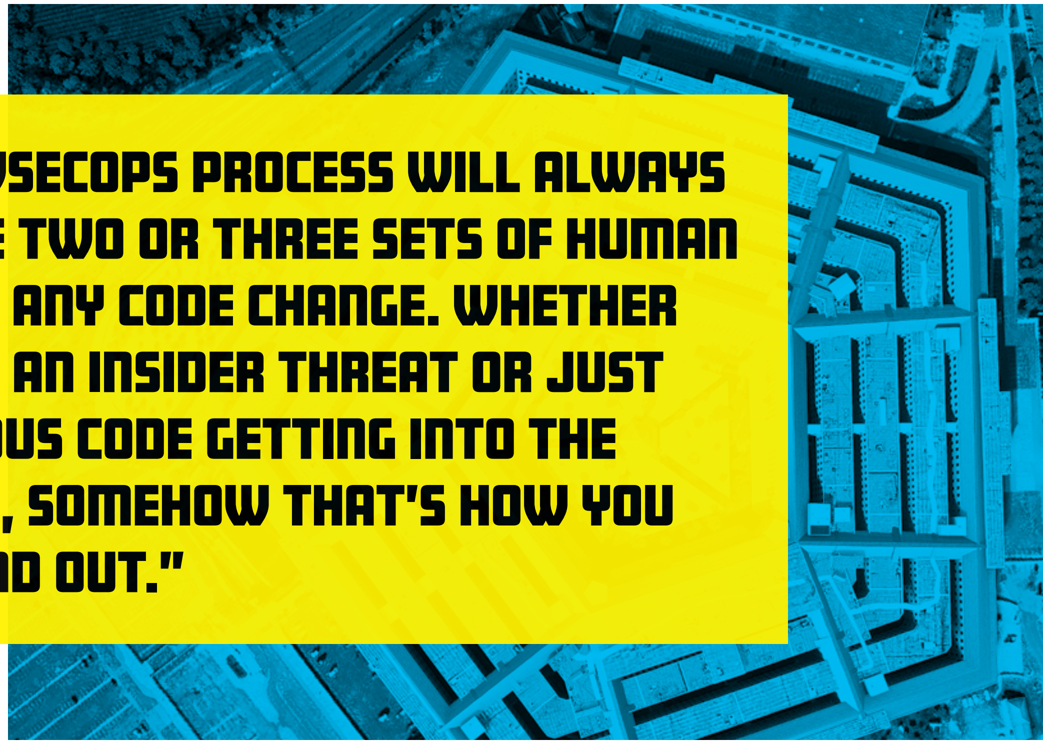
Retiring block upgrades

Right now, much of the military — Chaillan estimates 80% — still upgrades software via the block process, including "the big production aircraft," he says. By 2025, he wants them to follow the SpaceX example of making smaller, more frequent improvements. The legacy block software would not vanish by then, but it would gradually be phased out.

For the military, that would be achieved by empowering its contractors to make software from reusable code and common application tools protected in centralized repositories controlled by Platform One, an Air Force team that wants to manage software development across the services. Software updates would be delivered by a network (defense officials declined to describe it) to computers throughout the military, and by secure datalink to aircraft in flight when necessary.

Last October, the Air Force grabbed headlines by demonstrating the most far-reaching aspect of the concept, delivering over-the-air upgrades to aircraft in flight. Small increments of code were transmitted to a U-2 spy plane flown by a pilot from the 9th Reconnaissance Wing in California. The service reported that the software improved the ability of onboard algorithms to recognize targets for reconnaissance or strikes by other aircraft. Automatic target recognition requires spotting weapons on the ground with visual images, with radar or by the electronic signals the weapons emit. This would require the U-2 to compare its collected signatures to those in a database of known weapons. A U-2 stays up for many hours, and it's possible that in that time it could miss the signature of a new weapon identified elsewhere in the military intelligence apparatus. An in-flight upgrade could catch such a development. Upgrades like this can help the Air Force keep pace with adversaries, Chaillan says.

Still, the first operational examples of in-flight



"OUR DEVSECOPS PROCESS WILL ALWAYS REQUIRE TWO OR THREE SETS OF HUMAN EYES ON ANY CODE CHANGE. WHETHER THERE'S AN INSIDER THREAT OR JUST MALICIOUS CODE GETTING INTO THE SYSTEM, SOMEHOW THAT'S HOW YOU WILL FIND OUT."

updates could be less consequential. "It might be as simple as changing the color of a button in a cockpit display," he says.

It's also likely that live delivery of code to aircraft on the ground or in flight would be done operationally in "canary releases." In other words, code might be pushed to only a few aircraft of a certain type before an upgrade goes out to every F-35A in the Air Force fleet, Chaillan explains.

"We can send code to a few aircraft initially, establishing hardware-in-the-loop testing to make sure software works as intended, improving capability and not breaking anything. We can also get feedback directly from the users, the pilots and aircrew."

The U-2 flight is an example of the "momentum" that Chaillan says the DevSecOps initiative has gained. After we spoke, for instance, I learned that the Air Force issued a request for information seeking contractors "to transition legacy C-130 software to a DevSecOps infrastructure" that meets "all regulatory testing and cybersecurity requirements."

With such transitions gaining traction, Chaillan spends much of our conversation seeking to defuse concerns that could erode the momentum, SolarWinds perhaps being one of them.

In that hack, Russian operators allegedly managed to inject malicious software into the supply chain for the Texas-based company's popular Orion software. Orion monitors the performance and security of websites, applications, databases and other functions that run on company or government online networks for customers including the U.S. Department of Homeland Security and Treasury Department. As long ago as March 2020, SolarWinds reportedly sent out updates for Orion that unwittingly included malware that left a backdoor for hackers who exploited it to install spyware.

Chaillan brings up the SolarWinds nightmare before I can even ask.

"SolarWinds kind of stuff" requires "eyes on code," he says. "The only way to truly find malicious software today is by human review." In any case, the Pentagon did not need SolarWinds to realize this: "That's why our DevSecOps process will always require two or three sets of human eyes on any code change. Whether there's an insider threat or just malicious code getting into the system somehow, that's how you will find out."

Even so, SolarWinds has, for most cyber experts, vividly underscored the need for human eyes in the loop. Should the Defense Department weaken its emphasis on artificial intelligence and hire more eyes for such tasks as identifying suspicious behavior within the repositories or networks and triggering protective actions? Of course not, he says. For behavior detection, "automation and AI can do much more than any human can do."

Chaillan is not alone in recognizing the need for automation. "A human workforce couldn't keep up with all the work," says Justin Taylor, director of weapons systems engineering at Lockheed Martin Skunk Works in California. The company already uses DevSecOps processes internally and is working closely with the Air Force through a "basic ordering agreement," a contract to provide engineering, software development, cybersecurity and operations, and information technology support for Platform

▲ **The U.S. Government Accountability Office** criticized the Defense Department's program for modernizing F-35 software, which began three years ago and is scheduled to continue into 2027.
U.S. Army

One for an unspecified price. In addition to behavior monitoring, automated testing is part of the Air Force's DevSecOps process at "every step in building an upgrade," Taylor says. Algorithms probe code during development, "making sure upgrades don't break existing apps," he adds.

With Chaillan, I summarize the concerns I'm hearing from cyber experts such as Amir Jerbi, co-founder of Tel Aviv-based Aqua Security, a cloud security firm unaffiliated with the Air Force's DevSecOps initiative. Jerbi fears that if the monitoring and testing are not done exactly right, the military's software updates could be compromised during the process of developing them from code in the repository.

"Then, the minute something is updated you're opening the door to something malicious," Jerbi tells me. "If there is one blind spot in the supply chain, this is where you're going to be attacked."

He wonders what might happen if the code sent in an update to a U-2 acted normally until activated to do something damaging.

Chaillan signals that he's aware of such concerns. He says that the new process, far from increasing such risks, significantly reduces them. For instance, the military once needed a year to fix software. Wherever DevSecOps is fully implemented, an update "could take as little as four hours. That's game changing for security," Chaillan says.

As an example, he notes that the Air Force realized it made a mistake when it ruled that SpaceX could not update the software in its launch vehicles carrying military payloads up until the day prior to a launch, as it does with commercial launches.

"The Air Force launches were less secure than SpaceX's own commercial launches because they had fixes for the software that we couldn't use. We were frozen in time 60 days prior to a launch," he says. "We were actually creating more risk by setting the software baseline than by using the latest update from SpaceX."

Also, security would be built into the code from inception to deployment with multiple layers to prevent or rapidly find and fix anomalies in software. The more automated testing that can be done, the more confidently software upgrades can be made, Chaillan maintains, explaining that if a functionality or security issue is found in a software upgrade, a new test can be created immediately to prevent it from occurring again.

"Fail fast but don't fail twice for the same reason" is Chaillan's motto.

Genius or new vulnerability?

To speed up and safeguard software creation, developers get access to a range of approved Platform One development tools and a set of department-vetted programming languages and databases, plus access to Iron Bank, one of the repositories.

Iron Bank stores discreet pieces of open source, commercial code and also custom code created to meet Pentagon requirements in containers, the cloud-computing term for discrete packages of software that hold pieces of code needed to create or run software applications.

All containers in Iron Bank are hardened, meaning the code inside them has been reviewed and accredited for use by the Air Force's Office of the Chief Software Officer. Developers can contribute new code to the repository, expanding the library of containers. Chaillan likes to refer to them as Lego blocks, explaining that the Pentagon wants developers to assemble code from Iron Bank's containers for applications and upgrades for everything from aircraft to ships to electronic warfare sensors.

I give Chaillan the short version of the long list of reservations that cyber experts have expressed to me.

Jerbi worries about a "unique, crafted attack" in which a nation-state will try to find a supplier — a company within the defense industry that creates new code to be contributed to Platform

▲ **Officials at the Air Force's U-2 Federal Laboratory** participate in a computing experiment. Days later, the lab proved that the service can update a U-2's software while it's in flight.

U.S. Air Force

One's repositories — "that uses a certain component, let's say a Java library, and attempts to poison that library. This will be their Trojan horse into the environment."

The poisoned code might "slowly, methodically move laterally through Platform One," affecting the software build process, making its way into containers meant for upgrades.

"You will select a container," Jerbi says. "You will insert a piece of code" for a sensor upgrade, for example, "that looks and acts normal as legitimate software, connecting to whatever components it should or needs to connect with, meeting whatever conditions it needs to meet."

Once sent to the mission computers onboard an aircraft, the malicious code in the container "will find small holes enabling it to add or subtract data where possible," Jerbi explains.

Then, "when [an aircraft] is connecting to a cloud or a network to download the next upgrade or code version, it might add a few more pieces of data to the new services or it might reveal an additional few bytes of data."

Malicious code in a container could alternately exfiltrate data, directing a file to be downloaded to a container an adversary has access to. That would be a veiled way to gather intelligence on a system or operations.

"As we've seen with SolarWinds and as our own research team is seeing with containers, there are active measures being taken to create backdoors through the supply chain in a way that is not detectable with simple signature-based or vulnerability testing," Jerbi says.

He's not saying this will happen. Testing and monitoring will be the keys to going beyond "run of the mill hygiene," he says. If enough testing can be done "with nothing that hasn't been approved or tested moving to deployment" then continuous updates "could be successful in theory," Jerbi says.

Another expert, Tamer Hassan, the founder of WhiteOps, a New York City-based cybersecurity firm and a former Air Force C-130 and HH-60G Pave Hawk pilot, puts the stakes in human terms.

"If bad data got into a navigation system on a Pave Hawk, that could spoof position information or interfere with the mission you do, combat search and rescue." Would he be confident flying a Pave Hawk helicopter that received a software upgrade in flight?

The answer might be surprising: "Absolutely," he says, "if I knew that if X, Y or Z breaks because of an upgrade, there's a plan — that any problems, like a bug pushed to the navigation system, can be mitigated fast."

Still, the overall message from cyber experts is one of caution and perhaps nervousness. Is it wise to collect code in centralized locations this way?

Chaillan does not waffle at all. "If you ask the same thing of the Secret Service about the White House, they're going to tell you that centralizing all the risk into a central place" makes it "easier to secure the White House," Chaillan says.

True, Platform One is "the crown jewel of the department," and "if someone were to get access or get inside of Iron Bank" — he compares it to someone jumping the White House fence — "that's a big problem." And it could well happen: "Nothing is perfect." But the possibility of a breach doesn't mean that centralization is not "the right thing to do."

Like the Secret Service, he is not just relying on perimeter defense alone. "At the end of the day, it's always scary to put all your eggs in the same basket, but at the same time, our basket in Platform One is sort of diversified," he explains. "We're not locked into a single product or a single tool. We always have a lot of options."

Also, "centralizing talent and execution in Platform One" enables the Defense Department to "do a much better job of securing software for rapid upgrades as a unified team than doing it in a vacuum" with teams in industry and the military working separately. And DevSecOps requires the testing and monitoring that Jerbi and other experts highlight as crucial.

As for the containers, "If a bad actor gets into container A, and it tries to send a command to get into container B, and it has never tried to do that before, our behavior detection system will detect that this isn't normal and will kill container A, alert us and restart container A back to immutable state."

The practice is part of a strategy known as "moving target defense" wherein continuous software updates yield an ever-changing target, Chaillan adds. "That makes it very difficult for any bad code to remain in the system for a long period of time."

Here is Chaillan's bottom line about security: The DevSecOps cybersecurity "is probably the most advanced on the planet." Activating malicious code will be extremely difficult, and if an application acted abnormally, it would be detected and stopped or patched fast.

Trust nothing and encrypt

Last year, the Air Force and the rest of the Defense Department began to adopt a cybersecurity strategy known in the software industry as Zero Trust, so called because it assumes that no request from outside or inside a network like Platform One is trusted at the start. Every action must be challenged and authenticated.

Chaillan describes Zero Trust as "denial by default," adding that it can prevent malicious code from migrating through containers and stop any adversary from trying to penetrate Platform One via the cloud computing network that hosts it.

The starting point is that no piece of code or application in a container can communicate with or make a request of another piece without approval.

"If I want to create connectivity between two things — two containers — I have to 'white list' or approve that traffic. That's one pillar of Zero Trust," he says.

The second pillar is encryption. Any time a container communicates with another container to execute a service, the data will be encrypted, according to Chaillan. "No data will ever be transferred in the clear," he says, such as when a new container is sent to an aircraft in flight.

The third element of Zero Trust is a certificate authenticating communication between containers. "The software managing containers issues a short-lived certificate, or identity if you will, so we know container A is container A and not container B pretending to be container A," Chaillan says.

Each container gets rotating identities that expire as often as every hour. Even if a hacker "managed to steal one of the identities to use to authenticate, that identify will expire quite soon."

Zero Trust also applies to the cloud network underpinning Platform One. All developers must go through a single access point.

A series of Zero Trust protocols protect Platform One, challenging every request, even when a user has gained access into the platform. Any request to pull code from the repositories or make use of security or development tools is fully authenticated, authorized and encrypted before access is granted. This "microsegmentation" also prevents lateral movement, Chaillan says.

Software and defenses can never be perfect, Chaillan says. But because adversaries are developing capabilities faster than the U.S., "the risk of not continuously updating software, even in flight, is greater than the risk of not doing it." ★

Ben Iannotta contributed to this story.

▲ **Software on a U.S. Air Force U-2 was updated** while the aircraft was in flight, a method that can help the Air Force keep pace with adversaries, says Nicolas Chaillan of the Defense Department.
U.S. Air Force

OPINION

Demanding more of Space Force

Today's U.S. Space Force does little if anything beyond what the Air Force did when it led the country's military space operations. Humanity's terrestrial history and the increasingly bold plans of entrepreneurs to settle and economically exploit space suggest that change is coming. Don't be afraid. Peter Garretson explains.

BY PETER GARRETSON

Today, the majority of humanity's political and economic interests reside on Earth, and it is terrestrial militaries that can capture or threaten those interests. Most observers, therefore, assume that the primary role of the U.S. Space Force will be to serve as a support service for the Army, Navy and Air Force.

That view is shortsighted. Over time, American citizens are sure to demand a greater role for their new Space Force.

As America's entrepreneurs work to create an economy of space stations, factories and mines in cislunar space and beyond, the Space Force's roles and missions must be broadened. The great American naval theorist Alfred Thayer Mahan remarked that the need for a navy arises with commercial shipping. As America becomes a spacefaring nation, it will develop economic and political interests in space that require protecting.

Over time, the roles and missions of the Space Force should come closer to resembling the roles and missions performed by our Navy and Coast Guard. A constant peacetime presence along the lines of commerce will ensure freedom of navigation and safety of navigation, promote peace and provide a vigilance that deters coercion.

Terrestrial militaries rescue individual citizens from natural or human-made dangers, evacuate citizens, provide humanitarian relief and clear hazards that threaten safety of navigation. They also provide support to civilian regulatory and law enforcement authorities, and build and maintain public works such as roads, bridges and canals. Similarly, we can predict that the Space Force will be asked to perform such functions.

Surveillance, for starters

First will come simple vigilance. As American and competitor activities extend beyond geostationary orbit to the environs of the moon, our national leadership will expect to know what is happening. Certainly, the National Reconnaissance Office, if it survives as an independent organization, will have a role to play in the surveillance of adversary activities. The Commerce Department, which now has the lead for space traffic management, is also likely to have a role. But there will be an operational necessity to piece together a common operating picture synthesizing adversary and U.S. commercial, civil and military activities to provide situational awareness and recommendations to policymakers. While such a common operating picture would be managed by Space Command, it would be built using spacecraft, assets and personnel from the Space Force. Space Force is already the lead for space domain awareness and precision navigation and timing through the GPS constellation, and it is well practiced at timely operational collision avoidance and space control. It will be natural to look to the Space Force to develop that common operating picture, which is the foundation for vigilance.

Simple vigilance is a powerful deterrent. Malign actors are less likely to threaten U.S. interests if they know their actions can be observed and attributed. This is one reason why the U.S. revealed its previously classified Geosynchronous Space Situational Awareness Program and why the Space Force is exploring the concept of deploying Cislunar Highway Patrol Satellites, or CHPS, to observe activity around the moon.

But vigilance may not be a deterrent if the adversary knows you can't do anything to respond to a provocation. Therefore, response capabilities will be required. On the sea, lines of commerce are not defended by keeping warships omnipresent to protect from every threat. Rather, warships threaten retaliation with their ability to punish. Therefore, we can expect that the Space Force will develop patrol craft capable of a variety of responses. Inevitably, adversaries will compete for spacecraft that are capable of deeper and more responsive operations, which will force a competition for advanced propulsion.

Most of the time, those general-purpose patrol craft will not be countering coercion or engaging in war. But they will be significant investments with significant logistics and response capability. Therefore, when U.S. or allied citizens, companies or activities run into problems, it will be natural for policymakers to ask for the Space Force to come render assistance.

Such a request may initially be treated by Space Force leadership with the same attitude of other militaries when first asked to conduct "military operations other than war." The reaction is typically, "Not my job." But the need for leaders to protect their nation's global reputation and appear as responsive to the media, the public, or powerful or wealthy constituents will overcome such objections. And America will not want to duplicate its investment just to create a separate constabulary service.

Even if services are routinely accomplished by commercial actors, we can expect to see Space Force asked to assist in debris removal, towing, inspection and emergency servicing in the near term. But as more human activity begins to take place in orbit, we can expect to see search and rescue operations, medical evacuations, vessel-board search and seizure for contraband or illegal activity, and perhaps even requests to cope with unruly space tourists or hostage situations. If the Space Force is capable, it might even be politically expedient to rescue astronauts or citizens of one's political rival.

Natural threats

At some point, our nation, its allies or friends will be confronted with the threat to the homeland of

When U.S. or allied citizens, companies or activities run into problems, it will be natural for policymakers to ask for the Space Force to come render assistance.

an asteroid or comet impact. "Not my job" or "no one told us that's our job" will not be acceptable responses. The American people will naturally expect that if someone is going to defend their lives and property from an asteroid, it will be the Space Force. Certainly, America's stature would be diminished if another power had to come to our rescue or the rescue of others. Therefore, I think it is likely that the American electorate will demand the Space Force take on planetary defense.

As detailed in my book with Namrata Goswami, "Scramble for the Skies: The Great Power Competition to Control the Resources of Outer Space," there are ongoing efforts by nations and private actors to access the vast energy and material resources of outer space. These resources are so vast that they could alter the balance of power and pecking order among nations. In the past, such opportunities led to significant efforts by European powers to capture new resources in the New World and Africa.

Although the U.S. and others are attempting to moderate such conflict by establishing rules of the road, such as NASA's Artemis Accords, with respect to space resources, history would suggest that at some point, actors will have conflicting interests and conflicting interpretations. We can hope for negotiation, but in an anarchic system, there is no authority above nation-states to prevent the use of force or war. Past agreements to divide up the world were honored until they weren't.

Already we know of certain regions with concentrations of resources. Access to those resources and commerce are controlled by astro-strategic terrain. Just as the United States sought Alaska, Texas and the Louisiana Purchase for its economic ambitions, and just as militaries appreciated the ability of Puerto Rico, Pearl Harbor and the Panama Canal to secure trade and control commerce, the nations and militaries of the world have already begun to perceive the strategic value of important regions in space for economic or military power. The competition to occupy and control these regions — or challenge such control, such as through freedom of navigation operations — will become an important activity of the Space Force.

Economic interests

We can't know at what point resources on the moon or asteroids will reach vital economic significance, but the footholds of the European powers were geostrategically important to future wealth long before they were profitable. Moreover, stretched to the limit of a nation's logistics efforts, the winners and losers were often determined by tiny expeditionary forces at the farthest reaches from the nation. At such limits, a very small amount of force can blockade, starve, coerce or capture. Thus, we can anticipate that nations will aggressively protect their fragile footholds, and America will expect its Space Force to be there to protect the significant investments of the nation and its citizens. Such situations could result in a military crisis decades before economic dependencies have arisen.

At some point, Earth will have significant economic interests and dependencies in space, and it is likely to have significant off-Earth communities, whether Elon Musk's SpaceX colony on Mars or Jeff Bezos' dream of trillions of people in free-flying space colonies.

The possibility of having Space Force personnel in space or having crewed spacecraft may seem remote or frivolous today. But over time, as more and more citizens are residing in space, and as the costs come down, it will seem silly for the Space Force not to have personnel in space.

It is perhaps natural for those space professionals who have spent two to three decades in relatively unchanged satellite support operations to dismiss such projections. Small, embattled and fearful of ridicule both by the public or the other services, it may appear a wise course for the Space Force to project a cautious view of a limited set of roles and missions for a Space Force that looks down to protect America's Joint Force, as we call our military services.

But such a narrative is dangerous and must not be encouraged. The more serious risk is that the U.S. commercial sector will move faster and that a visionless Space Force will be caught flat-footed and unable to defend U.S. interests. Therefore the U.S. electorate must insist that the Space Force plan ahead — that it takes seriously the visions and plans of industry. ★

Peter Garretson
is a senior fellow in defense studies at the American Foreign Policy Council in Washington, D.C., and co-director of its Space Policy Initiative. Garretson is the co-author with Namrata Goswami of the 2020 book "Scramble for the Skies: The Great Power Competition to Control the Resources of Outer Space."

AIAA Bulletin

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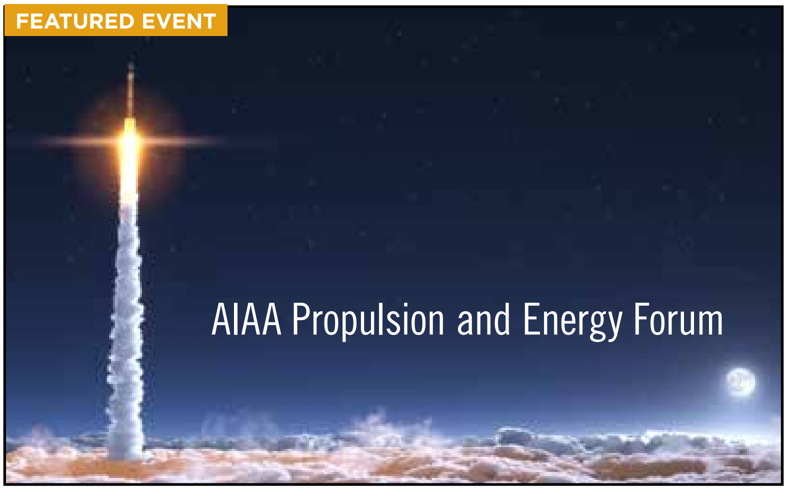
Calendar

FEATURED EVENT



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The world's only conference to showcase both aeronautics and space propulsion and energy technologies in a single event. This forum brings together the global propulsion and energy community's diverse interests to cover a broad range of technologies and applications ranging from discreet components to advanced, complex subsystems.

aiaa.org/propulsionenergy

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2021			
9 Jun	Professional Virtual Career Fair	VIRTUAL (aiaa.org/events-learning)	
15 Jun	ASCENDxSummit	VIRTUAL	
21–23 Jun*	3rd Cognitive Communications for Aerospace Applications Workshop	VIRTUAL (http://ieee-ccaa.com)	
23–24 Jun	OpenFOAM CFD Foundations Course	ONLINE, 2 full days (learning.aiaa.org)	
24 Jun–13 Jul	Computational Aeroelasticity Course	ONLINE (learning.aiaa.org)	
5–30 Jul	Optimal Control Techniques for UAVs Course	ONLINE (learning.aiaa.org)	
20–29 Jul	Digital Engineering Fundamentals Course	ONLINE (learning.aiaa.org)	
26–29 Jul	1st AIAA Ice Prediction Workshop	ONLINE (learning.aiaa.org)	
2–6 Aug	AIAA AVIATION Forum	VIRTUAL	10 Nov 20
9–11 Aug	AIAA Propulsion and Energy Forum	VIRTUAL	11 Feb 21
11–13 Aug	AIAA/IEEE Electric Aircraft Technologies Symposium	VIRTUAL	
12 Aug	AIAA Aerospace Spotlight Awards Gala	VIRTUAL	
17 Aug	AIAA Fellows Induction Ceremony	VIRTUAL	
1 Sep	2021 Section Awards Presentation	VIRTUAL	
6–10 Sep*	32nd Congress of the International Council of the Aeronautical Sciences	Shanghai, China (icas.org)	15 Jul 19

AIAA Continuing Education offerings

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

14–16 Sep	AIAA DEFENSE Forum (Postponed from April)	Laurel, MD	17 Sep 20
15–24 Sep	Hypersonic Applications: Physical Models for Interdisciplinary Simulation Course	ONLINE (learning.aiaa.org)	
16 Sep–7 Oct	Uncertainty Quantification: Machine Learning for Quantifying Uncertainties in Engineering Applications Course	ONLINE (learning.aiaa.org)	
22 Sep– 29 Oct	Turbomachinery for Emerging Space Applications: Liquid Rocket Propulsion Course	ONLINE (learning.aiaa.org)	
29 Sep–22 Oct	Satellite Thermal Control Engineering including SmallSats Course	ONLINE (learning.aiaa.org)	
4 Oct–10 Nov	Design of Spacecraft & Systems Engineering Course	ONLINE (learning.aiaa.org)	
28 Sep	ASCENDxSummit	VIRTUAL	
25–29 Oct*	72nd International Astronautical Congress	Dubai, UAE	
15–17 Nov	ASCEND Powered by AIAA	Las Vegas, NV, & ONLINE	30 Mar 21
15–17 Nov	AIAA International Space Planes and Hypersonic Systems & Technologies Conference	Las Vegas, NV, cE	30 Mar 21
29–30 Nov	Australian International Aerospace Congress & Region VII Student Conference	Melbourne, Australia, & ONLINE	15 Sep 21

2022

3–7 Jan	AIAA SciTech Forum	San Diego, CA, & ONLINE	1 Jun 21
7 Jan	3rd AIAA Geometry and Mesh Generation Workshop (GMGW-3)	San Diego, CA	
7 Jan	4th AIAA CFD High Lift Prediction Workshop (HLPW-4)	San Diego, CA	
8–9 Jan	1st AIAA High Fidelity CFD Workshop	San Diego, CA	
1–3 Apr	AIAA Region VI Student Conference	Merced, CA	5 Feb 22
4–6 Apr*	3rd IAA Conference on Space Situational Awareness (ICSSA)	Madrid (http://reg.conferences.dce.ufl.edu/ICSSA)	15 Jun 21
19–22 Apr	AIAA DEFENSE Forum	Laurel, MD	
30 May–1 Jun	29th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia	
21–24 Jun*	ICNPAA 2021: Mathematical Problems in Engineering, Aerospace and Sciences	Prague, Czech Republic (icnpaa.com)	
25–26 Jun	7th AIAA Drag Prediction Workshop ("DPW-VII: Expanding the Envelope")	Chicago, IL	
26 Jun	2nd AIAA Workshop for Multifidelity Modeling in Support of Design & Uncertainty Quantification	Chicago, IL	
27 Jun–1 Jul	AIAA AVIATION Forum	Chicago, IL	
24–26 Oct	ASCEND Powered by AIAA	Las Vegas, NV	

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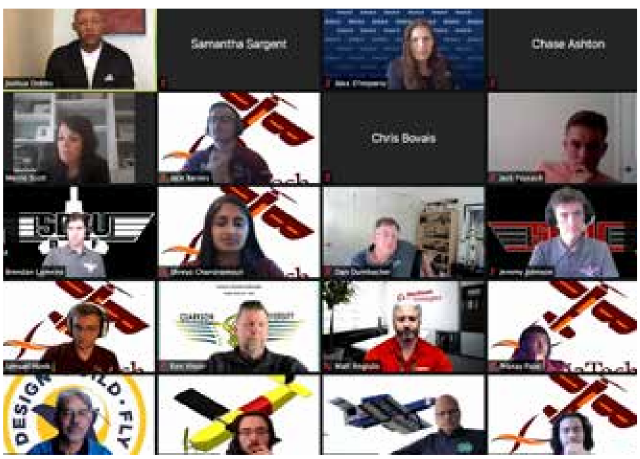
MAKING AN IMPACT

25 Years of Design/



Pittsburgh Steelers quarterback Joshua Dobbs spoke at the awards ceremony about his DBF experience (seen here at the 2017 DBF).

Each year AIAA invites university students from around the globe to participate in the AIAA Design/Build/Fly (DBF) Competition (**aiaa.org/DBF**). DBF is a premier event for student aerospace engineers because it provides a real-world aircraft design test for them by giving them the opportunity to validate their analytic studies. DBF experience is known to give students a resume boost.

This year we celebrated the 25th annual DBF fly-off virtually. The objective was for teams to design, build, and test a UAV with a towed sensor. Committed to providing teams the opportunity to highlight their aircraft, the DBF Organizing Committee add in a third round to this year's competition. This allowed teams the opportunity to submit video footage demonstrating and presenting their aircraft in flight.

On 15 May a virtual Zoom awards ceremony was held to announce the winners. 2017 DBF alumnus Joshua Dobbs, who majored in aerospace engineering at the University of Tennessee, Knoxville, and currently is a quarterback for the Pittsburgh Steelers, shared his DBF experience and how he has applied his aerospace engineering degree on and off the field.

AIAA is proud to have had 92 teams compete in our 2020–2021 competition. This year's top three winners are:

First Place ($3,000): Dayananda Sagar College of Engineering

Second Place ($2,000): University of Central Florida

Third Place ($1,500): Embry-Riddle Aeronautical University, Daytona Beach

The Best Report Score went to the University of Michigan, Ann Arbor.

The full list of team placements can be found at **www.aiaa.org/dbf**. You also can watch footage of all of the 2020–2021 teams flying their aircraft at AIAA's YouTube channel (**https://youtube.com/playlist?list=PLOl5RDXeYOMCvy5-l5g23OfVVRrtunu-B**).

DBF's success is thanks to our sponsors from Textron Aviation, Raytheon Missiles and Defense, and Mathworks and our volunteers. Volunteers from AIAA Applied Aerodynamics, Aircraft Design, Flight Test, and Design Engineering Technical Committees collectively set the rules for the contest, publicize the event, gather entries, judge the written reports, and, in all other years, organize the fly-off.

Build/Fly

Faculty advisor: Hareesha N. G.

Team members

Nayan Ganguli
Anirudh Vasist
Saurav Deshmukh
Ayush K
Raghav M
Dhruv Dhaduk
Anjali A
Preethi S
Srinivasa G S
Ronith Palaksha
Sai Sanketh R S
Sakshi Rastogi
Gagana B

Please consider donating $25 in honor of the AIAA Foundation's 25th anniversary. Programs like DBF help inspire the next generation of aerospace professionals. For more information about how to get involved with AIAA and make an impact please visit aiaa.org/foundation or contact Alex D'Imperio, alexandrad@aiaa.org.

University of Central Florida's Team Dark Knights and their aircraft, Knightmobile

Faculty advisor:
George Loubimov

Team members
David Silva-Melendez
Devin Unterreiner
Kyle Ramos
Dillon Graves
Mariangelo La Rosa
Andrew Schroeder
Jack Faysash
Harshavardhan Bangaru
Abhilash Manjula Prasad
Bilal Rauf
Mark Aldritz Dela Virgen
Joseph Barr

Embry-Riddle Aeronautical University, Daytona Beach's Team Embry-Riddle Eagles and their aircraft Sensor Towing Air Tractor (STAT)

Faculty advisor: J. Gordon Leishman

Team members
Carson Raleigh
Hunter Gray
Harshil Patel
Caleb Reeves
Daniel Garlock
Joseph Ayd
Eva Dave
Alexander Roy
Marissa Murphy
Daniel Chen
Andrew Bunn
Victor Chang
Zefu Ren
Alex Neuman
Nicholas Marshall
Brandon Babey
Vedang Patil
Matthew Mueller
Ryan Hickerson
Patric Hruswicki
Riley Cox-Grosss

Nominations for AIAA Directors Being Accepted Through 23 July

The AIAA Council of Directors Nominating Committee (CNC) will compile a list of potential nominees for the open Director positions on the AIAA Council of Directors. This list will include nominees who will be selected to go to the next step of competency review held by the nominating committee. The nominating committee will select specific candidates for the open Director positions who will be voted on by the AIAA membership. The final slate of candwidates will be publicized by December 2021 for the election that will be held January/February 2022.

Nominations are being accepted for Regional Directors, Integration and Outreach Group Directors, and Technical Group Directors for the term May 2022–2025. AIAA members may self-nominate or nominate members qualified for the open position by submitting a nomination at aiaa-awards.org/a/solicitations/1173/home **no later than 23 July 2021**.

Regions coordinate the activities of geographically related sections to facilitate cooperative efforts between the various geographical areas. A Regional Director shall lead each region. The voting members who belong to that region shall elect the Regional Director for that region. The Regional Director for each group shall be a member of the Regional Engagement Activities Division (READ) as well as a delegate to the Council of Directors. The term for Regional Directors shall be three years and there shall be a limit of the Regional Director serving two consecutive terms. Nominations are being accepted for:

Region IV – South Central, Director
Region V – Mid-West, Director

For more information on AIAA regions and sections, visit the AIAA website aiaa.org/get-involved/regions-sections

Integration and Outreach Groups coordinate the activities of related Integration and Outreach Committees to facilitate cooperative efforts between the various professional areas. An Integration and Outreach Group Director shall lead each Integration and Outreach Group. All voting members shall elect the Integration and Outreach Directors. The Integration and Outreach Director for each group shall be a member of the Integration and Outreach Activities Division (IOD) as well as a delegate to the Council of Directors. The term for Integration and Outreach Group Directors shall be three years and there shall be a limit of the Integration and Outreach Group Director serving two consecutive terms. Nominations are being accepted for:

Aerospace Outreach Group, Director
Integration Group, Director
Young Professionals Group, Director-Elect

For more information on AIAA integration and outreach, visit the AIAA website aiaa.org/get-involved/committees-groups/Integration-and-Outreach-Division-Committees

Technical Groups coordinate the activities of related technical committees to facilitate cooperative efforts between the various technical disciplines. A Technical Director shall lead each Technical Group. The voting members who belong to that group shall elect the Technical Director for that group. The Technical Director for each group shall be a member of the Technical Activities Division (TAD) as well as a delegate to the Council of Directors. The term for Technical Directors shall be three years and there shall be a limit of the Technical Director serving two consecutive terms. Nominations are being accepted for:

Information Systems Group, Director
Propulsion and Energy Group, Director

For more information on AIAA technical activities, visit the AIAA website aiaa.org/get-involved/committees-groups/technical-committees

To nominate an AIAA member in good standing for the open positions on the AIAA Council of Directors, please submit the nominee's bio and/or CV, history of AIAA activities and/or engagement with other professional societies, and a statement from the nominee of willingness and ability to serve if elected.

Please submit nominations directly at aiaa-awards.org/a/solicitations/1173/home no later 23 July 2021. For more information please direct questions to Christopher Horton, AIAA Governance Director, chrish@aiaa.org.

Call for Participation: AIAA Standards Revision

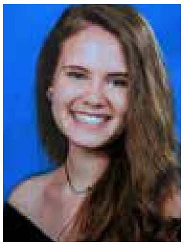
AIAA G-095B, Guide to Safety of Hydrogen and Hydrogen Systems

This guide that is being proposed as an American National Standards (ANS) presents information that designers, builders, and users of hydrogen systems can use to ensure safe hydrogen systems or resolve hydrogen hazards. Guidance is provided on general safety systems and controls, usage, personnel training, hazard management, design, facilities, detection, storage, transportation, and emergency procedures. For more information, or if you wish to participate, please contact Nick Tongson (nickt@aiaa.org).

First Kahn Scholarships Awarded

AIAA was excited to have over 180 high school seniors from all over the world apply for the inaugural Roger W. Kahn Scholarships, which honors the memory of Roger Kahn and his passion for aviation and entertainment. The four $10,000 scholarships have been awarded to **Natalie Brenton, Madison Chubb, Daichi Horiguchi,** and **Gloria Johnson**. These students also will receive a travel stipend for an AIAA event and an AIAA professional member mentor to help guide the student on their career path. We can't wait to see how they shape the future of aerospace!

Natalie Bretton, Menchville High School, Newport News, VA



I have participated in FIRST robotics programs for almost a decade. Now, as the mechanical fabrication lead and pit crew lead of Menchville High School's FIRST Robotics Competition team, I am responsible for the design and building of our robots, training mechanical sub-team members on using machine shop tools, and troubleshooting mechanical problems under pressure. At competitions, I led my team's first all-girl pit crew to win several prestigious technical awards, making us one of the youngest, yet most successful, pit crews the team has ever had. My team also partnered with VCU's Occupational Therapy program, where we worked collaboratively with Ph.D. students to design and implement assistive technology (AT) – technology that helps those with disabilities. I led the process of designing, modifying, and implementing AT, an experience that taught me just how much STEM can help the people around me. After completing two invitation-only NASA summer academies, I discovered that I have a passion for aerospace engineering. As a student at the Governor's School for Science and Technology (GSST), I was able to further explore this passion through a mentorship at NASA. I worked alongside an aerospace engineer to develop a customizable turbofan engine component in a program called OpenVSP. I am going to continue this project through a paid internship this summer, and hope to publish my work. This coming year, I am excited to be attending the University of Virginia as a Rodman Scholar where I plan to double major in mechanical and aerospace engineering.

Madison Chubb, Timber Creek High School, Orlando, FL

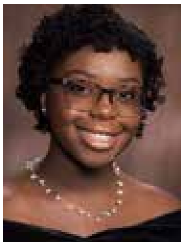
My parents believe that growing up in their own country they were never permitted to figure out who they were. My four younger siblings and I are first-generation Americans and have always been allowed and encouraged to follow our individual passions. This freedom has allowed me to discover who I truly am inside and what I want to do with my life. I have always been allowed to freely investigate everything I loved. I built, I fixed, and I took a zillion things apart. As a child I would spend hours in my sandbox building different shapes, or sitting on the floor pouring pasta from one saucepan to another through funnels and cardboard tubes. As a six-year-old I asked for a model jet engine for my birthday. Ever since then I knew I wanted to work with planes. I built hundreds of Lego sets, later moved onto Meccano, and now VEX Robotics advancing to States and Worlds. All these things I did as a child have allowed me to realize my passion for aero engineering. Living in different countries I learned to be at ease with who I am. I was the one who was different, and I chose to embrace that, wherever I might be. I am so excited to take the next step into aero engineering and I look forward to all the new exciting things that my future holds! I will be attending the University of Florida in fall 2021.

Daichi Horiguchi, Mira Costa High School, Manhattan Beach, CA

I've had the chance to delve into many different endeavors and skills. I've painted thousands of artworks, recently got scouted into and entered a talent agency, have been learning martial arts for the past decade, and have spent a great fraction of my life on music. I began learning the violin when I was two and performed a solo with orchestra accompaniment by the time I was four. I have been on news and media since five and have led numerous orchestras as a concertmaster. Music has provided me with phenomenal opportunities like performing solo with the Mira Costa Symphony in Spain, performing for former President Bill Clinton, and getting to mentor many young musicians.

Despite my varying interests, engineering has always been my biggest passion. As a child, I used to break apart and fix household machineries like clocks and printers. I loved finding out the mechanics of any device and gaining knowledge by hands-on experience. I learned woodcrafting and the handling of electric tools in elementary school, and I learned programming and 3-D modeling in junior high. After learning metalwork during high school I turned scrap pieces of motorcycles into a cafe-racer. I now feel that my childhood ambitions and curiosity have grown over the years. It's always been my dream to become an astronaut, but now I cannot stand not knowing what lies beyond our reach in the universe. My absolute goal is to take part in the Mars colonization plans as an engineer-astronaut and help advance the astronautical-engineering world. I will attend the University of Southern California in the fall.

Gloria Johnson, Brooke Point High School, Stafford, VA



I'm an aspiring aerospace engineer with the goal of changing the face of the fueling of aircraft. I grew up as a military child and was born to immigrant parents from Liberia. As we constantly relocated, I found a love for flying and aircraft. Because I grew up with a more global perspective, due to my cultural background and constant relocation, I wanted to ensure that I was also learning from a holistic approach. To achieve this objective, I applied and was accepted into the International Baccalaureate (IB) Program at my high school. IB is an academically extensive program that requires students to be well rounded in their academics and extracurriculars. While in high school, I also participated in the Virginia Aerospace Science and Technology Scholars Program (VASTS), which further inspired me to reach my goal of becoming an aerospace engineer.

In pursuit of becoming an aerospace engineer, I have accepted a summer NASA Internship prior to beginning college. I will attend Washington & Jefferson College in fall 2021, and participate in its dual-degree program with Case Western Reserve University where I will receive bachelor's degrees in Mathematics and Aerospace Engineering. I am thankful for this scholarship, which will assist in supporting my education to help me reach my goals. This investment is not only a blessing to me and my future but will also impact my contributions globally through Aerospace Engineering. Thank you for this opportunity!

Applications for the 2022 Roger W. Kahn Scholarships will open 15 August 2021. AIAA again will award up to four $10,000 scholarships to high school seniors who enroll in an accredited college or university and intend to pursue an aerospace or STEM major. A $2,500 travel stipend will also be given for the students to attend an AIAA event such as AIAA SciTech Forum, AIAA AVIATION Forum, or ASCEND. The Institute will provide each student with a mentor from AIAA's professional members to help guide the student to achieve a career in aerospace. Underrepresented students are encouraged to apply. For more information, visit aiaa.org/get-involved/k-12-students/scholarships or email K-12STEM@aiaa.org.

National Capital Section Presents Future City 2021 Special Award

By Bruce Cranford

What a year! The Covid pandemic presented new challenges to the Future City organizations and teams. They were successful in reorganizing and conducting a very successful Future City 2021 Competition and Awards. On 13 March, regional Future City winners from 44 middle schools, afterschool organizations (e.g., scouts, 4H, boys/girls clubs) nationwide and China to Nigeria, participated in the Future City National Finals. The Special awards judging were done remotely, via Zoom, while meeting local and regional Covid pandemic restrictions. This presented special challenges to foreign teams, many time zones away from the judges located in the United States.

In its 29th year, this year's Future City theme was "Living on the Moon." Middle school students were asked to create cities of the future, first on a computer and then as large tabletop models. Working in teams with a teacher and volunteer engineer mentor, students create their cities using the SimCity 3000 TM video game donated to all participating schools by Electronic Arts, Inc. Students wrote an abstract and an essay on using engineering to solve an important social issue. Then they presented and defended their cities before engineer judges at the competition. More than 45,000 students from more than 1,350 schools participated in the 2020–2021 competition.

The students created detailed – often fantastic – cities of tomorrow that give intriguing insight to how young minds envision their future. At the same time, their bold designs and innovative concepts provide a refreshingly optimistic appreciation of how our nation can realistically deal with the many challenges facing its cities, including the power of public spaces.

As part of the Future City's program, the AIAA National Capital Section (NCS) presented the 19th annual Special Award for the Best Use of Aerospace Technology to Morgan Fitzgerald Middle School Center for Gifted Studies from the Tampa Bay, FL, region. Future City Name: Selene. Team Members: Megan Pace, Kassidy Farrar, Lily Meloy, Laura Meyer. Educator: Peter Scalia. Mentor: Diana Wolff. The AIAA NCS congratulates the team for their outstanding efforts. Nitin Raghu, NCS Chair and Space Product Manager Technical at Amazon Web Services, presented the award on 7 April at a virtual awards ceremony conducted by Future City. Each student team member received a savings bond and a plaque. The AIAA NCS thanks the NCS judges for the Best Use of Aerospace Technology: Ananthakrishna (Sarma) Sarma, Lt. Col Anna Gunn-Golkin, and Sri Ayyalasomayajula.

For more information and a list of all the winners, visit futurecity.org.

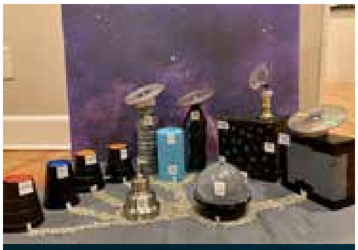


Figure 1: Tabletop model of the Selene Future City.

Figure 2: AIAA NCS judges: (pictured top left and right) Nitin Raghu, NCS Chair; Ananthakrishna (Sarma) Sarma, Technical Fellow at Leidos; (bottom left and right) Sri Ayyalasomayajula and Lt. Col. Anna Gunn-Golkin, USAF.

Photographs by Bruce Cranford

AIAA New England Section 2020/2021 Honors and Awards

The AIAA New England Section honored 12 individuals for sustained achievements and three for special service for 2020/2021. The sustained achievement awards follow the 10-year criteria used at the national level for our section-level activities, while the special service awards celebrate activities over a more-concentrated time period.

Members recognized for sustained achievements:

John Blandino
Hsiao-hua Burke
Ian Dargin
Deborah Douglas
Sheryl Grace
David Guo
Philip Hattis
Col. Douglas Joyce
Bruce Mackenzie
Albert Moussa
Gene Niemi
John Wilkes

Members recognized with special awards for outstanding service:

Yari Golden-Castaño
Hiroaki Endo
Martina Stadler

Kammeyer Receives AIAA Special Service Citation

Mark Kammeyer, AIAA Associate Fellow and St. Louis Section Chair, recently received AIAA's Special Service Citation for outstanding leadership in the development of the St. Louis Section's Policies and Procedures. Not only will the documentation provide valuable reference for how the section conducts business and its roles and responsibilities, but it has been a model and served as a benchmark across all sections. The Special Service Citation is an AIAA nationally recognized award for service that goes above and beyond at the local level.

Obituaries

AIAA Senior Member Moorman Died in June 2020

General Thomas S. Moorman Jr., USAF (Ret.), died 18 June 2020. He was 79 years old.

Moorman began a distinguished 35-year Air Force career after graduating from Dartmouth College in 1962. He served as an intelligence officer with the B-47 bombardment wing, the Director of the Office of Space Systems, Vice Commander of the 1st Space Wing, several staff positions at Air Force Space Command, and numerous operational and staff positions in space, aircraft reconnaissance, and intelligence units.

In 1987, Moorman became Director of Space and Strategic Defense Initiative Programs where he directed the development and procurement of satellites, launch vehicles, antisatellite weapons, strategic radars, and space command centers. From 1990 to 1994, he served as vice commander and commander of Air Force Space Command, responsible for the operation of the Air Force space systems, space surveillance radars, and the ICBM force. Moorman 's last military assignment was as Vice Chief of Staff of the Air Force. From July 1994 until his retirement in August 1997, he oversaw and managed the day-to-day activities of the Air Staff, chaired the Air Force Council, and was the Air Force representative to joint and interagency organizations, including the JROC and Quadrennial Defense Review.

After retirement, Moorman served until 2008 as senior executive advisor and partner with Booz Allen Hamilton, responsible for the firm's Air Force and NASA business. He remained engaged with numerous boards and studies, including the congressionally directed Space Commission. He also served on space-related studies and task forces on behalf of the Department of Defense, U.S. intelligence community, and the National Oceanographic and Atmospheric Administration.

Moorman was the 1998 winner of AIAA's von Kármán Lecture in Astronautics Award.

AIAA Associate Fellow Leithiser Died in March

Major General (Ret.) Richard E Leithiser, 91, died on 29 March.

Major General Leithiser was a a Distinguished Military Graduate of the Virginia Military Institute, Class of 1950B, and an Honor Graduate of the Army Command and General Staff College. Following his Army active duty tour in 1950, he served for many years in the U.S. Army Reserve, retiring as a Major General in 1989. He held numerous command and staff assignments, retiring as the Commanding General of the 79th Army Reserve Command. He received the Army Distinguished Service Medal and several other medals and awards.

Major General Leithiser held several challenging engineering and management assignments during his 34 years with the General Electric Company's Missile and Space Division, in an era spanning from Sputnik to the early design phases of the International Space Station. He was an Eagle Scout, an AIAA Associate Fellow, a member of the Military Officers Association, the Reserve Officers Association, the Association of the U.S. Army, the Society of the Cincinnati, and a Registered Professional Engineer in Pennsylvania.

AIAA Associate Fellow Lin Died in April

John C. Lin died on 9 April. He was 64 years old.

He grew up in Taiwan until his family moved to Washington, DC, in 1970, and began an unparalleled 43-year career at NASA Langley Research Center in 1978.

Lin's career at NASA Langley Research Center was marked by incredible innovation in flow-control technology that embodied NASA's mission to discover, explore, develop, and enable. He made an extraordinary impact with his research on advancing the U.S. commercial and defense industries. As an

internationally recognized authority in flow-control technology, his significant contributions cover the

entire spectrum of technology development, from fundamental research to important applications on

aircraft and marine vessels.

Lin worked on many different projects with aerodynamic and hydrodynamic applications during

his tenure at NASA, and his contribution to the development of micro vortex generators has found the

widest impact in the field as an inexpensive, effective means of reducing flow separation. Using this

technology, Lin helped aircraft manufacturers expand flight envelopes and controllability of their aircraft. The innovation also resulted in 50 national and world records, as well as the Collier Trophy. By solving

performance problems, he enabled sales of over $2.4 billion by accelerating the introduction of aircraft into the market earlier than planned.

Lin's commitment to fundamental science extended to advancing national security as well. He also worked with Newport News Shipbuilding to provide valuable assistance to Northrop Grumman and the Navy through his support of the Advance SEAL Delivery System. His willingness to provide hands-on assistance, operate effectively within a multi-organizational team, and brilliant technical performance under tough testing conditions led to an affordable, low-impact design modification that exceeded the Navy's expectations.

In addition to distinguished accomplishments as an engineer and scientist, Lin was extremely active in the local AIAA Hampton Roads Section (HRS), where he served in a number of leadership positions, including the Section Chair, as well as newsletter editor for 14 years (which won the section a first place Communications Award in the annual Section Awards). His work as the AIAA HRS Representative to the Peninsula Engineers Council allowed him to reach far beyond the aerospace community, where his positive attitude and ever-present willingness to lend a hand where needed was an inspiration to his colleagues. His involvement with the Langley Toastmasters inspired the admiration and respect of many, and his affinity for tall tales garnered state recognition and a feature in a Daily Press article entitled "He's No Stuffy Scientist."

Over the course of his career, Lin received 72 professional honors and awards, including: NASA

Distinguished Service Award,
Best Paper Award from AIAA Applied Aerodynamics Technical Committee, the NASA Exceptional Engineering Achievement Medal, Peninsula Engineer of the year, AIAA Region I Engineer of the Year Award, NASA Engineering and Safety Center (NESC) Engineering Excellence Award, and the AIAA Sustained Service Award. His work with the ERA project contributed to the team being awarded the Aviation Week Laureate Award for Technology and the ARMD Associate Administrator Award on Technology and Innovation.

AIAA Associate Fellow King Died in April

William (Bill) S. King died 19 April; he was 85 years old.

King received his B.S. in Mechanical Engineering from the University of California Berkeley. He received his Master's in Mathematics/Physics and his Ph.D. in Applied Mathematics/Physics and Engineering from UCLA. He had a background of over 40 years of aerospace engineering and was recognized nationally as an expert in the field of fluid mechanics. King worked at Rockwell International (Rocketdyne Division), The Aerospace Corporation, and the Rand Corporation.

While working at the above research institutions, King also worked part-time in the Mathematics Departments at Santa Monica Community College and Los Angeles City College. He taught math, fluid mechanics, and heat transfer at UCLA. and California State University at Northridge. He was also a member of Sigma Xi, the scientific research honor society.

CONTINUED FROM PAGE 64

and predictable. There needs to be an agreed upon digital twin and library of this domain in order to support decision-making. To be sure, pulling this off will be thorny because of the complexities of the space domain as compared to the binary world of the Soviet Union and United States during the Cold War. A growing number of participants in the space sector today make decisions alone without knowing the decision-making criteria of others. They face conflicting evidence, have competing interests, and operate in an environment plagued by non-linear consequences and unknown interdependencies.

At the University of Texas at Austin, where I teach, I led the development of ASTRIAGraph, a database that eventually will become a comprehensive and robust participatory sensing network, like the Waze app for road traffic. Right now, an initial community of space users share information with each other via ASTRIAGraph, but as this community grows, the database will provide an unprecedented means of sharing knowledge, including the intent behind specific actions. Participants will be able to ask questions of each other, much like the Soviet Union did when I was at Malmstrom. As it exists now, ASTRIAGraph is a credible first step toward the needed digital twin and library. "Our" motto is the Latin "Nihil arcanum est," which loosely translates to "nothing hides." The space operator community is already benefiting from an increased ability to prevent any single entity from biasing or prejudicing opinions about what has, could or is happening in space.

Back when I was a missile cop, I could have never imagined that many years later I'd be motivated by my experiences of the Cold War and applying these toward making space safer, more secure and sustainable. The global space operator community must avoid assuming things are threats just because assuming malicious intent is easy to ascribe through prejudice. Harmony can be achieved in space, not by assuming the worst in others, but by working inclusively to develop protocols and practices leading to transparency and confidence building measures. ★

LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1921

1 **June 8** The first flight of a pressurized cabin airplane, the Engineering Division USD-9A, is flown by Army Air Service pilot Lt. Harold R. Harris. The aircraft is a highly modified version of a de Havilland DH-9 fitted with a pressurized cockpit. Eugene M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 13.

2 **June 15** Bessie Coleman obtains her license from the Federation Aeronautique in Paris, thus becoming the first African American female aviator. Born into a poor family in Texas in 1892, Coleman became interested in aviation during World War I but faced discrimination in seeking to become a pilot in the U.S. and went to France where she attended flying school. **Air & Space Magazine**, September 1994, pp. 54-58.

June 28-29 Lawrence Sperry conducts the last tests of his Aerial Torpedo, this time for the U.S. Army at Mitchell Field on New York's Long Island. He added radio control in the last phases of the tests and the torpedo hits the target twice at 27 meters, three times at 100 kilometers and once at 145 kilometers, although the system requires a lead aircraft with a radio transmitter to fly a kilometer or more from the torpedo all the way to the target. Neither the Army nor Navy develops it further. William Davenport, **Gyro!** pp. 215-218.

1946

June 20 Britain and Australia agree to establish a permanent rocket-testing station in Woomera in the southwestern Australian desert. In 1971 Woomera also serves as the launch site for Britain's first satellite, when a Black Arrow rocket orbits the Prospero X-3. **Flight**, June 20, 1946, p. 634; F.H. Winter, **Rockets into Space**, p. 108.

3 **June 22** The W.9, the first British helicopter with jet assistance, makes a surprise appearance at the Southampton Air Pageant. Produced by Cierva Autogiro Co., the W.9 is powered by a D.H. Gipsy Six engine, which drives a compressor to form an anti-torque jet thrust instead of the usual anti-torque rotor. **The Aeroplane**, June 28, 1946, p. 747.

June 24 The U.S. Office of Naval Research approves Project Helios, in which clustered balloons are to be used for upper atmospheric research, particularly for the study of the sun's interaction with Earth. The project is based on a concept by Swiss balloonist Jean Picard. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 54.

June 28 Using Avro Yorks and Lancastrians, British South American Airways begins a service that will run three times a week from Britain to South America. The Yorks can carry 21 passengers and the Lancastrians 14. **Flight**, June 20, 1946, p. 628.

1971

June 1 NASA announces a joint U.S.-Canadian program to fly satellites and aircraft to survey the natural world. The objective is to advance remote sensing technology for monitoring air, water, land, forest and crop conditions; and for mapping ice movements; ocean currents; and geological, hydrological, vegetation and soil phenomena. **NASA Release 71-95**.

June 1 British aviator Sheila Scott departs from London Airport in a twin-engine Piper Aztec for a 55,000-kilometer flight around the world one and a half times during which her pulse, breathing, voice, brainwaves, mental alertness and other bodily functions are to be relayed via the U.S. Nimbus 4 satellite to a ground station in Fairbanks, Alaska, and then to computers at NASA's Goddard Spaceflight Center in Maryland and the United Kingdom's Institute of Aviation Medicine. **Chicago Tribune**, June 2, 1971.

June 6 The Soviet Union's Soyuz 11, carrying cosmonauts Georgi Dobrovolsky, Vladislav Volkov and Viktor Patsayev, is launched from the Baikonur Cosmodrome to dock with the Salyut 1 space station. However, when the Soyuz 11 returns to Earth after the crew's record-breaking 24 days in orbit, the cosmonauts are dead. An investigation determines an imperfectly sealed hatch caused the capsule to lose pressure during reentry. **Newsweek**, July 12, 1971.

4 **June 7** William O'Sullivan, who had conceived and developed the NASA Echo 1 communications balloon that was launched on Aug. 12, 1960, dies in Newport News, Virginia, at age 55. He had received NASA's Exceptional Scientific Achievement Award in 1961 and a National Rocket Club award for his contribution and use of lightweight inflatables for communications and air-density studies. **Washington Pos**t, June 8, 1971, p. C8.

June 10 The U.S. and the Soviet Union exchange lunar samples in a Moscow ceremony to mark the expansion of their cooperation in space. **New York Times,** June 11, 1971, p. 10.

Jun 24 Astronomers at Lowell Observatory in Arizona announce that have made the first accurate mapping of Mars weather as a result of worldwide cooperation among observatories in a NASA-funded ground-based planetary patrol program centered at Lowell. The program that began in 1969 shows Mars weather patterns are comparable to those in arid regions of Earth. NASA, **Astronautics and Aeronautics, 1971**, p. 174.

1996

June 4 The first Ariane 5 rocket is launched but it explodes 40 seconds into the flight, destroying four satellites of the Cluster System that were to measure the magnetosphere. A software problem in the guidance control is found to be responsible. The first commercial launch will be in December 1999 when the rocket places the European Space Agency's X-ray Multi-Mirror Mission observatory and two communications satellites into orbit. **New York Times**, June 5, 1996, pp. D1, D5; **ESA Press Release No. 37-97**.

5 **June 7** Rising 2,000 feet above the White Sands Missile Range in New Mexico, the experimental DC-XA completes its first flight. The uncrewed DC-XA is intended to replace the space shuttle as a reusable vehicle. Its ability to take off and land vertically is hoped to cut operating costs dramatically. NASA, **Astronautics and Aeronautics: A Chronology, 1996-2000**, pp. 22-23.

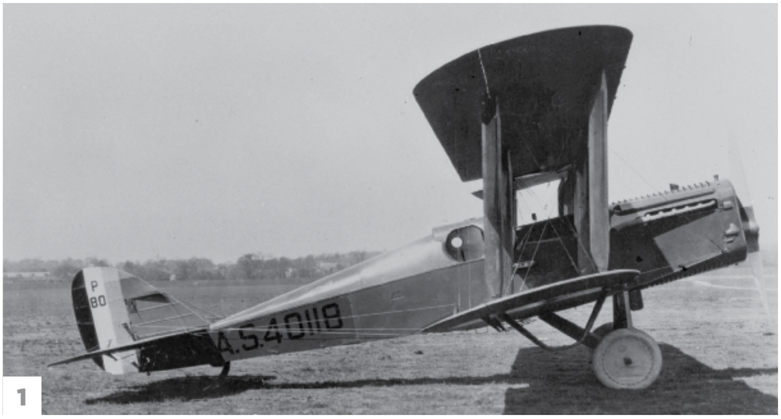
June 20 Mission STS-78 commences as space shuttle Columbia is launched from Cape Canaveral. The shuttle is carrying equipment from the Office of Life and Microgravity

Service to conduct experiments on human subjects concerning musculoskeletal physiology and the effects of microgravity on humans. NASA, **Astronautics and Aeronautics: A Chronology, 1996-2000**, p. 24.

6 **June 26-27** The Galileo spacecraft makes its closest approach to Jupiter's giant moon Ganymede. Galileo comes as close as 840 kilometers and produces photos of far greater resolution than previously obtained. A long geological fault and a surprisingly strong magnetic field are among the discoveries. **Aviation Week**, July 1, 1996, p. 17, and July 15, 1996, pp. 20-22.

During June 1996

Transaero Airlines, the first privately owned Russian airline formed after the fall of the Soviet Union, begins its first nonstop service between Los Angeles and Moscow. Transaero flies the McDonnell Douglas DC-10-30 on this route. The airline also has five Boeing 757s and an Ilyushin Il-86. **Aviation Week**, June 24, 1996, p. 17.



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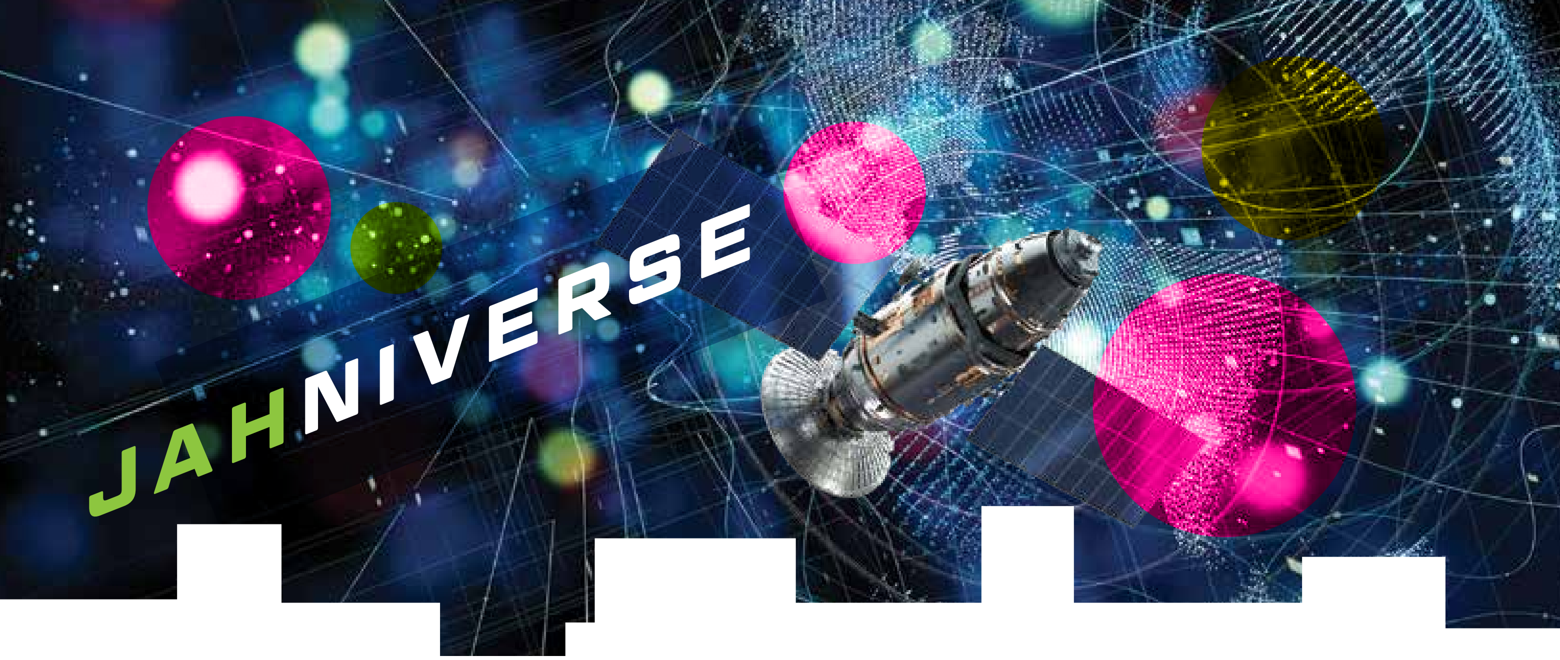

From nuclear cop to space cop

BY MORIBA JAH

On duty one day at Malmstrom Air Force Base in Montana as a security policeman, I cleared a maintenance crew to access one of the Minuteman missile sites out on the High Plains. It was sometime in the late 1980s or early '90s, a fascinating time to be at a nuclear missile base. I watched news clips of the Berlin Wall fall in 1989 and the Soviet Union and United States sign the Strategic Arms Reduction Treaty in 1991. Within hours of my clearing the maintenance crew, the Soviets inquired why the maintenance vehicle was different that day from the one that normally serviced that specific site.

I was amazed that for nukes, everyone knew where everything was, all of the time. This experience stuck with me as I became an astrodynamicist and space environmentalist. If this transparency existed in the space domain, our world would, likewise, be safer in important ways. There would be less risk of orbital collisions that could pollute low-Earth orbit for decades and less risk of nation-states miscalculating each other's intent.

As a missile cop, I was taught that a threat is the concurrent presence of three ingredients: opportunity, capability and intent to cause harm. Today, many technologies in space have the opportunity and capability to interfere with satellite services such as military and civil communication or Earth observing for weather forecasting or reconnaissance. The difficulty is inferring the intent of an actor. Right now, space actors lack the kind of detailed information that the Soviet Union must have had about Malmstrom. They also lack an easy way to ask other actors about changes, like that new vehicle at Malmstrom. This situation is concerning, given the escalating rhetoric and actions in space by China, Russia and the United States in recent months and years. Russia has accused the United States of engaging in threatening behavior, and the United States has accused Russia of doing the same. China is allegedly developing space weapons. France and the United Kingdom are developing their own versions of the U.S. Space Force.

Space-faring nations set themselves up for the potential calamity when they make malicious intent their null hypothesis or default belief. To reduce risk of miscalculation, these nations, with input from their commercial satellite operators, must jointly establish operational protocols and practices that will make actions in the domain more transparent

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