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JET FUEL FROM SMOKESTACKS

One company's journey to a sustainable aviation fuel for the growing demand PAGE 14

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14

Jet fuel from smokestacks

Chicago-based LanzaTech is turning gases emitted from steel mills into sustainable aviation fuel. Its technology, which includes bacteria from rabbit intestines, could help to produce SAF for airlines in much higher volumes than has been possible previously.

By Keith Button

26

Suborbital scrapbook

Virgin Galactic's and Blue Origin's flights had more in common than just billionaire benefactors, but the technology set each trip apart.

34

Certifying urban air mobility aircraft

Dozens of startups are going to market with electric vertical takeoff and landing vehicles they say can be inherently safer than conventional helicopters.

By Paul Marks

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AIAA SHAPING THE FUTURE OF AEROSPACE

IN THIS ISSUE

Keith Button

Keith has written for C4ISR Journal and Hedge Fund Alert, where he broke news of the 2007 Bear Stearns scandal that kicked off the global credit crisis.
PAGE 14

Cat Hofacker

As our staff reporter, Cat covers news for our website and regularly contributes to the magazine.
PAGES 9, 10, 20

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.
PAGE 64

Paul Marks

Paul is an award-winning journalist focused on technology, cybersecurity, aviation and spaceflight. A regular contributor to the BBC, New Scientist and The Economist, his current interests include eVTOL aircraft, newspace and the history of notable inventors — especially the Wright brothers.
PAGE 34

DEPARTMENTS

CALL FOR TECHNICAL BRIEFINGS

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19–21 APRIL 2022 | LAUREL, MD

TOPICS

- Advanced Prototypes
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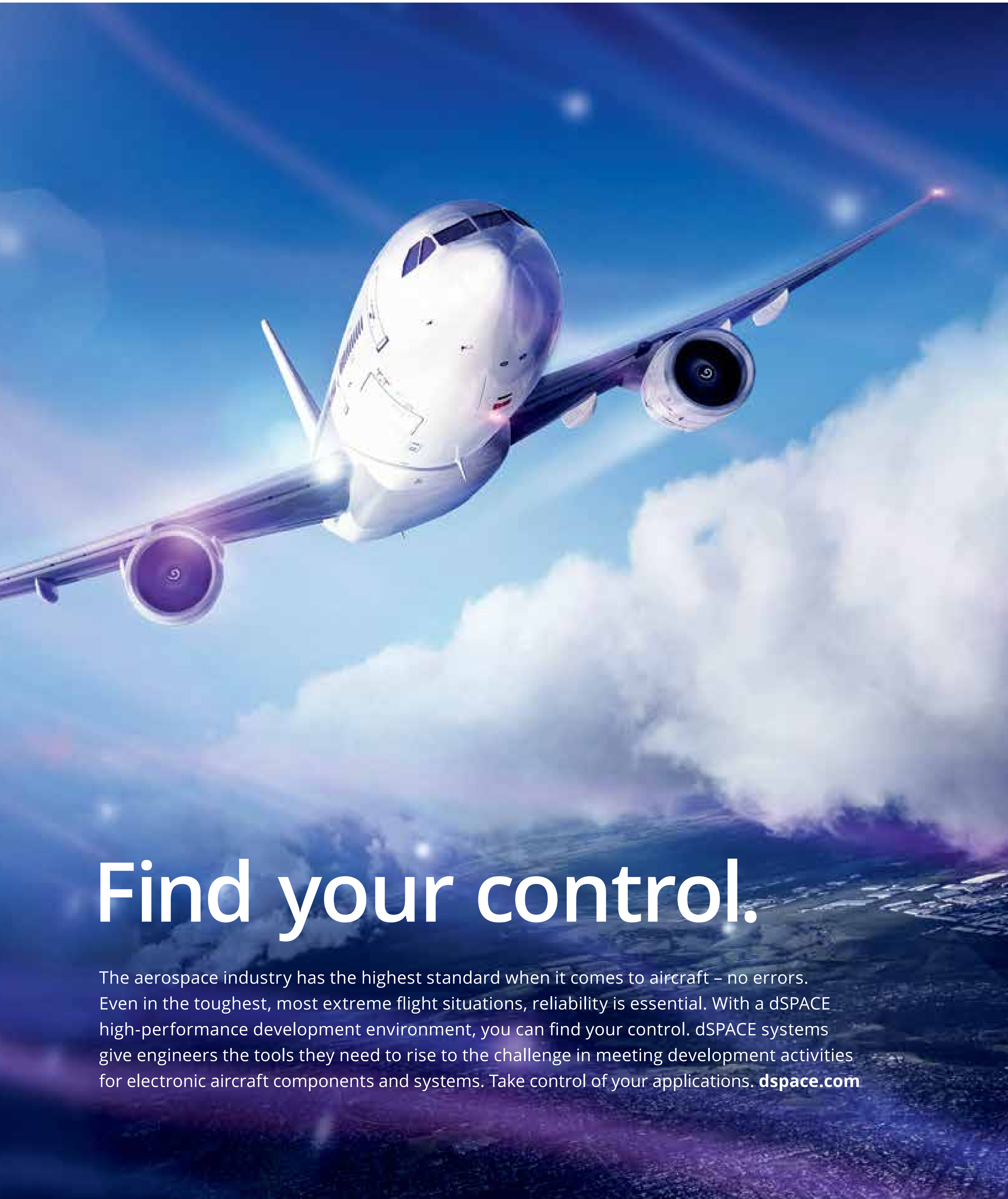


Building the Future Through Excitement and Inspiration

In July, the AIAA Foundation received a $1 million grant from Blue Origin's Club for the Future. As we announced at the time, this generous gift will allow the AIAA Foundation to fuel the next generation of space professionals who will create our off-world future. It is a valuable and important next step in the work of the Foundation and builds upon other gifts to the Foundation from its corporate partners, The Boeing Company and Lockheed Martin, as well as the gifts, resources, and support of all sizes received from AIAA corporate and individual members.

At AIAA, we work daily on shaping the future of aerospace. The programs of the AIAA Foundation help us do that by inspiring young people to pursue careers in aerospace. For 25 years, the AIAA Foundation has impacted countless students and educators due to the generosity of our members and creativity of our partner organizations. This inspiration is vital to the future of our industry. It's a tremendous way for AIAA members to help pay it forward.

It is essential to continue attracting and retaining the skilled, diverse 21st-century workforce who will lead the aerospace industry into the future. However, we face a skills gap in this future group of dreamers and leaders due to significant hiring and retention challenges (see description of the challenges in 2021 AIAA Key Issues document: aiaa.org/advocacy/Key-Issues). AIAA believes we must enable a diverse and robust STEM workforce pipeline, and support workforce development for all skill types and career stages to advance learning commensurate with technology and product advancement. Today's students will tackle tomorrow's challenges and lead innovation in the 21st century.

This challenge is precisely what the AIAA Foundation is set up to address. The AIAA Foundation leads programs and forms partnerships that ignite the fuse of K-12 students and equip educators who shape young hearts and minds. Their work spans the three domains AIAA is organizing around in the coming year – Aeronautics, Space, and Aerospace Research and Development (R&D). The AIAA Foundation's programs are designed to support the students – who will make up the teams – who will become the most technically proficient, professionally equipped, culturally diverse, AND successful workforce on the planet. I am confident they will take us in directions we may never have dreamed.

From scholarships, to design competitions, to technical papers, to conferences and forums, the Foundation is working daily to turn financial contributions into meaningful activities that propel aspiration into career success. Yet, what else could we do to inspire and educate our successors? Our community excels when we collaborate. We need your input, ideas, and contributions.

> "Today's students will tackle tomorrow's challenges and lead innovation in the 21st century."

Back to inspiration – I'm curious what inspired your own career journey. I know the source of my inspiration, the date and the time. On February 20, 1962, I watched John Glenn on a black and white TV do something no one else in America had done yet. (My mother claimed I had seen the previous launches too!) From then on, my curiosity was sparked and I followed the first building blocks of the U.S. space program being assembled. My high school and college studies led me to an internship at NASA Marshall Space Flight Center in Huntsville where I could do more than watch – I got involved and added my personal contributions to the Space Shuttle program as it progressed. The rest is history. And history is still being made in our industry by our community's shared pursuits of space – and aeronautics – and aerospace R&D.

During this anniversary year, help us make the next 25 years of the AIAA Foundation even more impactful than the first 25 years. Get involved with the AIAA Foundation. Together we will make a lasting impact on our profession, our industry, and our society.

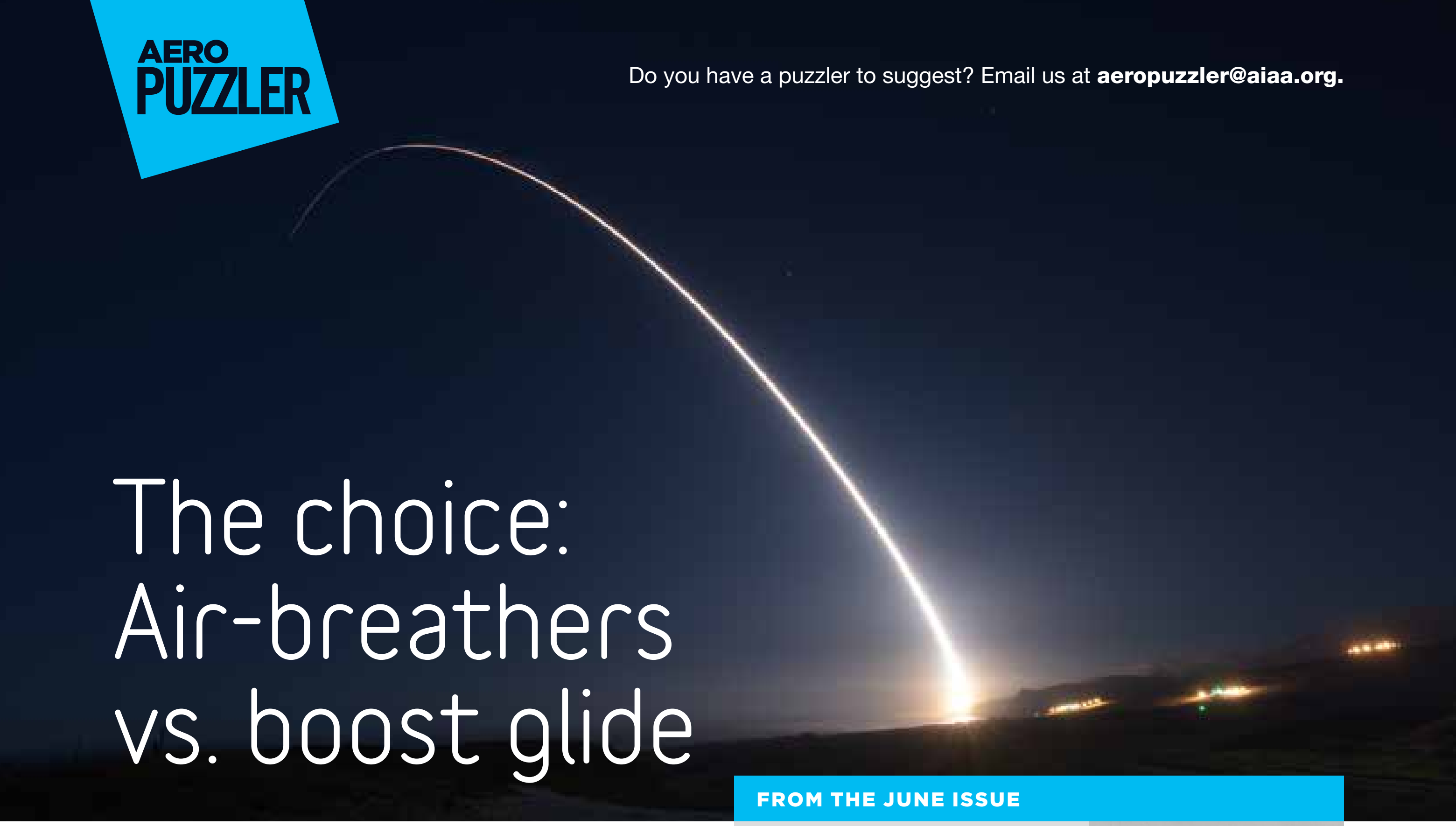
Let's build the future, together! ★

Dan Dumbacher
AIAA Executive Director

See page 53 for more information on how AIAA is making an impact on and inspiring the next generation of aerospace professionals.

AERO PUZZLER

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



The choice: Air-breathers vs. boost glide

Q. Your friend the novelist has asked you to finish the climactic scene of a thriller. The story is set in the near future, and centers on a nuclear weapon that's gone missing and is designed to deliver lethal radiation via the winds upstream of a target. The climax begins with the CIA director telling the president that the weapon has been located aboard a container ship in the Pacific Ocean. Terrorists are minutes away from exploding the weapon to deliver lethal fallout along the West Coast. No U.S. or allied warplanes or vessels are in range. The president faces a choice: Her party forced hypersonic air-breathing weapons through Congress, and the opposition party did the same for rocket boosted glide versions. Neither party funded operations adequately, and so only one kind of weapon can be launched at a time. The president asks about launching the air-breathers. The political appointees nod, but one general's back stiffens: "Madam President, due to the time constraint, boost glide is the only choice we have." What should happen next to save the West Coast?

FROM THE JUNE ISSUE

CLAIMING AN AVIATION FIRST: We asked you to explain, based on a question submitted by Lone Star Analysis, a software, technology and system engineering firm, why there's some debate over who should be deemed the first U.S. naval aviator.

WINNER: Both Eugene Ely and Ted Ellyson were groundbreaking naval pilots during the early days of aviation. Eugene Ely was the first aviator to take off and land on a ship. He is considered the father of naval carrier aviation. However, he was not the first naval pilot. That honor goes to Ted "Spuds" Ellyson. While his first flight in January 1911 resulted in a crash landing on a wing, he would earn pilot certificate No. 28 later in the year and the U.S. Navy would eventually name him Naval Aviator No. 1. Ironically, both of these aviators perished in aircraft crashes — Ellyson in 1928 at age 44 in a crash in the Chesapeake Bay and Ely in October 1911 at age 25, during an exhibition in Macon, Georgia.

Thomas "Tav" Taverney
Taverney is a retired U.S. Air Force major general and an AIAA senior member who lives in La Habra Heights, California.

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

For a head start … find the AeroPuzzler online on the first of each month at https://aerospaceamerica.aiaa.org/ and on Twitter @AeroAmMag.

Mach 5 air travel? Start your engines

BY CAT HOFACKER | catherineh@aiaa.org

Speed dictates everything about a hypersonic aircraft, from the materials and shape of the plane to the engine designs required to achieve and maintain combustion at five times the speed of sound. Hermeus of Atlanta is also letting that need for speed shape the strategy of its initial flight campaign.

The startup on Aug. 5 announced plans to build and fly in succession three remotely piloted aircraft by the end of 2024, a step toward proving the design for a planned Mach 5 passenger plane that is among the handful of high-speed airliners in development by U.S. companies and, reportedly, China. The test campaign will be partially funded by a $60 million U.S. Air Force contract awarded in July, part of an ongoing assessment of how Hermeus' design could be modified for purposes including ferrying high-ranking U.S. officials.

Hermeus calls the test aircraft design Quarterhorse, because the short bursts of speed for which the American quarter horse is famous represent the learning Hermeus expects to achieve when each plane flies.

The Quarterhorse design "really serves as a flying demonstration of our engine," says Skyler Shuford, Hermeus co-founder and chief operating officer. "It's the smallest vehicle that we can wrap around our engine to prove that the engine works across the full flight range."

At about 12 meters long, slightly bigger than a Cessna, each single-engine Quarterhorse plane would be smaller than the planned 20-passenger jet. And because the demonstrators don't require life support systems and other features necessary for piloted aircraft, Hermeus can build the Quarterhorses more quickly and inexpensively.

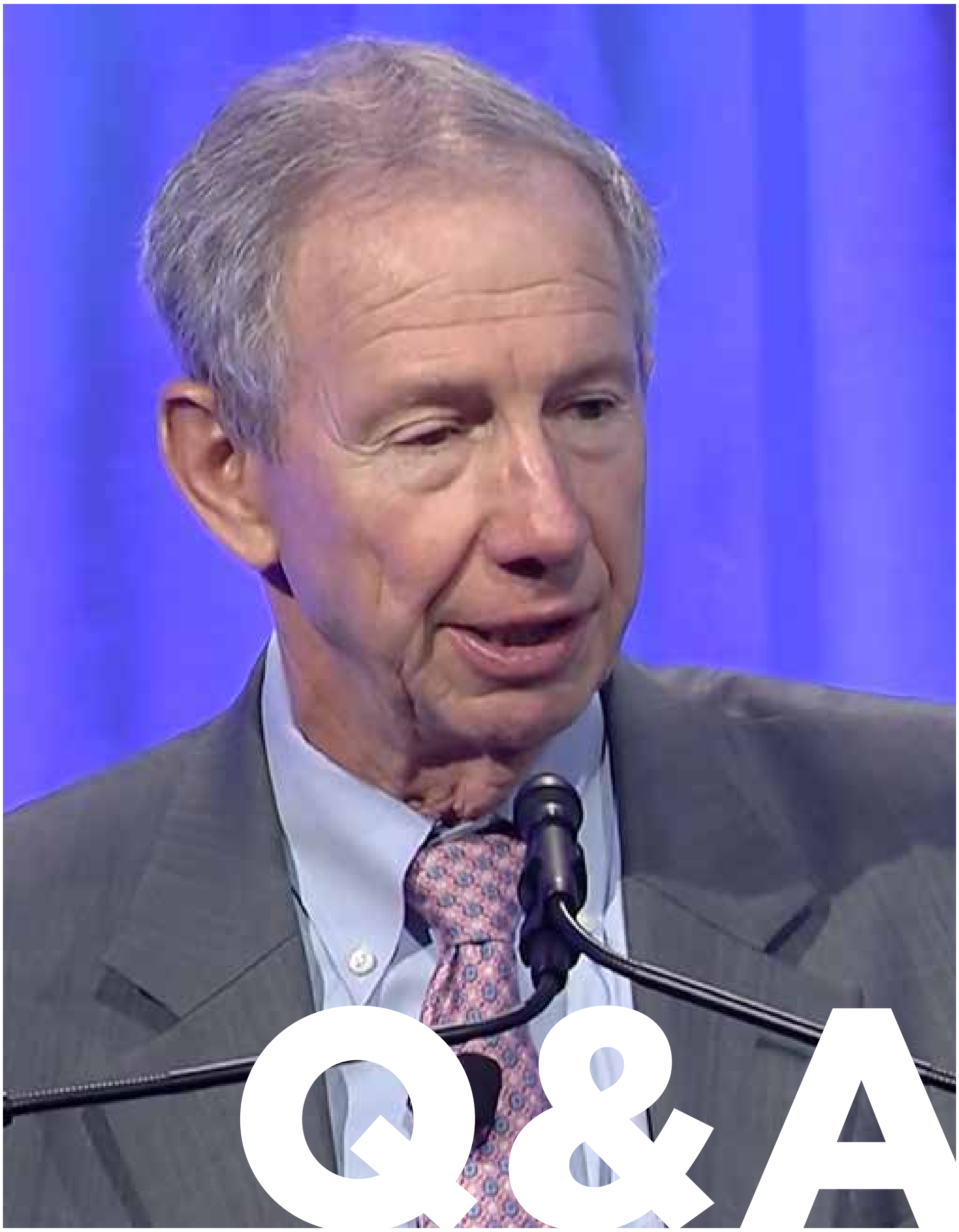
Hermeus plans to begin flying the first Quarterhorse in late 2022 at a location still to be determined, gradually increasing the aircraft's speed to Mach 5. Among the major challenges is proving that Hermeus' turbine-based combined cycle, or TBCC, engine design can maintain combustion at supersonic speeds. TBCC designs pair conventional turbine engines — in this case, Hermeus is using off-the-shelf GE J85s — with ramjet engines, which Hermeus is custom building in house out of a proprietary alloy. Engineers in August began assembling ramjet components at the company's Atlanta headquarters.

At subsonic speeds, compressor blades in the turbine portion of the engine will compress incoming air for combustion, but once the plane reaches Mach 3, the air will flow too fast for the blades to compress it. So the engine must switch to ramjet mode, in which air entering the inlet is slowed and compressed via shock waves produced by the aircraft's speed.

Maintaining a steady air stream around Mach 3 has been tricky for previous high-speed aircraft. Former pilots of the U.S. Air Force's SR-71 Blackbird reconnaissance planes in memoirs have recounted unstarts, or temporary engine stalls, from sudden shock waves produced by increased air pressure inside the inlet.

"It's one thing to have a bunch of paper designs, but you really have to start building hardware and integrating it and then testing it to really understand what's happening in these more exotic untested flight regimes," Shuford says. ★

▲ GE J85 engines in Hermeus' Atlanta headquarters. Over the next year, engineers will assemble and install ramjet components to these turbine engines for Quarterhorse test flights.
Hermeus



Independent voice

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Mike Griffin worked on the Strategic Defense Initiative during the Ronald Reagan and George H.W. Bush years, ran NASA for President George W. Bush, and was in charge of research and development at the Pentagon for much of the Donald Trump administration. While Griffin's time at these agencies has come and gone, the Defense Department and NASA continue to grapple with the topics that dominated his tenure. Now that Griffin is an independent consultant in Virginia and Alabama, it seemed like the right time connect with him on Zoom to talk about China, space launch and the early universe. — *Ben Iannotta and Cat Hofacker*

MIKE GRIFFIN

POSITIONS: In June 2020, co-founded LogiQ (pronounced "logic") with Lisa Porter, a former Pentagon and NASA colleague, to provide strategic advice to technology companies; under secretary of defense for research and engineering, February 2018-June 2020; AIAA president 2012-13; NASA administrator, April 2005-January 2009; head of the Space Department at Johns Hopkins University Applied Physics Lab, 2004-05; president of In-Q-Tel, the CIA-funded nonprofit investment company, 2002-04.

NOTABLES: In the Trump Pentagon, elevated hypersonic weapon research to a top priority; as NASA administrator, oversaw the space shuttle's return to flight after the disintegration of the Columbia orbiter in 2003; and started the George W. Bush administration's Constellation moon program, later reborn as the Space Launch System rocket and Orion crew capsule efforts; at the Johns Hopkins University Applied Physics Lab, helped design Delta 180, a 1986 Strategic Defense Initiative experiment in which a Delta rocket's second stage was intercepted by a Phoenix missile in a test of tracking and seeker technology for space-to-space weapons; licensed pilot and owner of a Beechcraft Bonanza.

AGE: 71

RESIDES: Arlington, Virginia, and Madison, Alabama

EDUCATION: Bachelor of Arts, Physics, Johns Hopkins University, 1971; Master of Science in Engineering, Aerospace Science, Catholic University of America, 1974; Ph.D., Aerospace Engineering, University of Maryland, 1977; Master of Science, Electrical Engineering, University of Southern California, 1979; M.S., Applied Physics, Johns Hopkins University, 1983; MBA, Loyola College, 1990; M.S., Civil Engineering, George Washington University, 1998.

Cat Hofacker: Let's start with the Space Launch System: It seems like the rocket's been in development so long that NASA has evolved into a different agency.

Mike Griffin: I think you're right. The agency seems to be evolving into a government bureau whose job it is to write checks to billionaire entrepreneurs. And while I have a great deal of admiration for billionaire entrepreneurs, writing checks to them or to other large prime contractors is not the proper function of government. The purpose of NASA was originally, and I think properly, to manage, to design, to orchestrate, to conduct, to carry out the publicly funded space program. SLS is an example of what NASA and other government agencies used to do: Lay out the requirements for something that you want. In this case, a heavy-lift launch vehicle to accomplish space exploration beyond low-Earth orbit. You run a competition and you hire a contractor to build it to your design, and the contractor is being paid public money to do a job in the public interest. So we've gone from that to an evolution where NASA competes a human lunar landing mission, and the contractors are not even being told what the specifications are, and they're not building to government direction. So in that kind of an environment, there really isn't a purpose for NASA.

C.H.: NASA's approach seemed to work well for Commercial Crew, considering the goal of ensuring access to ISS.

M.G.: I did not approve of Commercial Crew. And, oh, by the way, they're not commercial. A commercial enterprise is one in which a company develops a product or a service on their own dime, brings it to the market and sells it for whatever the market will bear. I was not in charge at the time and certainly had no voice in the decision, but speaking personally, I would have opposed any decision to turn the design of human-rated spacecraft over to industry to do as they wished. Because when it goes wrong — as I can tell you from the return-to-flight experience after the space shuttle Columbia — the appropriate government managers are the ones who will be held accountable, because it's publicly funded. It's not the industry CEOs. The money and the accountability have to go together, and when you try to separate those, it fails.

C.H.: What about the Commercial Orbital Transportation Services program you started as a precursor to Commercial Crew?

M.G.: We at NASA conducted an experiment to which we allocated $500 million to see whether cargo transportation to the space station could be provided by independent contractors crafting their own rocket designs. The experiment turned out positively because shortly before I left the agency in December of 2008, Bill Gerstenmaier signed the first actual commercial cargo contracts to SpaceX and what was then called Orbital Sciences. I think the contractors did it pretty well. That's not the same as saying that those same contractors are ready to provide the much more difficult solution to human space transportation. In my judgment, they weren't ready then, and since they didn't fly until 2020, I think that judgment turns out to be correct. So I would not have done Commercial Crew in the same way that commercial cargo was done. NASA funded the program and yet gave up a large measure of control over what the designs were going to be and how they would be carried out. I don't approve of such structures where public funds are involved.

Ben Iannotta: Here at Aerospace America we have a lot of conversation about what the word commercial means.

M.G: The term has been expropriated by a very large group of people who would like you to believe that because something is built by a nontraditional contractor, meaning a new entry into the field, that it's commercial. That's not the definition. Now look, I'm a huge fan of Christensen's disruptor thesis [a reference to the late economist Clayton Christensen, author of "The Innovator's Dilemma"] and the idea that new entrants to the field would come along and disrupt established prime contractors and set them back on their heels and make them rethink what they're doing, couldn't support that more strongly, but that's not the same as commercial.

B.I.: Aren't there now — or soon will be — truly commercial spacecraft like Starship that would be able to do basically what SLS would do?

M.G.: Maybe. We haven't seen Starship get higher than what? 10,000 feet. I hope for their eventual success. I'd like Starship to succeed. I'd like New Glenn to succeed. I'd like ULA's new Vulcan Centaur to come online. But the SLS was intended to be the taxpayer's vehicle for space exploration. As an analogy, we have lots and lots of commercial air transportation, but the Air Force operates Military Airlift Command [Now Air Mobility Command] on behalf of, ultimately, the taxpayer. If commercial enterprises don't want to do what you want them to do, or if they decide it's no longer in their interest to do so, well, there's still Military Airlift Command.

"I would not have done Commercial Crew in the same way that commercial cargo was done. NASA funded the program and yet gave up a large measure of control over what the designs were going to be and how they would be carried out. I don't approve of such structures where public funds are involved."

B.I.: A lot of taxpayer dollars are going into the Starliner service Boeing is creating, and yet the NASA-Boeing report about the aborted attempt to reach the space station has not been released. Would that be acceptable for a government-owned spacecraft?
M.G.: You're getting at the heart of my objection to labeling something as commercial and treating it from a government oversight point of view as if it is commercial, when in fact the funding is largely public funding. The government actually didn't have a right to get all of the data in question with the Starliner failure because of the way things were set up. Now, if Boeing were funding all of that on its own nickel, then I would say that the public has absolutely zero right to any knowledge of what goes on inside that program.

B.I.: How is that different from government insight into the crash of a Boeing plane?
M.G.: I think there's a bit of a different situation there with a transportation service, such as what airlines and railroads provide. We have determined in our society as an output of the democratic process that we want certain safety standards in transportation to be promulgated and enforced. So when common carriers breach those standards, yes, there is a legitimate public right of intervention through the appropriate agencies. That's not the same as if a company like SpaceX or Blue Origin or any other company wishes to create a private space transportation capability. Carrying paying passengers at their own risk is decidedly not a public utility. It's a joy ride. Now, if such an enterprise progresses to the point where one of these companies or a new company is offering to convey people from Chicago to San Diego by means of rocket travel — "we'll get you there in 15 minutes for a very high price" — now it becomes a public conveyance and it's going to be governed by the same safety standards as the National Transportation Safety Board imposes on other public conveyance.

B.I.: So on these suborbital flights, are you in the camp that thinks they're breaking new ground, or are they repeating what people like Alan Shepard did half a century ago?
M.G.: They have, in fact, not repeated, but done things in a different way. That's good. I'm hoping for more privately funded space transportation capability. That's great. To use an analogy, there was a time when the only computers in existence were built by governments. It's a good thing when things can transition from the only people who can build them are our government enterprises to you can buy it in the store.

B.I.: Do you think these space tourism flights will help open the space frontier?
M.G.: That's a little excessive. A suborbital flight would be a great, fun experience for somebody who can afford to pay for it. Good luck and good on them, but it's not within a loud shout of opening the space frontier. The design is not remotely close to what you need to get to orbit, because the energy difference between a suborbital flight, such as we saw a few weeks ago, and orbit is more than a factor of 50. Nonetheless, it's still a pretty impressive private accomplishment.

B.I.: How do you think this growing competition between the United States and China in deep space is going to play out?
M.G.: China under President Xi seems to be, I can only say, purposely picking fights with the West. To what point, I don't understand. It is adversarial behavior to build islands in what everyone else believes to be international waters. Many things that China is doing today seem to me pointlessly adversarial in a world that doesn't need more adversarial behavior. No one was picking on China when they were allowed into the World Trade Organization, two decades ago, and yet now China seems to be trying to pick fights with the West. So collaboration with China in deep space seems to me to be dependent more upon their behavior than ours. I would point out, the United States never declares anybody to be an adversary. We don't like having adversaries. We like cooperating with others as best we can. We do not pick fights with other countries. It's just not our history. In fact, you could argue that historically we've been late to need when confronting bad behavior.

B.I.: If you were to testify to Congress today, would you still warn as you did in 2018 that U.S. aircraft carriers are vulnerable, and the U.S. has no corresponding way to hold China at risk?
M.G.: That comment is still true, and now I think we're making progress toward fixing it. But you don't need me to talk about this and you don't need a classified discussion to talk about it. Just Google DF-21 or DF-26 and, and you'll find that they come up under the slang term of "carrier killers." That's what the Chinese designed them to do.

B.I.: So in hindsight, was it a mistake for the U.S. to focus so much on air-breathing propulsion with the X-43 and X-51 rather than trying boost glide right away?
M.G.: It's not an either-or thing. It's an "and" thing. The United States needs high-speed air-breathing, long-range strike for a variety of reasons, not least of which is that they are individually cheaper and you can greatly increase the load-out on ships and planes. I will always, until something better comes along, be a fan of high-speed air-breathing capability that we need to create for the longest ranges. And

▲ Griffin, then NASA administrator, in the Launch Control Center at Kennedy Space Center in Florida during a launch of the space shuttle Discovery in 2008,
NASA

for the most timely application of force, you need the rocket-powered boost glide. It will always be quicker on target than air-breathing strike, and we'll always have the capability for longer range.

CH: Let's talk about the Webb telescope. Will the fact that it is way behind schedule and over budget have a chilling effect on future ambitious concepts?

M.G.: That depends on when you take that view. I personally worked on Hubble, and when the telescope was put into orbit, there were congressional hearings and such about what a disaster it was because it was not competently done at first. And there was no other way to say it: NASA screwed up and the contractors screwed up and in a big way. Fast forward 30 years — the only people who think Hubble was a mistake were people who were in another branch of science and resented the money that went to Hubble. I had to deal with a lot of that at NASA. There were people who absolutely did not want another Hubble servicing mission because it was going to take money away from whatever it was they wanted to do. And I just didn't agree. Webb has had enormous development problems with obvious and visible lack of competence at times on the part of both the government and the contractor. Mistakes were made that shouldn't have been made. When you move a large telescope and nuts and bolts start falling out, somebody has clearly screwed up: There's no other way to put that. But if it is all fixed — and we won't know until it's launched — and if it works well, and if it reveals underlying new truths about how the universe is put together, then in 30 years, nobody's going to think it was a mistake.

CH: But tomorrow's telescopes are being designed today, so it seems like they will experience that chilling effect.

M.G.: They probably will. Webb got started for real either shortly before or during my tenure at NASA, and by that time Hubble had proved itself to be an enormous success. Could you have started another big telescope earlier had Hubble been a success from the first? Sure. So yeah, there will be a penalty to be paid by others in the astronomy community for the performance on Webb. ★

JET FUEL FROM SMOKESTACKS

The air transport industry lacks enough suppliers of bio-based sustainable aviation fuel to meet the anticipated demand as airlines become more aggressive about reining in their carbon footprints and more travelers take to the air. Keith Button describes one company's unique approach to meeting the demand.

BY KEITH BUTTON | buttonkeith@gmail.com

The visuals aren't attractive — a kind of bacteria found in rabbit intestines and gases from steel mills — but a sustainable aviation fuel made from these could prove very attractive to airlines in the coming months and years.

Most companies in the emerging field of SAFs make these synthetic kerosene fuels from used cooking oil, agriculture residue or other waste. The downside of those feedstocks is the variability of their composition, which reverberates through the production process. So, LanzaJet, a 2020 spinoff of the LanzaTech renewable fuel company founded in New Zealand 16 years ago, plans to start selling a SAF made indirectly from steel mill emissions, possibly as soon as next year.

If LanzaJet succeeds, the new SAF, already among the eight approved by regulators around the world, could help satisfy the growing demand among airlines for sustainable fuels. These fuels reduce the carbon footprint of air travel by recycling carbon that's already in the environment, and they are increasingly sought after by airlines looking to reduce their climate impacts.

Steel mill flare

The LanzaJet story starts in 2001 when British molecular biologist Sean Simpson moved to New Zealand from Japan to work for a forestry company. At the time, the United States and other nations were on a push to increase ethanol production as an additive for gasoline, and Simpson's job was to research how wood might be efficiently turned into ethanol.

Simpson soon came to realize that wood wasn't a viable feedstock for ethanol.

"Ultimately, you're probably turning gold into silver by turning a tree into fuel," Simpson tells me. "You need feedstocks that are available, and volumes that have already been aggregated that are extremely cheap," he says.

He talked matters over with his boss and friend, fellow molecular biologist Richard Foster, who died in 2014. Together they decided that waste from farms, household garbage or industry would be a better feedstock for ethanol production. So in 2005, they started their company, LanzaTech, in New Zealand to capitalize on that potential. They chose the word Lanza, "spear" in Spanish, to represent the company's mission of spearheading new technology.

Waste was cheap and available in large quantities, but they discovered that superheating the waste into gases as a precursor to renewable fuels delivered

inconsistent results due to the material's varied composition. Those gases had to then be converted to liquid fuel, and the results of that conversion, accomplished with the aid of metal catalysts, also produced inconsistent results. Simpson and Foster looked to bacteria as a possible solution, knowing that some strains could ingest a variable mix of gases and still consistently excrete ethanol that could be sold as a fuel additive or as a precursor to other products.

Initially, Simpson and Foster fixated on converting garbage from businesses and households into ethanol. But one day in 2005 Simpson was visiting Foster on his small farm outside of Auckland, which happened to be in sight of the only steel mill in New Zealand. During a walk, they noticed something unusual. "There was a bloody great flare on the top of this steel mill, like a massive birthday candle," Simpson says. "And we're like: 'Well, I wonder what's in that gas?'"

They did some research and learned that carbon monoxide was the main ingredient, and that steel mills all over the world produced similar emissions: a plentiful and untapped potential feedstock.

Next, they looked for bacteria that would eat that carbon monoxide. In the academic literature they read about a strain of bacteria that lives in the digestive tracts of rabbits and consumes carbon dioxide, carbon monoxide and hydrogen gases and emits ethanol. As exciting as it was, the literature also said that the amount of ethanol released by the bacteria was minuscule. It wasn't nearly enough for commercial-scale production. Foster and Simpson needed to figure out how to cultivate a substrain of bacteria that would be extraordinarily good at producing ethanol.

▲ A LanzaTech scientist checks a bacteria sample, part of the process of making ethanol, at a laboratory in Illinois.

LanzaTech

FACT

In short supply

The global air transport sector has pledged to halve its net carbon emissions by 2050, compared to 2005 levels. Accomplishing this will require turning to sustainable aviation fuels made from sources of carbon that are already in the environment. Demand for jet fuel, including SAFs, will only grow as more people around the globe take to the air. The U.S. Department of Energy anticipates that the demand will more than double by 2050 to 870 billion liters per year from a 2019 baseline. At present production levels, SAFs could only cover a small portion of that demand. In 2018 — the latest year for which figures are available — 7.6 million liters of SAFs were produced. Production technologies like the one described in this article could be part of the solution.
— Keith Button

Best of the best

They ordered a rabbit-gut bacteria strain from a bacteria culture collection. It arrived in the mail in a tube containing what looked like a saturated Q-tip, along with instructions for how to grow it. Simpson and Foster — the only employees of LanzaTech at this point — drove to the source of their epiphany, the Glenbrook Steel Mill, the one they saw during the walk near Auckland. With the permission of the mill's owners, they syphoned off emission gases into some commercially available gas collection bags resembling large shiny silver pillows with valves. Back at their lab, they injected the carbon dioxide, carbon monoxide and hydrogen into 200 slightly pressurized sealed test tubes containing the bacteria in a water-based growing solution. They shook the test tubes to dissolve the gas into the liquid and measured how quickly the bacteria grew. They selected the test tube where the bacteria grew most quickly and produced the most ethanol. They divvied those up into 200 more test tubes and repeated the growth-and-selection process over and over for three years.

"It's pretty boring, but at the end you've got a bacteria that absolutely loves growing on steel mill gas and almost nothing else," Simpson says.

The next challenge was expanding from making millimeters of ethanol in the lab to making tons and then thousands of tons of ethanol — at commercial scale, in other words. "It's only when you go to the refineries or you go to a steel mill that you understand the scale of an industrial process," Simpson tells me.

The startup needed to quickly "demonstrate something in the real world with the real feedstock, at production rates that make commercial sense in order to give investors confidence to give you more money," Simpson adds. At this point, the company was not yet thinking about turning ethanol into SAF, but that would change soon.

Going commercial

Simpson and Foster put their steel-gas-loving bacteria to work starting with a small pilot plant at the Glenbrook Steel Mill in 2008, which helped attract interest from Chinese venture capital investors. The performance of the pilot plant was encouraging. In 2010 LanzaTech began considering turning some of its ethanol into SAF, and two years later the company built two larger, demonstration plants at steel mills in China. The company moved its headquarters to Chicago from Auckland in 2014 partly to take advantage of the chemical engineering talent there and an international airport with better access to the U.S., Europe and Asia than New Zealand.

By 2018, LanzaTech was producing ethanol with bacteria at a full-scale rate at the Jingtang Steel Mill outside Beijing. The bacteria live in six 30-meter-tall tanks filled with water and some essential nutrients — nitrogen and phosphate. Trace amounts of hydrogen cyanide and oxygen — which is poison to the bacteria — are scrubbed from the emissions gas before it is piped to the bottom of each tank. By the time the gas bubbles up to the top of each tank, the bacteria have eaten 95% of the carbon dioxide, carbon monoxide and hydrogen in the gas. The company draws liquid from the tops of the tanks, heats it to distill the ethanol, and then recycles the nutrient solution back into the tanks. All told, the LanzaTech plant at Jingtang pipes thousands of

cubic meters of emissions gas to the bacteria per hour, and the bacteria produce 60 million liters of ethanol per year.

LanzaTech added a second commercial-scale plant in China, and another plant is under construction in Haryana, India, where bacteria will turn oil refinery emissions into ethanol starting next year. Two more plants are under construction, one in Belgium and another at a ferro-alloy mill in China. Those are slated to begin making ethanol in 2022.

SAF potential

The turning point toward SAF began after the arrival of new LanzaTech CEO Jennifer Holmgren. She had helped pioneer the production of the first SAFs that were tested and certified. At about the same time, LanzaTech learned that the U.S. Department of Energy's Pacific Northwest National Laboratory in Washington state was working with Imperium Renewables, a nearby energy company, to research how ethanol might be converted into SAF.

LanzaTech was intrigued by the duo's laboratory scale recipe for this conversion. Water was removed from the ethanol to make ethylene, a flammable gas. The ethylene was forced through porous acid catalysts to create liquid hydrocarbons with eight to 22 carbon atoms per molecule — the range suitable for creating jet and diesel fuel. Hydrogen gas was then added to the mix to turn it into paraffin liquid which was then distilled into SAF and the diesel fuel. It took 1.7 liters of ethanol to make a liter of this SAF, known officially as alcohol-to-jet synthetic paraffinic kerosene, ATJ-SPK. LanzaTech worked toward adapting the process to a commercial scale while also conducting demonstration flights with the fuel in 2018 and 2019. The company won approval for this SAF in 2018, making the fuel the only one among the eight currently approved SAFs to be made from ethanol.

Last year, the decadelong foray into SAFs paid its first dividends. With financial backing from Suncor Energy Inc. in Canada and the Mitsui & Co.

FACT

Waste nothing

In the early years of his biofuel company, LanzaTech, British molecular biologist Sean Simpson studied how other nascent industries developed and scaled up. In the early years of the oil industry, one key for success was to extract value at every step of production. Simpson realized that because the bacteria in his ethanol production process were mostly protein, the spent ones could be sold as an additive for animal feed, so he devised a method of filtering them out. Also, about 90% of the water in his bacteria-growing solution is recycled to minimize the waste footprint.

— Keith Button

◀ At the Jingtang Steel Mill outside Beijing, LanzaTech stores bacteria in six tanks filled with water, nitrogen and phosphate as part of the company's process to turn the mill's emissions into ethanol.

LanzaTech

▶ The Glenbrook Steel Mill in New Zealand whose flare stack at far right inspired the founders of LanzaTech to tap steel mill emissions as a feedstock for ethanol.

investment firm in Japan, LanzaTech created the LanzaJet spinoff. British Airways and Shell, the oil giant, joined as investors, while LanzaTech retains control of LanzaJet.

LanzaJet is building a small demonstration plant in Soperton, Georgia, to refine SAF at a rate of 34 million liters per year, or one-third the output of a full-sized commercial plant. Based on the efficiency and costs of operating this refinery, company officials and potential investors will be able to predict the production capacity and cost of a future full-scale plant, says Laurel Harmon, LanzaTech's vice president of governmental relations. The company expects that confidence to lead to construction of such plants.

Liberation from smokestacks

Right now, LanzaTech can only apply its process in steel mills or oil refineries, because in addition to carbon dioxide the bacteria must ingest carbon monoxide and hydrogen for energy and nutrition. The company wants to liberate itself from total reliance on installing equipment at smokestack sources. The answer could lie in electrolysis, in which electric current can applied to decompose molecules in a gas. LanzaTech and Carbon Engineering of Squamish, British Columbia, aim to show how carbon dioxide can be pulled from the atmosphere and converted to carbon monoxide through electrolysis. The bacteria would eat the carbon monoxide and other compounds and excrete ethanol, which could then be converted to SAF, explains Freya Burton, LanzaTech's chief sustainability and people officer. Hydrogen also could be supplied to the bacteria through electrolysis by splitting water molecules into oxygen and hydrogen.

The electricity for these processes would need to be produced sustainably, such as from solar or wind sources, to retain the reduced carbon footprint of the shift to SAF.

"We're very, very close to being able to do that," Simpson says. ★

CHILLING EFFECT?

Development of the James Webb Space Telescope has dominated NASA's astrophysics budget for a full decade longer than planned. In fiscal 2013, for instance, the agency spent more on Webb than the rest of its astrophysics programs combined, and it nearly did the same in 2014. The total estimated cost soared to $9.6 billion, shattering a 2008 estimate of about $5 billion.

We wondered what impact the Webb saga has had on the zest for innovation in astronomy.

The issue is a timely one, not only because of Webb's launch possibly in November on an Ariane 5, but because the latest U.S. Decadal Survey of astronomy priorities is due for release shortly following a peer review that began in June. These reports by the National Academies of Sciences, Engineering and Medicine have historically guided NASA's astronomy spending, including the decision to build Webb. The 2020 Decadal Survey committee (whose work was bumped to this year by the pandemic) has been deliberating over four Webb-class telescope concepts submitted to it by NASA.

To find out if Webb has had a chilling effect on technical ambitions, we spoke to four of those who know the Webb program and its impacts the best:

- Former NASA Administrator Daniel S. Goldin, whose administration conceived of the concept that would become the Webb telescope.
- Astronomer Alan Dressler, who advocated a smaller telescope.
- NASA astrophysicist John Mather, who has been with the program since the beginning and remains its top scientist.
- Astrophysicist Martin Elvis, an outspoken critic of NASA's current strategy.

We posed the same question to each. On the following pages are their answers. — *Cat Hofacker and Ben Iannotta*

“Should the Webb telescope experience whet the appetite for technological advancements among those charting the future of space-based astronomy or should the experience be viewed as a cautionary tale?”

The first boss looks back: Regrets? "Get outta here."

Dan Goldin

NASA Administrator, Washington, D.C., April 1, 1992-Nov. 21, 2001

During discussions in the mid-1990s over what should come after the Hubble Space Telescope, Goldin became personally engaged and pushed astronomers to think big in both a literal and figurative sense.

Breaking down the technical barriers and opening up the space frontier is really hard. People love to sit in the galleries and watch space developments unfold as though they were watching a soccer game, and in real time criticize those who are in the arena, pouring their guts out trying to make it happen. So, to answer your question, I got up about a half hour ago, and I just typed out some words. Here goes:

"Evolution and destiny of the universe, life therein, and the laws of nature are essential to understanding who we are, providing knowledge to improve the quality of our lives here on Earth and ultimately giving us access to the stars. Building Webb was not an easy task. It was really hard. The audacity of attempting to see the first stars that ignited after the Big Bang and to see primordial solar systems deep in the heavens is outrageous. It took courage, hard work, dealing with failures along the way, and the self-confidence of those who followed me at NASA. I salute the courageous NASA and industrial team that persevered while addressing head-hurting issues. The process was messy. Could it have been done more efficiently? Absolutely. However, we are here on the threshold of launch and I wish them Godspeed on their most important mission: to lift the collective eyes of humanity.

"Astrophysics is one of the loves of my life. At TRW **[later purchased by Northrop Grumman]** before I came to NASA, I oversaw the Compton Gamma Ray Observatory and the Chandrasekhar **[later shortened to Chandra]** X-ray space telescope. In fact, I oversaw the grinding of the developmental lens for Chandrasekhar. So, about six months after Hubble got its contact lenses, maybe in '94, a group of cosmologists visited me. They said, 'Dan we gotta replace the Hubble." I said, 'For God's sake it's now working for the first time.' And they said, 'No, we got to start thinking about a replacement now.' Their original idea was a 4-meter visible and ultraviolet telescope. I asked them what scientific question they'd like to answer. They said they'd like to see the first stars that ignited after the Big Bang, but that you couldn't do it because that would require a 6-to-7-meter infrared telescope that has to be cooled, and it wouldn't fit in the biggest rocket shroud. I said we're not going to build another telescope unless we're answering a fundamental scientific question that's going to have an impact on the lives of the people on this planet. Astronomers battled me for a year when I challenged them to consider a 6-to-7-meter infrared telescope. I called them Hubble huggers, but it was kind of said in friendship. Now, I did not interfere with the process. NASA took the concept to the National Academy of Sciences, to the Space Studies Board.

"That is how the Webb space telescope began. There were some early cost studies, but during my tenure there wasn't a mature design yet to start doing really strong cost studies. Do I regret that Webb turned out to be hard? Hell no. Get outta here! [he laughs] There had to be work done after me. But I believe we can't walk away from hard things. If we walk away, we are not worthy of the resources the American public gives us to explore the unknown." ★

From the astronomer's whose report was overruled: Reasons for caution...

Alan Dressler

Staff astronomer, now emeritus, Carnegie Observatories in California, 1981-present

Dressler chaired a committee that in 1995 recommended a telescope with a 4-meter-diameter primary mirror as a successor to Hubble and its 2.4-meter mirror. Then-NASA Administrator Dan Goldin viewed this recommendation as timid and dismissed proponents as "Hubble huggers."

When the Hubble Space Telescope and Beyond committee began our work in 1994, the fixing of Hubble was still in doubt. But once it was clear the Hubble was restored and it became a huge success, our committee was anxious to build something even more ambitious. NASA suggested a target budget of $500 million, so we recommended a 4-meter telescope with a more conventional design — not a segmented mirror and unfolding sunshield and all the things that the Webb will be.

"A few months after the report came out, NASA Administrator Dan Goldin addressed the 1996 American Astronomical Society meeting in San Antonio. I was in the front row, and I just remember him leaning over the lectern, looking straight at me. He called our recommendation too cautious, too timid. He wanted an 8-meter telescope, which increased both the development time and cost. **[NASA eventually settled on a 6.5-meter diameter primary mirror.]** Webb became the perfect storm: The more expensive it got, the more critical it was that it not fail, and that made it even more expensive.

"A similar decision point over complexity will come once the 2020 Decadal Survey is released, with the 10-meter to 15-meter LUVOIR design and the 4-meter HabEx that would both look for planets around other stars. I'm torn, just like I was when Dan Goldin looked down at me at the AAS meeting and urged us to go bigger with Webb. Your first reaction is, 'Ah, that's fantastic!' and the second is just, 'I'm terrified at this thought.'

"I think we better take Webb's cautionary tale very seriously. So if I were in NASA and the Decadal Committee said, 'If there's enough money we want to do LUVOIR, but if not we want to do HabEx,' we ought to have a technical study that goes much further into how much it will cost to build each telescope. We need to do the engineering, whatever it costs, so we can say with certainty what we're buying." ★

Lessons, yes. Chilling effect, no

John Mather

Astrophysicist, NASA's Goddard Space Flight Center in Maryland, 1974-present

Mather led the group that defined Webb's science objectives and chose its instruments. He began studying possible objectives in 1995, seven years before NASA named the future telescope after James Webb, NASA's second confirmed administrator. Mather is now senior project scientist, the top scientist on the program.

Your provocative question is about advancements versus a cautionary tale, and I'd say Webb has been both. We can't make progress in astronomy, most of the time, without inventing something, and that's always harder than people think it will be. Every single time. Success is a matter of people, as well as ideas. We find extraordinary talent out there in the aerospace industry, but mistakes set you back. On Webb, we had to invent a refrigerator, so NASA ran a competition, and in demonstrations the refrigerator worked fine, but when it came time to build the one that would fly, it didn't work so well. We got Northrop Grumman to give us a new manager. And within weeks of his coming in, progress increased very rapidly.

"So, astronomers know there is gold out there, but you need the right people and tools to find it. As for that next tool, within a month or two or three you should have a big story about what's in the Decadal Survey report. There were four Webb-telescope-class observatories that were to be evaluated by this giant committee of the National Academy of Sciences, and they all are extremely ambitious. At least three of the four build directly on the technology that the Webb developed, with better detectors, with things that unfold in space, with focusing the telescope after launch or with something very cold. One of those telescopes would actually run at about 4 or 5 degrees Kelvin, so that's a whole lot colder even than the Webb telescope.

"On Webb, we learned some things we will want to repeat. The mirrors were obviously a big challenge, so we had an external committee, a team, that came in to tell us whether we were doing the right thing. They kept us out of trouble. A more general lesson was: If you haven't got a complete plan, you shouldn't be promising the price. Everyone was surprised at how difficult it was to finish defining the test program. We actually had to change that after we had chosen Northrop Grumman. Nobody can really tell you how hard things are going to be when you start into the forest.

"We made that start under the very ambitious NASA administrator, Dan Goldin, who was very creative and very pushy toward rapid progress. In '96, he went to the American Astronomical Society, and he said, 'Why does Alan Dressler's committee ask for such a small telescope? We're going to build you a bigger one.' He got a standing ovation, and we said, 'Well, OK, we better do this.' That's sort of our first peer review. He urged us to do faster, better and cheaper. He said we know that the Spitzer Space Telescope is going to cost whatever the number was at the time, so we want you to build this bigger, better one for less. People didn't really believe that it was possible, but we said, 'OK, boss, we'll try.' No one should be surprised that if you start out with that kind of instruction you're not going to get the answer you wanted. Wishful thinking is not the same as truth. Never has been, and never will be. But the boss could see right away that Webb's segmented mirror technology was an investment in the future, because this was the only way we could break the boundary of telescopes bigger than the rocket." ★

"Should the Webb telescope experience whet the appetite for technological advancements among those charting the future of space-based astronomy or should the experience be viewed as a cautionary tale?"

Abandon the "flagship" obsession

Martin Elvis

Astrophysicist, now senior, Harvard-Smithsonian Center for Astrophysics in Massachusetts, 1980-present

Elvis has been an outspoken critic of NASA's approach of focusing on one flagship astronomy mission at a time, most recently in his book "Asteroids: How Love, Fear, and Greed Will Determine Our Future in Space," published in June.

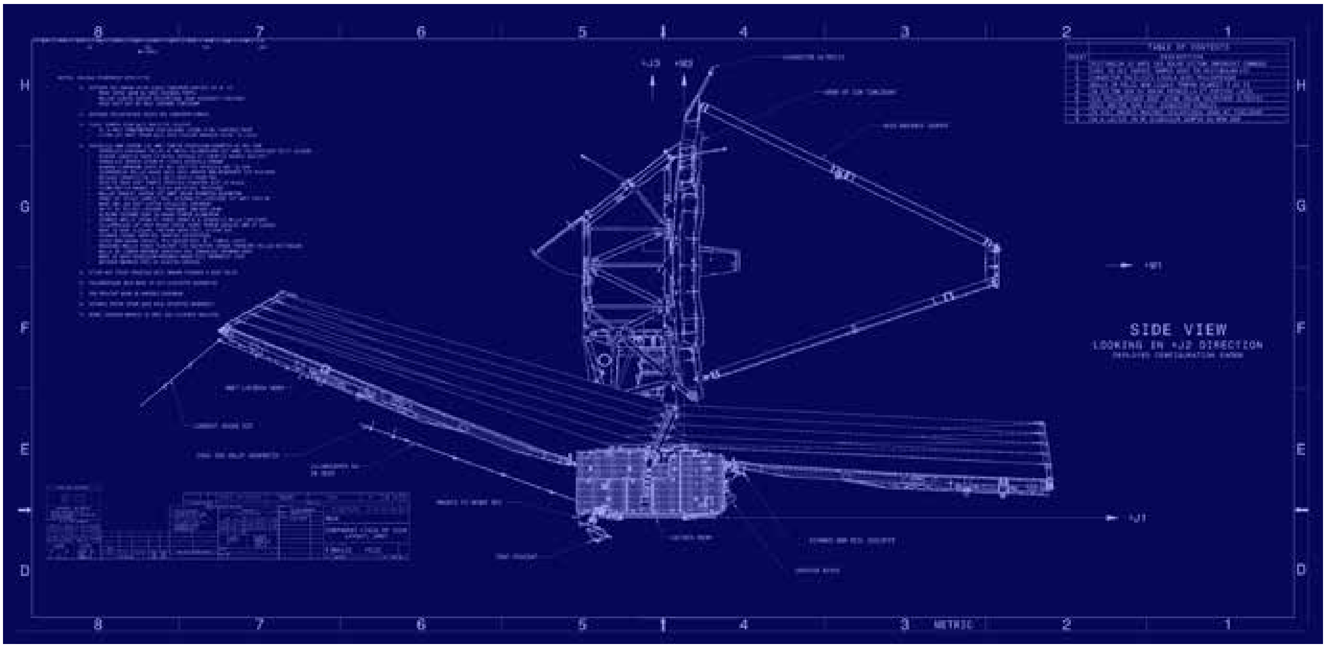
We will find things that will amaze us with Webb, and I hope those discoveries inspire us to pursue technological advances in different areas of astronomy to complement those findings. But the cautionary tale is: If we follow the Webb procedure of choosing one flagship mission that gets all the attention, gets the budget, then, when it runs into a problem, what can NASA do except throw more money at it?

"If Webb fails, if it doesn't deploy perfectly, then we'll have spent $10 billion for a turkey and that's going to hamper NASA astrophysics for sure, and maybe a broader part of NASA's science program, because who's going to risk giving NASA $10 billion again for a single thing?

"A smarter strategy would be to have multiple missions in development simultaneously, each with a fixed budget. You say, 'OK, you get $3 billion or $5 billion even, but if you go over that you're dead.' But NASA still has a flagship program. Having multiple missions and cost caps imposes what they call in the U.K. 'tensioning,' or discipline, that keeps costs realistic, keeps people focused.

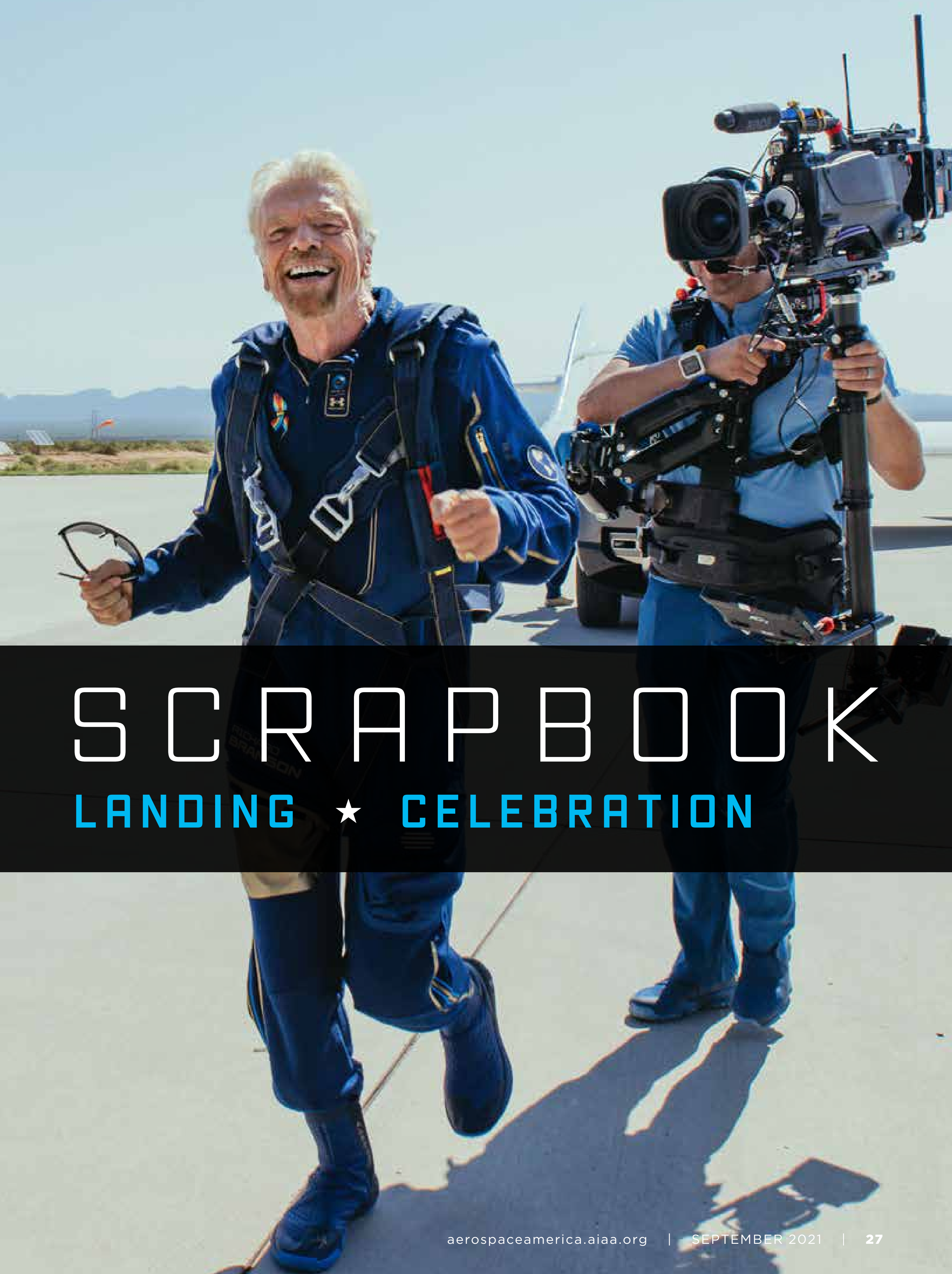
"The 2030 Decadal Survey should also consider emerging technologies that weren't mature enough in time for the 2020 report. We're now getting to the point where we could service telescopes to low-Earth orbit quite cheaply, I would think, using the SpaceX Dragon capsule, for instance. When you serviced Hubble, it cost you a billion dollars to launch the shuttle plus the instruments you were taking up. That cost comes down by more than an order of magnitude if you could put something like a new instrument or replacement computers in the Dragon trunk and take it up, where either astronauts or robots could make the repair. Another avenue is the bigger fairings on today's in-development launch vehicles which eliminates the need to fold up telescopes and then deploy them as Webb was designed to do. And their much bigger mass to orbit will spark a change in philosophy of the engineering for space that should be well established by the time we have a new decadal.

"We need to start thinking about these problems now before all the great observatories are gone. Hubble recently got a software fix; we've lost the Spitzer telescope and the Chandra X-ray telescope is clearly not as powerful as it used to be. You can't rely on any of them being there in five years' time, certainly not in 10. We need a new approach for the next generation of great observatories." ★



SUBORBITAL

LAUNCH ★ FREE FALL



SCRAPBOOK

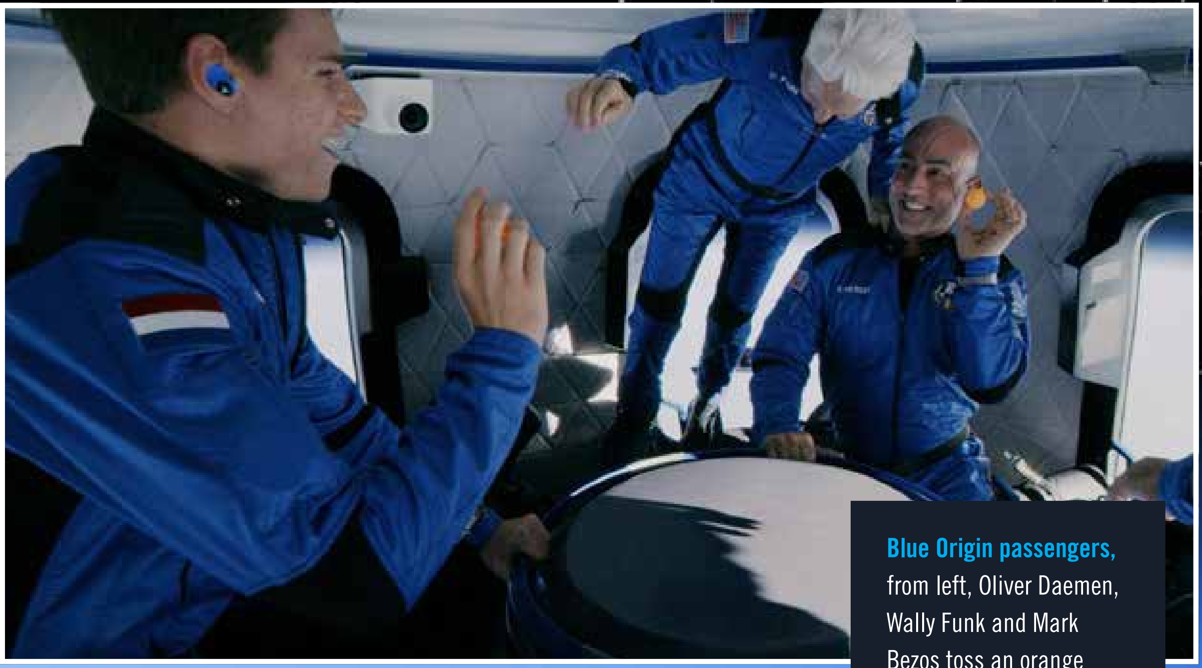
LANDING ★ CELEBRATION

LAUNCH

Wally Funk is seen through one of the six windows of the Reusable Space Ship First Step crew capsule as she and the three other passengers prepare for the launch.

Pilots Dave Mackay and Michael "Sooch" Masucci fly Virgin Space Ship Unity as Mackay tells the passengers they are "clear to unstrap" and enjoy a few minutes of free fall, also known as zero-g.

FREE FALL



Blue Origin passengers, from left, Oliver Daemen, Wally Funk and Mark Bezos toss an orange pingpong ball during their three minutes of weightlessness.

Virgin Galactic's Sirisha Bandla, vice president for government affairs and research operations, does weightless somersaults after VSS Unity reaches the apogee of its flight.

LANDING

Three parachutes slow Blue's New Shepard RSS First Step capsule for a landing in the West Texas desert, a few kilometers from the launch pad.

The New Shepard rocket lands on its pad after delivering the capsule to space.

Jeff Bezos in his New Shepard capsule after it touched down in Texas on what he declared was his "Best day ever!" Following the 11-minute flight, Blue Origin employees returned the capsule and rocket to the company's Texas facility for refurbishment ahead of a second passenger flight scheduled for late September or early October.

VSS Unity glides toward a landing at Virgin's runway at Spaceport America in New Mexico.

Blue Origin's company astronaut pin showing the feather logo that "represents freedom, exploration, mobility and progress," Blue's website reads.

Former Canadian astronaut Chris Hadfield, a member of the Virgin Galactic Space Advisory Board, after he attached the company astronaut pin to Richard Branson's flight suit. The gold pin shows a spaceplane between two sycamore seeds, which like Virgin's spaceplanes "detach from the mothership of their tree and float and tumble," Hadfield said.

EVTOL:
making the electric dream a safe one

Hundreds of startups are betting that electric aviation will finally provide safe, affordable urban air mobility services. But certifying the airworthiness of their myriad vertical takeoff architectures faces some stiff challenges.

BY PAUL MARKS | PaulMarksNews@protonmail.com


wisk

O On a Monday evening in May 1977, the landing gear on one side of a New York Airways commuter helicopter collapsed as it was picking up passengers atop Manhattan's 59-story Pan Am Building. The spinning rotors struck bystanders and passengers waiting to board, killing four. A fifth victim died on the ground, a block away, when falling rotor debris struck her as she waited for a bus.

That gruesome accident saw the Pan Am Building's heliport closed forever. But the tragedy has had a further effect: It has become a talismanic example of the risks inherent in trying to use conventional helicopters, with their high-energy rotary parts, to supply gridlock-busting air taxi services in heavily peopled urban areas.

Among those familiar with this case is Mary "Missy" Cummings, a former U.S. Navy F/A-18 pilot with a doctorate in systems engineering who researches transportation safety at Duke University in North Carolina. In studying the economics of such helicopter-based on-demand urban air mobility operations, her research group has found that business models tend to demand that they operate at high flight volumes — and that raises the chances of an accident with their unforgiving, high-energy rotor blades in urban spaces packed with people.

"We've tried to have helicopter air taxi services in the past, and they've all failed. History has taught us something very important about the economies of scale of rotorcraft-based air taxi services," says Cummings.

But that situation may not prevail for much longer: At least 100 energetic startups believe urban air mobility vehicles are not only about to become viable in the next few years, but that they will be safer, quieter and greener than anything conventional helicopters can ever offer — due to an ingenious twist in the way vertical takeoff and landing vehicles are designed, powered and fueled.

That twist? With the advent of distributed electric propulsion, tomorrow's air taxis and other forms of urban air mobility won't need a single, massive, high-energy, turbine-driven rotor disk plus a tail rotor to counter the resulting torque and assure stability. This emerging breed of lithium-battery-powered electric vertical takeoff and landing, or eVTOL, aircraft will be lighter and propelled by small, electric-motor-driven rotors, located strategically around the airframe, collectively providing lift, thrust and vectoring control.

▲ Joby Aviation's electric vertical takeoff and landing aircraft, shown in an illustration, will have six propulsors, all of them tiltable.
Joby Aviation

An accident like the one atop the Pan Am building would be less deadly because there would not be giant rotors slicing toward bystanders or hurtling toward pedestrians below. And, the control architectures of these eVTOL designs might make such a crash even be less likely to happen in the first place.

Simplifying flight controls

With the action of these far smaller, lighter rotors choreographed by software — no rotorcraft pilot could possibly control them all manually — the opportunity exists to greatly simplify rotorcraft flight controls in the short term, and in the very long term move toward fully automated, pilotless eVTOL flight if the public were to accept that automation can, in fact, be safer than a person at the controls.

There is no one-size-fits-all here: The eVTOL concept lends itself to myriad aircraft designs with

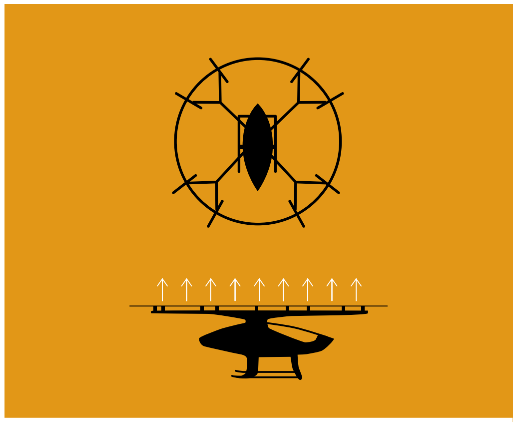
"The true beauty of eVTOL is that these electric motors are very compact, ultrareliable, have one moving part and are amazingly efficient. And once you use them to distribute propulsion, you can distribute thrust and control across the aircraft wherever you want it, very, very nicely."

"And that," Moore says, "changes the rules of aircraft design."

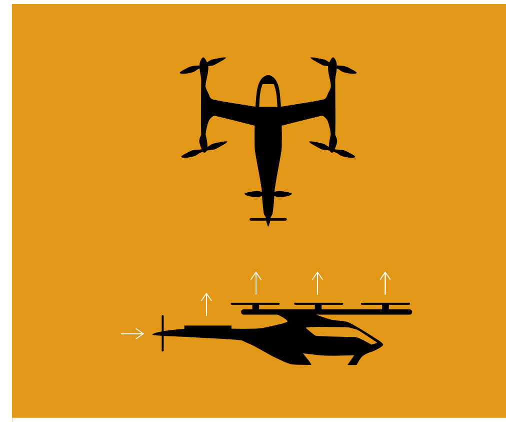
— Mark Moore, Whisper Aero

Forms of propulsion for urban air mobility

Distributing lift and thrust across multiple propulsors increases redundancy and makes urban air mobility designs safer from the start than conventional helicopters, designers say. Distributed propulsion concepts come in four basic forms.

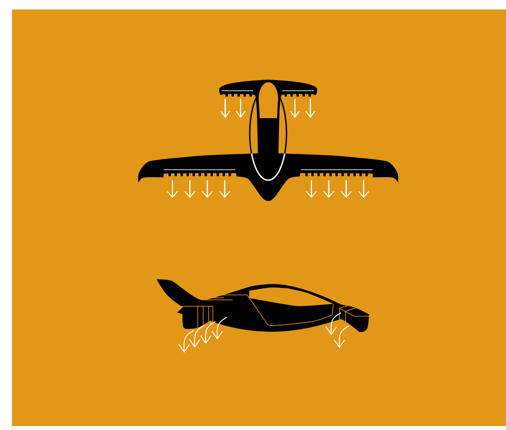


MULTICOPTER: Lifting rotors are arrayed around the circumference and spokes of a carbon fiber ring.



LIFT AND CRUISE: One group of vertical rotors lift the aircraft and another set provides forward thrust; wings boost cruise energy efficiency.

VECTORED THRUST: Tilting propulsors transition the aircraft from liftoff thrust to forward thrust; wings boost cruise efficiency.



MULTIPROPULSOR DUCTED FANS: Multiple, vectorable, electric fans, enclosed in ducts, reduce noise; wings boost cruise efficiency.

SOURCES:Images, Lilium; text, Aerospace America research

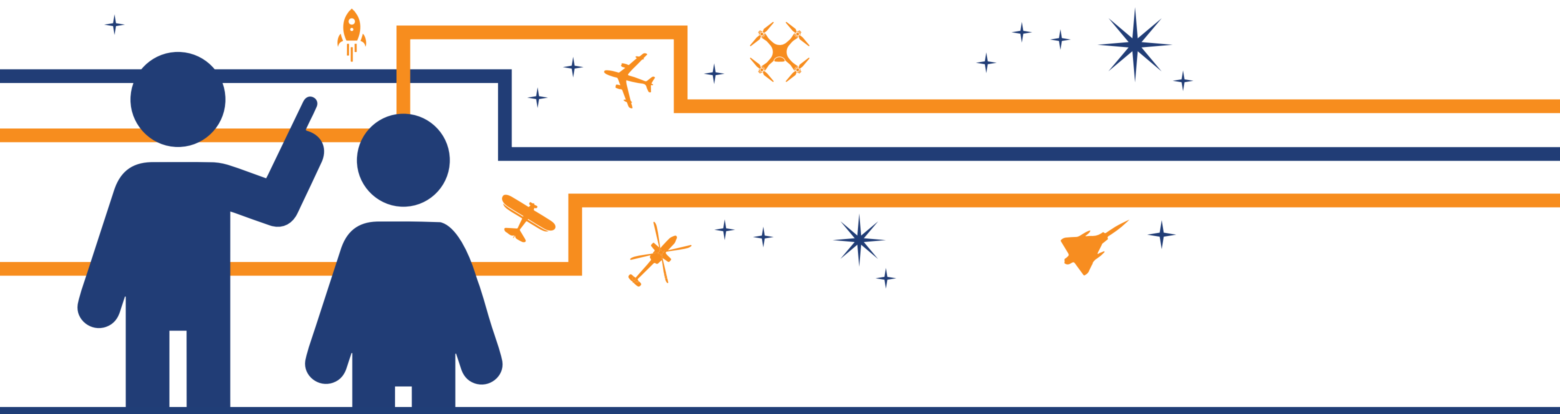
rotors or ducted fans and counts of such propulsors varying from six to 36. Each design can be geared to different mission profiles, such as intercity or intracity air taxi flights. And as Aerospace America wrote in the July/August issue, plans are already in train to build the vertiports that the eVTOL revolution will demand.

Some companies developing eVTOL technology are experiencing feverish investor interest, especially from special purpose acquisition companies which are firms with no commercial operations and that exist solely to raise funds through an initial public offering. The cash raised is then used to acquire a target company and to give it the funds to develop its product.

The eVTOL industry's apparent front-runner, Joby Aviation, for example, was acquired by just such a SPAC, called Reinvent Technology Partners, in August, raising $1 billion on the New York Stock Exchange to fuel Joby's manufacturing plans. Other eVTOL makers that have announced plans to raise funds via SPACs include Lilium of Germany, Vertical Aerospace in the United Kingdom and Archer Aviation in the U.S.

Driving this interest, in part, are the mind-boggling financial predictions from analysts. Investment bank Morgan Stanley, for example, predicts that the global eVTOL/urban air mobility market will be worth $1 trillion by 2040 and $9 trillion by 2050. And McKinsey, a management consultancy, projects that UAM firms worldwide will need to hire and train 60,000 eVTOL pilots by 2028.

AIAA ENGAGE



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▲ A pilot flies the Volocopter 2X (top right) on a rehearsal flight before the EAA AirVenture in Oshkosh, Wis. The 2X is a prototype of the company's planed VoloCity electric vertical takeoff and landing aircraft (inset).
Volocopter

But the analysts are getting ahead of themselves, cautions Cummings, and one should be deeply skeptical of their claims. "I wouldn't trust them as far as I can throw them," she says. One reason: Before the eVTOL market can take off, manufacturers have a mountain to climb in the form of gaining airworthiness safety certification from regulators including FAA, the European Aviation Safety Agency and Britain's Civil Aviation Authority.

But because there are so many ways to design eVTOL aircraft, and since some of their components are pretty new to aviation — such as high-power lithium battery packs, electric motors and electric propulsor/wing tilt mechanisms — many have not been flown in safety-critical air applications before, so airworthiness certification could potentially be a more arduous process than for regular aircraft.

"Distributed electric propulsion is a great idea, a fantastic concept. But there's a huge difference from going to concept to some kind of operational, mature technology. Companies need to be in this for the long haul because the certification process is going to be long and costly," warns Cummings.

Promise of improved safety

But proponents say that improved safety should be viewed as an almost innate property of most eVTOL formats, suggests aeronautics engineer Mark Moore, founder and CEO of Whisper Aero, a Tennessee startup formed in February to develop ultraquiet propulsors for UAM aircraft. Moore pioneered the concept of distributed electric propulsion in a 30-year career at NASA's Langley Research Center in Virginia, and then spent four years evangelizing eVTOL concepts at Uber Elevate, which was acquired by Joby Aviation in December.

Moore says that in distributing lift and thrust across a number of propulsors on an airframe, eVTOL makers automatically provide a critical safety feature that helicopters lack: propulsor redundancy. On a six- or eight-rotor eVTOL, for instance, losing a propulsor to a motor or gear failure, or a birdstrike, would leave enough lift margin for the aircraft to continue flying to a safe landing. And that would be even more the case on designs with as many as 18 or 36 propulsors, as some eVTOL vendors are proposing.

"The vast majority of helicopters are single turbine, so that's critical. And helicopters have all sorts of different parts that are flight critical, where if any one of them fails, like the tail rotor, it can't fly," Moore says. And while a helicopter's rotors can autorotate and crash land without engine power, its pilot cannot choose where it will land, whereas an eVTOL, due to redundancy, can.

On top of this basic, in-built contribution to safety, he says, there is also the safety proffered by the utter simplicity of electric motors versus that of complex turbines and reciprocating engines. "The true beauty of eVTOL is that these electric motors are very compact, ultrareliable, have one moving part and are amazingly efficient. And once you use them to distribute propulsion, you can distribute thrust and control across the aircraft wherever you want it, very, very nicely."

"And that," Moore says, "changes the rules of aircraft design."

How have those rules changed? Well, the four chief architectures for eVTOL aircraft that address the rotor arrangements, means of propulsion and other factors throw this into sharp relief. **See graphic, Page 36.**

Each of those architectures can in turn be varied in many ways, perhaps by adding lifting surfaces, or attaching more propulsors along wings, or maybe be running with combinations of open rotors, tiltrotors and ducted fans.

So how are the backers of some of these architectures attempting to assure safety? One company adopting two of those formats is Volocopter of Karlsruhe, Germany. At the EAA Airventure show in Wisconsin in July, the company flew the Volocopter 2X, a prototype of its planned VoloCity eVTOL, a two-seat, 18-rotor multicopter with a range of 35 kilometers (with today's battery technology). The company's winged VoloConnect aircraft, which is still in the concept phase, will be a four-seat lift-and-cruise eVTOL with a range of 100 km, propelled by six lifting rotors and two ducted fans either side of the tail to push it forward.

Oliver Reinhardt, Volocopter's chief risk and certification officer, says that although eVTOLs are a novel type of vehicle, certifiable standards exist for all of the types of components in their designs, be it motors, on-board electronics or safety-critical flight software. For instance, he says, although the design of the motors in the VoloCity differ in size, shape and electrical characteristics, the certification requirements for the electric motors flown today in some electric light aircraft, like the Pipistrel, apply to VoloCity's version.

"There is a lot of commonality in the generic set of requirements and the levels of safety that we need to meet," Reinhardt says.

Volocopter opted for a lift-and-cruise design, rather than vectored thrust, for its VoloConnect eVTOL in part because of the U.S. military's experience with its V-22 Osprey tiltrotors. Perhaps most infamously, an Osprey crashed into the Potomac River south of Washington, D.C., in 1992 in front of VIPs who had reportedly assembled to watch the new aircraft land in the D.C. area for the first time. All seven aboard were killed. "When you look into

Gauging public acceptance of UAM

The European Union Aviation Safety Agency hired consulting company McKinsey & Co. to produce a study on societal acceptance of urban air mobility operations. The company surveyed 3,690 people across six European cities between November 2020 and April 2021. Among the top three concerns were safety, environmental impact, noise and security.

Among other key findings, 64% said they were rather or very likely to try out delivery drones, and 49% said they would be rather or very likely to try air taxis.

Respondents indicated they were more comfortable with the idea of crewed urban air mobility vehicles than uncrewed. Here are the percentages who agreed with the following statements from the survey:

"As a pedestrian on the ground, I would feel safe with unmanned delivery drones potentially flying above me." **56% AGREE**

"As a pedestrian on the ground, I would feel safe with manned air taxis potentially flying above me." **70% AGREE**

"I would be interested in trying out a manned air taxi myself." **75% AGREE**

"I would be interested in trying out an unmanned air taxi myself." **43% AGREE**

Source: "Study on the Societal Acceptance of Urban Air Mobility In Europe," EASA

"Distributed electric propulsion is a great idea, a fantastic concept. But there's a huge difference from going to concept to some kind of operational, mature technology. Companies need to be in this for the long haul because the certification process is going to be long and costly."

— Mary "Missy" Cummings, Duke University

the history of the Osprey, military certification development started sometime in the 1980s. But since then, no manufacturer has been able to obtain a civilian type certificate for any tilt-rotor or tilt-wing design." So adopting such technology for civilian eVTOLs, Reinhardt says, might have made gaining certification "extremely complex."

Vertical Aerospace, however, is going for a tiltrotor-based, thrust vectoring design for its VA-X4, a winged, eight-rotor, 160 km-range eVTOL. The VA-X4 will have four lift-only rotors behind the wing, but four tiltable thrusters on the front of the wing, that transition from vertical to horizontal flight and vice versa. The firm has major league technology partners, too, in the form of Rolls-Royce, which is supplying its motors, and Honeywell, which is providing eVTOL fly-by-wire control systems.

The company rejected a straight lift-and-cruise design early on, says Paul Harper, head of certification at Vertical Aerospace, because "the vertical takeoff and landing part is, clearly, only used during takeoff and landing. So for the rest of the flight regime, you're lugging around dead weight."

"We needed to be able to minimize the amount of pure VTOL kit onboard the aircraft. And the tilting rotors at the front allow us to do that. They buy their place onto the aircraft mass budget by providing the forward cruise thrust. It adds some complexity, but it saves significant weight," Harper says.

And Vertical Aerospace is unfazed by the Osprey's record in the military sphere, says Harper. "At the end of the day, the tilting system is an actuation system, and there are safety critical actuators on existing [commercial] aircraft — such as on elevators.

▲ An illustration of the VA-X4, Vertical Aerospace's eight-rotor electric vertical takeoff and landing concept. Rolls-Royce is building the motors, and Honeywell the control systems.

Vertical Aerospace

We just need to make sure that the consequence of a single actuator failing is benign to the aircraft."

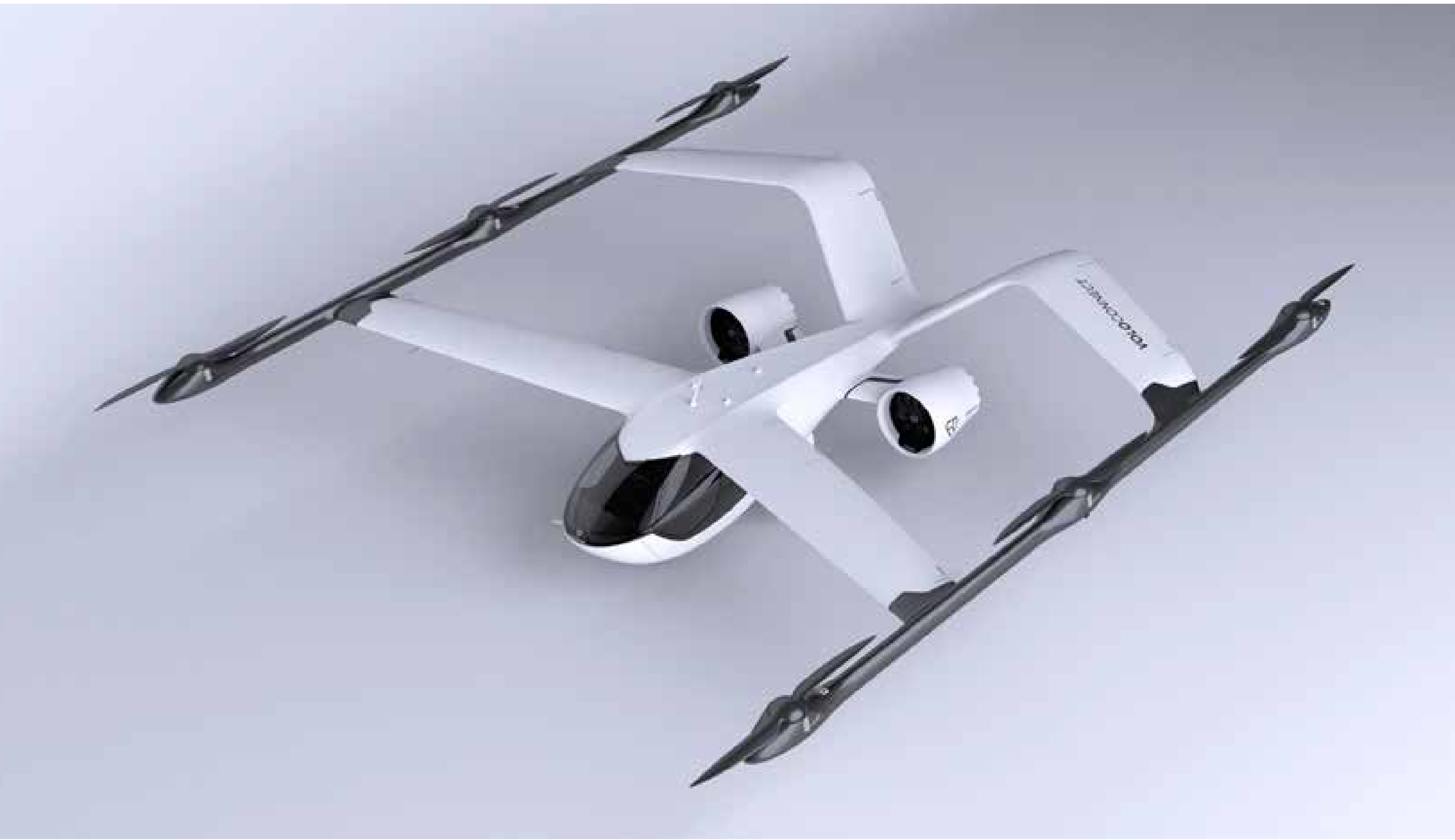
At Joby Aviation in Santa Cruz, California, the choice of eVTOL architecture eschews Vertical Aerospace's back line of lift-only propulsors; it is a fully thrust vectoring machine, with all six of its propulsors tiltable for the lift-to-thrust (and vice-versa) transition.

Joby's chief test pilot, Justin Paines, says they "analyzed and tested many, many configurations, including constructing and testing a wide range of subscale aircraft" before homing in on that configuration.

Joby's road to proving airworthiness, he says, has for a decade been based on engineering "certifiable solutions" — in consultation with FAA. As a former Harrier jump jet pilot, and someone who has worked on the X-35 strike fighter and F-35 human interfaces, simplifying the Joby eVTOL's controls is a key aim for Paines. "By making the aircraft simple to fly, we can lower pilot workload, thereby reducing pilot error," he says.

But like most other eVTOL makers, Paines says Joby is in no hurry to go autonomous. "The current design of the Joby aircraft is designed to be flown by a pilot, and capabilities like fly-by-wire enhance operational safety. Clearly there is tremendous potential for increased automation and autonomy over the coming years, and Joby is taking a staged approach to that ultimate goal," he says.

Moore agrees that autonomy is a ways off yet. "It's going to be a slow evolution in terms of achieving that fully autonomous eVTOL capability. I'm convinced it's going to take another 10 years."



▲ Volocopter chose a lift-and-cruise design, rather than vectored thrust, for its VoloConnect concept partly because "no manufacturer has been able to obtain a civilian type certificate for any tilt-rotor or tilt-wing design," says Oliver Reinhardt, Volocopter's chief risk and certification officer.
Volocopter

Challenges to eVTOL certification

Despite the general bullishness from eVTOL manufacturers, Jacek Kawecki, former safety lead at Uber Elevate — and now a partner with Moore at Whisper Aero — says there remains a number of challenging aspects to eVTOL certification.

"One is understanding how to certify lithium-ion batteries; understanding their lifetime is a little bit difficult. But when the regulator is unsure, they tend to think more conservatively in the interests of public safety. With time, they'll understand how to better qualify such unknowns," says Kawecki.

There is also a trans-Atlantic sticking point in eVTOL certification, says Volocopter's Reinhardt. EASA wants all eVTOLs certified to the same level of safety as commercial airliners are worldwide, which allows one catastrophic event every 1 billion flight hours (a 10-9 probability).

But the FAA is considering allowing eVTOLs that have a wing to improve energy efficiency in cruise flight — and which can be used to glide to a safe landing after a power loss — to be certified to a 10-7 probability, or one catastrophic event every 10 million flight hours, the same as light aircraft must adhere to, rather than an airliner.

But Volocopter does not see the logic in the FAA allowing 100 times more catastrophic failures in UAM. "That doesn't make sense with the high numbers of eVTOL vehicles that we all want to have in the air," says Reinhardt. He hopes EASA's 10-9 probability will prevail worldwide for eVTOL.

EASA and the FAA are talking it through, both sides confirmed.

"The two authorities are in continuous exchange and dialogue to ensure that the respective regulatory environments will allow a fair and level playing field so as to enable the growth of the global eVTOL market," says Janet Northcote, head of communications at EASA in Munich. The FAA confirmed that it is working "to align and define" the certification requirements for eVTOL with "international aviation authorities."

With the Pan Am Building catastrophe in mind, agreeing to raise the threshold of acceptable accident limits might be the best thing the regulators could do. Everybody in the eVTOL community knows that any repeat of that tragic event with their new breed of electric aircraft will leave the UAM industry dead in the water. In May, Morgan Stanley cautioned in its latest UAM industry analysis that the marketing materials of eVTOL companies strongly echo the way New York Airways advertised its commuter helicopter service back in 1962. It is up to the eVTOL industry, and the regulators, to show that, this time, it's going to be different. ★

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Calendar

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2021			
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
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 Course	ONLINE (learning.aiaa.org)	
21 Sep–5 Oct	Advanced Space Propulsion Course	ONLINE (learning.aiaa.org)	
22 Sep– 29 Oct	Turbomachinery for Emerging Space Applications: Liquid Rocket Propulsion Course	ONLINE (learning.aiaa.org)	
28 Sep	ASCENDxSummit	VIRTUAL	
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)	
6–8 Oct	Understanding Cybersecurity in the Space Domain Course	ONLINE (learning.aiaa.org)	
7–28 Oct	Turbulence Modeling for Aerodynamic Flows Course	ONLINE (learning.aiaa.org)	
12 Oct–4 Nov	Hypersonic Propulsion Concepts: Design, Control, Operation, and Testing Course	ONLINE (learning.aiaa.org)	
19 Oct–4 Nov	Space Architecture: Designing a Lunar Habitation System Course	ONLINE (learning.aiaa.org)	
25–29 Oct*	72nd International Astronautical Congress	Dubai, UAE	
26 Oct–18 Nov	Aviation Cybersecurity Course	ONLINE (learning.aiaa.org)	
8–10 & 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, & ONLINE	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	

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.).

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2022			
8 Jan	Computational Aeroelasticity Course	San Diego, CA	
8–9 Jan	Design of Electrified Propulsion Aircraft Course	San Diego, CA	
8–9 Jan	Missile Guidance Course	San Diego, CA	
8–9 Jan	Agile Systems Engineering Course	San Diego, CA	
8–9 Jan	OpenFOAM CFD Foundations Course	San Diego, CA	
8–9 Jan	1st AIAA High Fidelity CFD Workshop	San Diego, CA	
8–9 Jan	Aircraft and Rotorcraft System Identification Engineering Methods for Manned and UAV Applications with Hands-on Training using CIFER® Course	San Diego, CA	
5–12 Mar*	2022 IEEE Aerospace Conference	Big Sky, MT (aeroconf.org)	
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)	
19–21 Apr	AIAA DEFENSE Forum	Laurel, MD	19 Oct 21
26 Apr	AIAA Fellows Induction Ceremony and Dinner	Arlington, VA	
27 Apr	AIAA Aerospace Spotlight Awards Gala	Washington, DC	
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	
16–24 Jul*	44th Scientific Assembly of the Committee on Space Research and Associate Events (COSPAR 2022)	Athens, Greece (cospar-assembly.org)	11 Feb 22
4–9 Sep*	33rd Congress of the International Council of the Aeronautical Sciences (ICAS 2022)	Stockholm, Sweden (icas2022.com)	10 Feb 22
18–22 Sep*	73rd International Astronautical Congress	Paris, France (iac2022.org)	
24–26 Oct	ASCEND Powered by AIAA	Las Vegas, NV	

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

2021 Virtual AIAA Aerospace Spotlight Awards Gala

AIAA presented its most prestigious awards at the virtual AIAA Aerospace Spotlight Awards Gala on 12 August. The gala is an annual event recognizing the most influential and inspiring individuals in aerospace, whose outstanding contributions merit the highest accolades.


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The 2021 premier award winners are:

1 **Gen. Ellen M. Pawlikowski,** U.S. Air Force (retired), recipient of the AIAA Goddard Astronautics Award. This award is the highest honor AIAA bestows for notable achievement in the field of astronautics.

2 **Michimasa Fujino,** Honda Aircraft Company, recipient of the AIAA Reed Aeronautics Award. This award is the highest honor AIAA bestows for notable achievement in the field of aeronautics.

3 **Merri J. Sanchez,** The Aerospace Corporation, recipient of the AIAA Distinguished Service Award. This award is given in recognition of an individual member who has provided distinguished service to the Institute over a period of years.

4 **Michael Watkins,** NASA Jet Propulsion Laboratory
5 **Michael A. Gross,** NASA Jet Propulsion Laboratory
6 **Frank Flechtner**, Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences
7 **Albert Zaglauer,** Airbus Defence and Space
Recipients of the AIAA International Cooperation Award. The award recognizes individual/s who have made significant contributions to the initiation, organization, implementation, and/or management of activities with significant U.S. involvement and that includes extensive international cooperative activities in space, aeronautics, or both.

8 **Marcia S. Smith,** SpacePolicyOnline.com, recipient of the AIAA Public Service Award. The highest recognition AIAA bestows on a person outside the aerospace community who has shown consistent and visible support for national aviation and space goals.

9 **Benjamin Jorns,** University of Michigan, Ann Arbor, recipient of the AIAA Lawrence Sperry Award. The award is presented for a notable contribution made by a young person, age 35 or under, to the advancement of aeronautics or astronautics.

10 **Humberto Silva III,** Sandia National Laboratories, recipient of the AIAA Engineer of the Year. This award is presented to a member of the Institute who has made a recent individual, technical contribution in the application of scientific and mathematical principles leading to a significant technical accomplishment.

11 **Suzanne Banas**, South Miami Middle Community School Miami, Florida
12 **Leesa Hubbard,** W.A. Wright Elementary, Mt. Juliet, Tennessee
13 **Mark Westlake**, Saint Thomas Academy, Mendota Heights, Minnesota
Recipients of the AIAA Educator Achievement Award. This award is given in recognition of the teachers' efforts to promote STEM education.

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For more information about the AIAA Honors and Awards Program:

Contact Patricia Carr at patriciac@aiaa.org

AIAA Sydney Section Hosts Lecture on Satellite Operations at UNSW Canberra Space

BY MICHAEL SPENCER (AIAA Associate Fellow), AIAA Sydney Section

On 16 June, **Dr. Courtney Bright** was a guest speaker at a public space lecture arranged by the AIAA Sydney Section. The talk covered her motivations and the beginning of her space engineering career, and her involvement to lead flight operations in the UNSW Canberra Space university space program involving five satellites in four discrete space missions, all now in orbit.

"I first became interested in space in early primary school, when I discovered the astronomy sections of an Encyclopaedia Britannica collection we had at home; I particularly remember having my mind blown when I read that the sun will eventually expand to engulf Earth. Some of my favourite childhood memories are annual visits to ScienceWorks in Melbourne with my grandparents."

Dr. Bright is responsible for planning, testing, and executing the operations of UNSW Canberra Space satellite missions. She has a bachelor's degree and a Ph.D. in mechanical engineering; her Ph.D. research focused on novel thrust vectoring methods for spacecraft propulsion. During her studies, she commenced part-time work with the first generation of the UNSW Canberra Space workforce formed in 2014. After submitting her thesis, she transitioned to a full-time position with the growing team and space program at UNSW Canberra Space.

During her student days, she was a student member of AIAA and joined the AIAA Sydney Section committee to assist in organizing space promotions and outreach activities. In 2017, Dr. Bright was a member of the student organizing committee for "Astronaut Stories Australia," a national public outreach to host international guest speakers, including former NASA astronauts Dr. Sandy Magnus and Pamela Melroy.

Dr. Bright briefly described the engineering, testing and flight operations conducted at UNSW Canberra Space. The university space program is designed to demonstrate new technologies for research at UNSW Canberra, including research areas into unique and bespoke systems engineering, software designs, onboard satellite processing, space situational awareness, and satellite formation flying. The research is benefiting space interests at the university and the Royal Australian Air Force.

She shared observations and experiences gained from the space program, which includes the Buccaneer Risk Management Mission (launched 2017), M1 (launched 2018), M2 Pathfinder (launched 2020), and the M2 twin-satellite mission (launched 2021). As the Flight Operations Lead, Dr. Bright and the team have had to formalize operating procedures that have influenced satellite engineering designs to optimize the use of available human resources. For example, the satellites are only operated during business hours and need onboard systems that can be trusted to keep the satellite safe until the next working shift.

Dr. Bright is the Flight Operations Lead at UNSW Canberra, Australia (UNSW Canberra image).

One of the most significant project lessons learned was to conduct end-to-end integrated system testing before launch: using the operations software and ground station software to communicate over-the-air with the "plugs-out" integrated spacecraft, with final versions of flight software loaded. During the program, a stressful event occurred when M1 was launched in 2018 by the SpaceX Smallsat Express, with another 63 satellites, all released in quick succession as a satellite cluster! The challenge for the cluster release is to identify each satellite. Two months after launch, only 50% of satellites were identified; two years later, twelve satellites are still not identified. Unfortunately, the M1 satellites failed to contact for unknown reasons, but the rapid response fault-finding and diagnostics served to benefit the designs for the follow-on missions. The next major milestone in the program is the pending "divorce" event where the M2 satellite pair will separate into two independent satellites to perform formation-flying experiments.

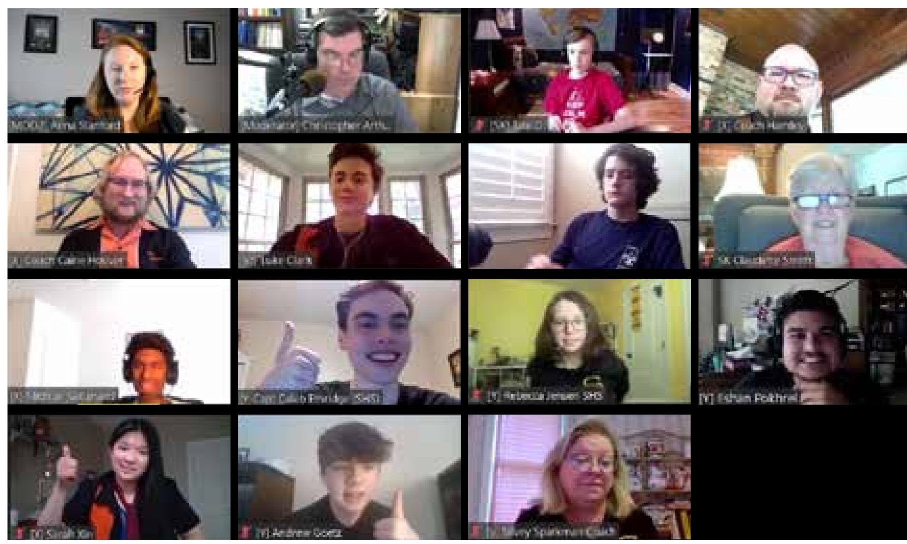
The nature of working in and with space in an Australian university space program demands a genuinely global approach involving international partners for space launch services, space surveillance and satellite tracking, and even with some of the research students at the university.

"Space is a genuinely multidisciplinary field, and with significant funding and growth of the space sector in Australia, it's now possible to get involved in impactful space projects and missions without moving overseas."

If you missed Dr. Bright's talk, you can watch the recording at **https://m.youtube.com/watch?v=wwysdhzLVco&feature=youtu.be**.

AIAA Greater Huntsville Section Saves Alabama Quiz Bowl State Championships from Cancellation

BY ROBIN OSBORNE, AIAA Greater Huntsville Section



The AIAA Greater Huntsville Section (GHS) partnered with the Alabama Scholastic Competition Association (ASCA) in spring 2021 to help save the State Championships for the Alabama Academic Quiz Bowl from inevitable cancellation during the COVID-19 pandemic. AIAA GHS hosted two large, traditionally in-person tournaments – one for middle school and one for high school – through Zoom sessions and an online buzzer system. Together with Jacobs Space Exploration Group and ERC, Inc., AIAA GHS sponsored the tournaments by providing support in the form of funding, volunteers, technical expertise, and even a tournament director to handle the logistics associated with live online tournaments.

ASCA President Lee Henry wrote, "On behalf of ASCA, I sincerely thank all of the good people at AIAA GHS for their hard work in making sure that our tournaments took place this year. I also want to thank Jacobs and ERC for their generous sponsorships. This has been an incredibly difficult year, and we likely would not have been able to host our tournaments without this assistance. Because so many wonderful people stepped up to help, we were able to give our students the high-quality academic competition that they have worked for and deserve. It was a pleasure working with everyone and I hope that this is the beginning of a long-lasting partnership!"

Eshan Pokhrel, a junior at Sparkman High School who has been active in Scholars' Bowl programs since 6th grade, commented, "After having our sophomore year and season cut short due to COVID-19, I was happy to see that ASCA and AIAA GHS were able to find a way to keep the state engaged in quiz bowl, despite the challenge of hosting our state districts and championship online threatening participation. It was by far the best and most efficiently-run tournament we attended this season."

The scholastic tournaments, which are traditionally in person, challenged students from 56 schools across Alabama with detailed questions related to the STEM disciplines, as well as other areas such as history, literature, fine arts, and pop culture. Teams competed by answering tossup and bonus questions related to those subjects. Quiz bowl is akin to Jeopardy! for students. The questions, provided by the National Academic Quiz Tournaments (NAQT), are complex and advanced for students' current grade levels, and in many cases the top-performing teams studied for years in after-school sessions under the guidance of teacher-coaches who have a passion for both the game and bringing out the best in their students.

In total, 64 volunteers consisting of members of the Huntsville aerospace community, teachers and students from across Alabama, and quiz bowl alumni assisted. Volunteers ranged from middle school students to Ph.Ds. Nishanth Goli, AIAA GHS chair, commented, "AIAA GHS members are usually enthusiastic for STEM volunteer events, but for the quiz bowl events, we received unprecedented enthusiasm. Members volunteered for 4-8 hours on the day of the middle school and high school events, and additional time was spent in the practice sessions beforehand. Our membership's passion for STEM is commendable and the GHS Council will keep their interests intact and remain actively involved with ASCA and quiz bowl. We are excited about this collaboration and helping shape the future of our community."

ASCA, consisting mostly of teachers, is the volunteer organization that hosts the annual Alabama State Championships each spring. During the previous school year, in March 2020, the sudden outbreak of COVID-19 necessitated cancellation of ASCA's High School State Championship, along with all other in-person tournaments throughout the United States.

Membership Nominations Are Now Open for AIAA Technical Committees and Integration and Outreach Committees for 2022/2023.

The Technical Activities Division (TAD) and Integration and Outreach Division (IOD) work diligently with their committee chairs to maintain a reasonable balance in appropriate representation to the field from industry, research, education, and government and the specialties covered in the specific TC/IOC scopes. TAD and IOD encourage the nomination of young professionals (those individuals 35 years and younger). Committees have a 50-person maximum unless approval is granted to exceed that limit. Nominees selected for membership who are not AIAA members in good standing must become members or renew their membership within 45 days of start of the membership term (1 May–30 April).

If you currently serve on a TC/IOC, you will automatically be considered for the 2022/2023 membership term. Nominations are submitted online. The nomination form can be found on the AIAA website at aiaa.org, under My AIAA, Nominations and Voting, Technical Committee Online Nomination. Nominations are due by **1 November 2021**.

Information about the committees can be found at

- **Integration and Outreach Committees** aiaa.org/integration-and-outreach-division-committees
- **Technical Committees** aiaa.org/technical-committees

AIAA Dayton/Cincinnati Section Members Honored with AIAA Special Service Citation

In May, **Dr. Brian Bohan** of the Air Force Institute of Technology and **Dr. Timothy Leger** of the Air Force Research Laboratory were honored with the AIAA Special Service Citation, an award given by AIAA Headquarters for service at the local level above and beyond the ordinary in type, intensity, or duration. Both were awarded in recognition of their roles and outstanding service to the Dayton-Cincinnati Aerospace Sciences Symposium, an annual technical event hosted by the section. Bohan served as the executive chair and Leger as webmaster. Both members received their awards at a section event in June.

Marc Polanka, AIAA Dayton/Cincinnati Section Honors and Awards Officer, presented both Brian Bohan and Tim Leger with their citations.

AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award

CALL FOR NOMINATIONS

Nominations are currently being accepted for the 2022 **AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award**. The recipient will receive a certificate and a $7,500 cash prize.

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

For nomination forms, please visit **aiaa.org/SpeasAward**. Presentation of the award will be made at the AAAE/ACC Planning, Design, and Construction Symposium, scheduled for February 2022.

DEADLINE: 1 November 2021
CONTACT: AIAA Honors and Awards Program at awards@aiaa.org

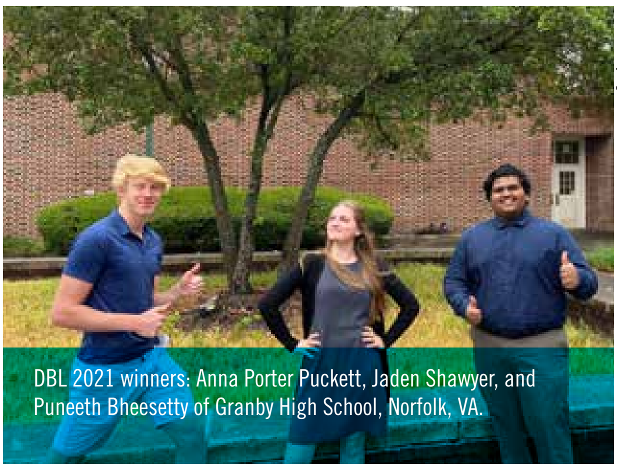
This award is jointly sponsored by AIAA, AAAE, and ACC.

aiaa.org/SpeasAward

AIAA SHAPING THE FUTURE OF AEROSPACE
AAAE
ACC AIRPORT CONSULTANTS COUNCIL

MAKING AN IMPACT

How Our Partners Help Us Inspire the Next Generation



DBL 2021 winners: Anna Porter Puckett, Jaden Shawyer, and Puneeth Bheesetty of Granby High School, Norfolk, VA.

Credit: Granby High School.

Mark Westlake, Physics educator at Saint Thomas Academy in Mendota Heights, MN

University of Texas at Austin students participating in the 2021 DBF

The AIAA Foundation inspires and supports the next generation of aerospace professionals. From classroom to career, the AIAA Foundation enables innovative K-12 and university programming. AIAA is working every day to reach our goal of impacting 1 million students a year where their aspirations begin.

We know the effect classroom teachers can have by making young students aware of the possibilities, helping students see themselves as possible contributors to society, and encouraging them to build their skills. This year through the Classroom Grant Program, 83 educators received grants of up to $500 that will affect nearly 24,000 students. The AIAA Foundation also has provided other resources through our K-12 partnerships and Aerospace Micro-Lessons that help educators spark a student's interest in aerospace. Our Design/Build/Launch (DBL) competition, in partnership with Blue Origin, invites high school students to develop research proposals in the fields of microgravity science or space technology, pairing their experiment with a public outreach plan to share the excitement of the field with others. The top proposal receives a free spaceflight for their payload on Blue Origin's New Shepard rocket and a $1,000 grant to prepare and develop the experiment for flight.

As these students begin their university years, the AIAA Foundation supports hands-on experiences like the Design/Build/Fly (DBF) competition and university design competitions, which provide students with a unique opportunity to apply engineering skills. We also encourage students to present their research at the AIAA Regional Student Conferences. These conferences allow undergraduate and graduate students to receive feedback on their research and presentation style from respected industry professionals. The AIAA Foundation also financially supports students; this year we provided over $75,000 in undergraduate scholarship and graduate awards to the next generation of aerospace professionals.

The AIAA Foundation recently received a $1 million grant from Blue Origin's Club for the Future. We are finalizing the strategy to inspire the most students with this gift. We'll do more of what we know works, and also try new, innovative programs that engage young hearts and minds to fuel the next generation of aerospace professionals. Through our partners and donors, the AIAA Foundation looks forward to reaching even more educators and students with resources, experiences, and programming.

Please consider making your own donation in honor of the AIAA Foundation's 25th anniversary; every donation makes an impact. For more information please visit aiaa.org/foundation or contact Alex D'Imperio, alexandrad@aiaa.org.

MAKING AN IMPACT

Scholarship and Graduate Award Winners

Each year, AIAA distributes over $70,000 in scholarships and graduate awards to undergraduate and graduate students studying aerospace engineering at accredited colleges and universities throughout the United States. In 2021, AIAA scholarship and graduate award winners came from all corners of the aerospace industry and are studying a variety of topics from digital avionics to hypersonics. Below, we profile this year's 20 scholarship and graduate award winners who are shaping the future of aerospace.

AIAA Graduate Award Winners

Neil Armstrong Graduate Award
Alexis Harroun
Purdue University
Amount of Award: $5,000

Alexis is a Ph.D. student in the school of Aeronautical and Astronautical Engineering at Purdue University. She currently researches rotating detonation engines and how to improve chemical rocket engine performance. Alexis graduated with her master's from Purdue in 2019 and her bachelor's from the department of Aeronautics and Astronautics at the University of Washington in 2017. She is a member of the AIAA Young Professionals Group and the ASCEND Guiding Coalition. Alexis is a National Defense Science and Engineering Graduate Fellow and was one of Aviation Week's 20 Twenties in 2019.

I am truly honored to receive the AIAA Neil Armstrong Award. The AIAA has contributed significantly to my educational and professional development and I am appreciative of how this award will support me as I continue my graduate studies.

Orville & Wilbur Wright Graduate Awards
Abhishek Shastry
University of Maryland, College Park
Amount of Award: $5,000

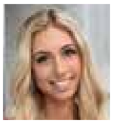
Abhishek is a doctoral student at University of Maryland. His present research pursuits at the Alfred Gessow Rotorcraft Center are on eVTOL aircrafts and UAVs for green electric aviation. In the future, he plans to explore entrepreneurship options in the field.

Receiving this AIAA award which is named after the pioneers of aviation means a lot to me. It says that leaders of aviation today trust me to revolutionize the industry tomorrow.

Akanksha Baranwal
Texas A&M University
Amount of Award: $5,000

Akanksha is a Ph.D. candidate in the department of aerospace engineering at Texas A&M University, working under the supervision of Dr. Diego Donzis. She holds Bachelor of Technology and Master of Technology degrees in aerospace engineering from the Indian Institute of Technology, Madras, India. Her Ph.D. dissertation focuses on fundamental understanding and modeling of momentum transport and non-equilibrium energy transport processes in high-speed turbulent flows using massively-parallel, high-fidelity simulations. She aims to pursue a career in research and academia. Akanksha wishes to gain expertise in wide-ranging physics in the broad field of fluid mechanics and thermal sciences and provide robust engineering solutions utilizing powerful tools such as high-performance computing and data-driven modeling techniques.

This award inspires me to continue my efforts towards my research and contribute to the progress of the field. This recognition would facilitate me in gaining wide experience in the company of erudite personalities of the field at various fora and better equip me to mentor the next generation of aerospace engineers.



Dr. Hassan A. Hassan Graduate Awards in Aerospace Engineering
Paige Drummond
North Carolina State University
Amount of Award: $5,000

Paige graduated in May 2021 with a Bachelor of Science degree in Aerospace Engineering. Throughout her undergraduate studies she was particularly interested in aerodynamics and computational fluid dynamics. This passion led her to pursue a Master of Science degree in Aerospace Engineering at NCSU with a concentration in computational fluid dynamics beginning in Fall 2021. During her graduate studies she will be working on a research project related to supersonic combustion and internal flows. She aspires to have a career in a technical company focused on applied research where she can utilize the skills she will gain from her graduate studies, as well as those she has built through her undergraduate degree, to design and analyze hypersonic vehicles.

Receiving this award is a great honor and has significantly reduced the financial burden associated with pursuing a graduate degree. This award will allow me to focus entirely on my graduate studies and research which will help me develop into a better Aerospace Engineer and best prepare for my desired career.

Evan Waldron
North Carolina State University
Amount of Award: $5,000

Evan is pursuing a Master's Degree at North Carolina State University in Aerospace Engineering, with a concentration in dynamics, vibrations, and controls. He also has an FAA Commercial Pilot Certificate with an Instrument Rating, and is planning on pursuing a Flight Instructor Certificate. He hopes to focus on controls for aerospace systems in his career. One of his main goals is to work as a guidance, navigation, and control engineer for NASA or a commercial spaceflight company.

Receiving the Dr. Hassan A. Hassan Graduate Award will help me complete my graduate studies and better prepare me to work as a controls engineer in the aerospace industry.

Luis de Florez Graduate Award
Laurens Voet
Massachusetts Institute of Technology
Amount of Award: $3,500

Laurens is a third-year Ph.D. student at the Gas Turbine Laboratory and the Laboratory for Aviation and Environment at MIT. His research focuses on quantifying the environmental impact of supersonic transport in terms of its take-off noise and emissions. Originally from Belgium, Laurens graduated with a BSc in Aerospace Engineering from Delft University of Technology, and obtained a MSc in Computational Methods in Aeronautics from Imperial College London, UK. After his undergrad, Laurens joined the Formula Student Team Delft as a full-time aerodynamics engineer and chief of CNC manufacturing. As part of his Ph.D., Laurens also interned at Aerion Supersonic. After his graduate studies, Laurens aspires to pursue a career in aerospace to develop projects having a positive impact on the world.

I am very grateful to receive the AIAA Luis de Florez graduate award. It is a recognition of my work, giving me a morale boost to keep pushing myself, and stimulating me to continue striving for excellence.

Guidance, Navigation, and Control Graduate Award
Oliver Jia-Richards
Massachusetts Institute of Technology
Amount of Award: $2,500

Oliver is currently a doctoral candidate and NASA Space Technology Research Fellow in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology where he also earned his S.B. and S.M. degrees. His research is on the use of microfabricated electrospray thrusters for the exploration of planetary bodies ranging from small asteroids to planets with a particular focus on the coupling between the propulsion and guidance and control subsystems. After graduation he intends to pursue a career in academia.

Receiving this award will help me to continue to explore research topics at the intersection of propulsion and guidance, navigation, and controls.

John Leland Atwood Graduate Award
Christopher Axten
Pennsylvania State University
Amount of Award: $1,250

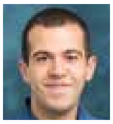
Christopher is a Ph.D. student studying Aerospace Engineering at Pennsylvania State University. His doctoral work focuses on the use of boundary layer transition modeling in computational fluid dynamics for aircraft design. Additionally, he is studying the effects of Görtler instabilities on slotted, natural-laminar-flow airfoils. He seeks to use his knowledge in aircraft design and background laminar flow modeling techniques to contribute to the creation of future laminar flow aircraft, such as the first laminar flow commercial airplane. He has completed internships with Naval Air Systems Command (NAVAIR), General Atomics: Aeronautical Systems, The Boeing Company, and the Army Aviation Development Directorate.

Receiving the John Leland Atwood Graduate Award is enormous to me. The award will help enable me to continue my graduate work; however, more than that, it demonstrates to me how vital and impactful my research is, which energizes me to pursue it all the more.

Martin Summerfield Propellants and Combustion Graduate Award
Hiba Kahouli
University of Southern California
Amount of Award: $1,250

Hiba is currently a third-year Ph.D. student at the University of Southern California's Viterbi School of Engineering. She is investigating the effects of pressure and fuel on the characteristics of highly turbulent jet flames with the end goal of improving the performance of jet engines. After receiving her graduate degree, she hopes to pursue her long-lived passion for high-speed flight and work toward the design of supersonic air-breathing propulsion systems. Before joining the Trojan family in 2018, Hiba obtained her Bachelor's Degree in Aerospace Engineering from the University of Notre Dame. Although she calls both Los Angeles and South Bend home, Hiba hails from Tunisia, the beautiful North African, Mediterranean country where she first fell in love with airplanes.

It is a great honor to be recognized as recipient of the Martin Summerfield Propellant and Combustion Graduate Award. I hope this serves as an incentive for me to persevere when the path gets turbulent and that I may one day inspire a younger generation to take on the exciting challenges of combustion and propulsion.

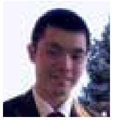


Gordon C. Oates Air Breathing Propulsion Graduate Award
Anil Yildirim
University of Michigan
Amount of Award: $1,000

Anil is a Ph.D. candidate in Aerospace Engineering and Scientific Computing in the Multidisciplinary Design Optimization Laboratory (MDO Lab), led by Prof. Joaquim R.R.A. Martins at University of Michigan. His research focuses on developing robust and high-performance tools for MDO applications, and applying these tools to multidisciplinary aircraft design problems. His research vision is to develop methods that can utilize the ever-growing power of scientific computing resources in the design of environmentally sustainable aircraft. His Ph.D. research focus is aeropropulsive design optimization, in which the aerodynamic and propulsion system designs are optimized in a coupled manner. He is working on this topic in collaboration with Dr. Justin S. Gray at NASA Glenn Research Center.

I am honored to receive the Gordon C. Oates Air Breathing Propulsion Graduate Award with my work on aeropropulsive design optimization. It is reassuring to know that experts in the field of aircraft propulsion see the value of this research topic, and I am excited to make more progress in this field.

AIAA Undergraduate Scholarship Winners



Daedalus 88 Scholarship
Matthew Tan
Stanford University
Amount of Scholarship: $10,000

Matthew is a rising Junior at Stanford University studying Aero/Astro Engineering and Computer Science, where he helps lead the Aerospace Club and Student Space Initiative. He plans to pursue a graduate degree in Aerospace after which he hopes to work in the field of autonomy and flight dynamics. His long-term goal is to contribute to the development of next-generation aircraft designs, particularly to advance efficiency, autonomy, and safety. Additionally, Matthew would like to lower the barrier of entry to aerospace, making general aviation and personal flying more accessible and sustainable.

I am so grateful to have received this scholarship, which will go a long way in supporting my education. Most importantly, the encouragement and support I have received continues to motivate me to work hard and make the most of this opportunity to achieve my goal of developing the future of aviation.

David and Catherine Thompson Space Technology Undergraduate Scholarship
Noshin Nawar
University of Arkansas
Amount of Scholarship: $10,000

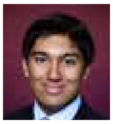
Noshin is pursuing a Bachelor of Science in Mechanical Engineering with an Aerospace Concentration at the University of Arkansas. She is currently interning in Houston, TX, for NASA Johnson Space Center in the PSION lab, researching astronaut exercise devices and software interfaces. She plans to become a professor of aerospace engineering, focusing research in electric propulsion (EP), and she aspires to become an civil servant astronaut at NASA, to someday conduct research on EP systems and more from space.

I was originally afraid I could not complete my degree due to a lack of financial ability to cover tuition. Thanks to AIAA and the Thompson family, I will now be able to complete my undergrad education and hopefully go on to pursue my PhD in Aerospace Engineering, focused on electric propulsion systems design.

Vicki and George Muellner Scholarship for Aerospace Engineering
Umar Padela
Harvard University
Amount of Scholarship: $5,000

Umar is a rising junior at Harvard studying mechanical engineering with an interest in aerospace. He has been involved with his school's aeronautics and rocketry teams for the past two years, and he is currently working with Boeing as a propulsion engineering intern. In the future, he hopes to attend graduate school for a Master's degree in aerospace. After graduate school, he would like to pursue a job related to aircraft design.

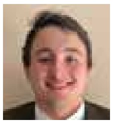
This scholarship will allow me to focus on my education and spend more time conducting aerospace related research, which will help me in applying to graduate schools.



Wernher von Braun Undergraduate Scholarship
Satvik Kumar
Georgia Institute of Technology
Amount of Scholarship: $5,000

Airplanes have fascinated Satvik since childhood and he was always known as the plane geek. Although he was always intrigued with aviation, he developed interest in rocketry, space exploration, and vertical flight after he started his Aerospace degree program and listening to space-related presentations during his NASA internships. Throughout his time at Georgia Tech as well as his internships at the NASA Ames Research Center, he has been conducting research. Being involved in groundbreaking research in the Aerospace field has been enthralling and continues to fascinate him. His future plan is to attend graduate school following his undergraduate degree to continue aerospace research, whether it is at the university level or at a research-oriented organization such as NASA.

Dreams, motivation, hard work, and focus have always been my recipe for success. Winning this scholarship has made one of my dreams come true and motivates me to work hard, soar to new heights, and reach higher goals.



Cary Spitzer Digital Avionics Scholarship
Alexander Gross
Texas A&M University
Amount of Scholarship: $2,000

Alexander is pursuing a degree in Aerospace Engineering with minors in Mathematics and Computer Science. While studying engineering in college, he plans to pursue co-op and internship opportunities to obtain real-world experience that he could apply further into his studies toward his degree and future career. Additionally, as an undergraduate researcher in the Texas A&M Vehicle Systems and Control Laboratory, he is continuously obtaining applicable knowledge in his field. Due to his admiration and passion for engineering feats in human spaceflight and space exploration, he aims to work in the aerospace industry as a vehicle guidance, navigation, and control engineer for spaceflight vehicles.

Throughout my collegiate career, I have always pursued avenues to continue my educational and professional development. Receiving this scholarship greatly reduces the financial burden necessary to continue my education, allowing my goal to enter the aerospace industry to become increasingly real every day.

Dr. Amy R. Prichett Digital Avionics Scholarship
Kiseuk Ahn
Bellevue College
Amount of Scholarship: $2,000

Kiseuk graduated this spring from Bellevue College, and is now transferring to Stanford University to complete his bachelor's degree in Mechanical Engineering. He is a 2020 All-Washington Academic Team Scholar, Washington NASA Space Grant Scholar, NASA Community College Aerospace Scholar, and the 2021 Jack Kent Cooke Undergraduate Transfer Scholar. He was an undergraduate research intern at Pacific Northwest National Laboratory before joining NASA Langley Research Center as the SCALPSS Lunar Lander structural analysis intern. Through advanced engineering courses, student-led organizations, and cutting-edge research opportunities, he hopes to continue broadening the horizons to better understand how an aircraft's future design and technology can be implemented more efficiently to reduce harmful environmental effects.

This scholarship will not only financially help me to better focus on my studies, but it also instilled in me better confidence to believe in my ability to continue pursuing a challenging endeavor to create a better tomorrow as an aspiring research scientist.

Dr. James Rankin Digital Avionics Scholarship
Elton Shinji Okuma Hayachiguti
Georgia Institute of Technology
Amount of Scholarship: $2,000

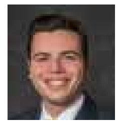
An intense love for airplanes made Elton pursue the best education possible in aerospace engineering. He left home in Guarulhos, Brazil, to study at Georgia Institute of Technology. After three years doing research in experimental aerodynamics, computational fluid dynamics, and systems engineering, as well as having built many aircraft with Georgia Tech's Design/Build/Fly team, he is happy to say that he wants to become an aircraft designer. He will pursue a graduate degree to further develop his knowledge before working toward a position in the industry where he can help create the next generation of airplanes.

Being recognized by AIAA is an incredible honor that motivates me to pursue knowledge and excellence in aerospace engineering even further. I will use this scholarship to fund my education, taking more technical courses relevant to aircraft design and safety before starting my career as an aerospace engineer.

Ellis F. Hitt Digital Avionics Scholarship
Noah Jacobs
University of Alabama in Tuscaloosa
Amount of Scholarship: $2,000

Noah is a Sophomore University Fellow at the University of Alabama studying computer science and aerospace engineering. He is passionate about activism in environmental conservation, and in his spare time, he enjoys hiking, volunteering at his local planetarium, and developing flight software for the UA Space Cube Satellite Team. He hopes to pursue a career in programming machine learning and computer vision algorithms for autonomous spacecraft, and also hopes to eventually open his own planetarium!

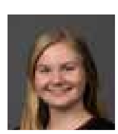
I am so thankful to have been granted the Ellis F. Hitt Digital Avionics Scholarship – knowing that I will have the financial capital to move forward in my aerospace education takes a huge burden off of my shoulders. I hope to use this money to propel myself into my future career as an aerospace engineer!



Space Transportation Scholarship
Ryan Udell
Rice University
Amount of Scholarship: $1,500

Ryan is a recent graduate of Rice University with a B.S. in Mechanical Engineering and a Certificate in the Rice Center for Engineering Leadership. He currently works at Boeing as a Systems Engineer in the Boeing Satellite Systems Engineering Rotation Program. He is the current External Affairs Director for the Students for the Exploration and Development of Space (SEDS-USA) and the former President of Rice University's SEDS chapter. He is also a founding partner of the Zed Factor Fellowship, an internship and community outreach program for underrepresented students interested in pursuing aerospace careers. In these roles, he strives to make an impact on students to explore space by developing immersive and hands-on programs.

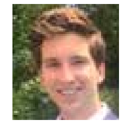
The AIAA scholarship will help me pursue my passion for human exploration and spaceflight!



Leatrice Gregory Pendray Scholarship
Rebekah Geil
Georgia Institute of Technology
Amount of Scholarship: $1,250

Rebekah is a 3rd-year aerospace engineering student at Georgia Institute of Technology. After a summer internship with the Air Force Research Laboratory working on deployable structures, she began taking part in undergraduate research in Model-Based Systems Engineering (MBSE). This summer, Rebekah is working with Tietronix Software, applying MBSE to risk management for NASA projects. In the future, she hopes to pursue a master's degree and then a career in human space exploration and operations.

To me, this scholarship goes beyond generous financial assistance. It shows me that the aerospace community is with me, and I am encouraged by your faith in my future.



Rocky Mountain Section Scholarship
Jarod Spencer
Colorado School of Mines
Amount of Scholarship: $500

Jarod is an Engineering Physics major at Colorado School of Mines with a minor in Space & Planetary Science & Engineering. His life vision is to use his talents, knowledge, and passion for space to push humanity into the future, especially a multi-planetary one. To that end, he is pursuing a career in aerospace and astronautics; he wants his work to mean something, and he refuses to be just another brick in the wall. And one day, that means going to space himself.

Thank you so much to AIAA RMS for this scholarship and also to everyone who has ever supported me in my journey! I couldn't be where I am without you. This scholarship will do wonders to relieve financial stress in my life as well as my family's. Now, I will have fewer loans to deal with after college and more freedom to chase my dreams!

Applications for the 2022 scholarships are being accepted from 1 October to 31 January

at aiaa.org/home/get-involved/students-educators/scholarships-graduate-awards. For information about how to get involved with AIAA and make an impact on the next generation of aerospace engineers, please visit aiaa.org/get-involved or contact Merrie Scott, merries@aiaa.org or contact Michael Lagana at scholarships@aiaa.org.

AIAA STANDARDS

ARC
AEROSPACE RESEARCH CENTRAL

It is crucial for aerospace students and professionals to have access to the latest standards in the industry. Using AIAA Standards encourages industry best practices and leads to economies of scale, expanded trade possibilities, and increased resource flow.

Accredited by the American National Standards Institute, AIAA manages an extensive range of national aerospace standards activities leading to the publication of Standards, Recommended Practices, and Guides. In addition to its primary focus on aerospace standards, AIAA also administers two subcommittees of the International Organization of Standardization.

Current Standards List (Topics/Subtopics)

Aeronautics

- Aviation and Aircraft
- UAVs
- Systems Engineering and Project Management
- Mission Assurance

Modeling, Simulation and Testing

- Ground Testing
- Computational Fluid Dynamics
- Atmospheric, Orbital and Space Environment Models

Space Systems and Vehicles

- Spacecraft Architecture
- Space Systems › Space Operations
- Launch Vehicles
- Space Power and Propulsion
- Safety
- CCSDS Space Link Extensions

Provide your institution with the best and most current guidelines for industry-wide practices by purchasing AIAA Standards.

arc.aiaa.org/r/standards

AIAA
SHAPING THE FUTURE OF AEROSPACE

Obituaries

Associate Fellow Duffy Died in February

Charles "Pat" Duffy Jr. died on 28 February.

Duffy graduated from the University of Idaho with a B.S. in Civil Engineering and as a Cadet Colonel in the Army ROTC (Distinguished Military Graduate/ROTC Gold Medal from the Society of American Military Engineers). After earning his M.S. degree in Civil Engineering at the University of Idaho, he served as a First Lieutenant with the Army Combat Engineers in Germany for two years.

Moving to Seattle, Duffy began a 35-year engineering career at The Boeing Company. He held key management positions in both the commercial airplanes and the defense and space divisions in the areas of human resources, industrial and labor relations, business management, corporate strategic planning, and acquisition of new business opportunities throughout the United States, Europe, the Middle East, and Africa. He also served as Vice President of the Boeing Management Association. Duffy retired in 1992 as Director of Operations, Business, and Quality Improvement for Boeing's Defense and Space Group.

Duffy dedicated many years of service to AIAA, serving as Region VI Director in the 1970s and as a Vice President. He worked on various committees, and also attended countless conferences and workshops across the country.

AIAA Senior Member Bhatia Died in April

Manav Bhatia died on 15 April.

He received his Ph.D. in 2007 from the University of Washington, where he worked on the problem of computational design procedures for high-speed flight vehicles. He gained industry experience as a Loads and Dynamics Engineer at Aviation Partners Boeing, before moving to Virginia Tech as a Post-Doctoral Research Associate. Bhatia also worked as a Research Engineer at the Air Force Research Laboratory, Wright-Patterson Air Force Base.

In 2014, Bhatia joined the Department of Aerospace Engineering at Mississippi State University, where he was an associate professor. Bhatia was a member of the Multidisciplinary Design Optimization Technical Committee, and he recently served as the Education Subcommittee Chair. He was a frequent attendee at the AIAA SciTech and AIAA AVIATION Forums.

AIAA Associate Fellow Scammell Died in May

Frank Scammell died on 3 May 2021 at the age of 88 years old.

Scammell received his B.S. and M.S. in Aeronautical Engineering from MIT. Early in his career, he developed new gyroscopes at Lincoln Labs, and then worked at Avco and Draper Labs on a variety of aerospace engineering projects, including missile defense, and received patents on novel mirrors for lasers. He cared deeply about the defense

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- Hap Arnold Award for Excellence in Aeronautical Program Management
- James A. Van Allen Space Environments Award
- Jeffries Aerospace Medicine and Life Sciences Research Award
- Lawrence Sperry Award
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Please submit the nomination form and endorsement letters to **awards@aiaa.org** by **1 October 2021.**

For nomination forms or more information about the AIAA Honors and Awards Program and a complete listing of all AIAA awards, please visit **aiaa.org/awards.**

AIAA SHAPING THE FUTURE OF AEROSPACE

of the United States, and in the 1980s, he worked at the Strategic Defense Initiative in Washington, DC, where he was Group Leader of Innovative Architecture.

AIAA Associate Fellow Stewart Died in June

Robert "Bob" Stewart died on 22 June 2021, one day after his 90th birthday.

He received a degree in Aeronautical Engineering from New York University and his entire professional career centered around aviation. He went to work for Grumman Aircraft on Long Island, as well as at the Redstone Arsenal in Huntsville, AL, until he was hired by Beechcraft in Wichita. He then moved to Savannah with the newly formed Gulfstream Aircraft Company.

He eventually left engineering to begin a career in private flight instruction. For many years he taught basic and instrument flying to students in Savannah working primarily through Savannah Aviation. With all the "touch and go's" he suffered through for all the years, it is acknowledged that he likely has logged more takeoffs and landings at the Savannah Airport than any other pilot. In addition to his teaching, he was also the FAA designated pilot examiner out of the Hilton Head airport for many years. Well into his 80s, he served on the national FAA committee to revise and update pilot training.

He was active in several aviation societies, and was a proud charter member of the HHI hangar of the Quiet Birdmen.

Remembrances may be made in memory of Stewart to the AIAA Foundation, aiaa.org/foundation.

Associate Fellow Bailey Died in June

Colonel Austin James Bailey, Jr. died on 24 June. He was 99 years old.

In 1941, he attended Northeastern University, College of Engineering in Boston where he completed Civilian Pilot Training, thereby launching a career as a military pilot followed by a career as an engineering test pilot.

He enlisted in the U.S. Navy in 1942 and flew as a Marine Corsair fighter pilot in the Pacific. After World War II, he completed engineering school, graduating in 1950. Soon after, he was recalled for the Korean Conflict. He was shot down over North Korea and rescued in the Yellow Sea.

In 1952, Bailey joined Honeywell as an engineering test pilot. He tested flight controls for automated carrier landings, fly by wire, side stick controls, and fire control systems for such aircraft as the F2H-3, Canadian CF-100, F-100, and F-101. He participated as a test crewman in the human factors review of the Mercury Space Capsule design, as well as working with Scott Crossfield and Neil Armstrong on the X-15 flight control system. Additionally, Bailey worked on the flight controls for the SR-71 and the X-20 orbital space vehicle. As a test pilot and consultant, he worked with the Swedish Royal Air Force on systems for the SAAB fighter series.

For his achievements, Bailey was recognized with many awards including the Safety Award from the USAF for accident-free test operations in 1961. He was awarded a Silver Cup for the success of the Microwave Landing System Tests. In 2003, he was inducted into the Minnesota Aviation Hall of Fame. Most notably, in 1979, he was awarded the Octave Chanute Flight Award (now the AIAA Chanute Flight Test Award), a national award that recognized his outstanding engineering skills and expert test pilot capabilities to develop several advanced flight control systems.

He was a member of the Society of Experimental Test Pilots, AIAA, the Minnesota Business Aircraft Association, and the Quiet Birdmen.

AIAA Fellow Lagacé Died in July

Paul Lagacé, a professor of aeronautics and astronautics at MIT, died 16 July. He was 63 years old.

Lagacé received his bachelor's degree in aeronautics and astronautics in 1978, his master's in 1979, and his Ph.D. in 1982. He joined the MIT faculty in the Department of Aeronautics and Astronautics in 1982, where his research focused on the design and manufacture of composite structures and materials mainly used in the aerospace industry. The Technology Laboratory for Advanced Materials and Structures (TELAMS), his research laboratory, worked on research ranging from characterizing a basic understanding of composite materials to exploring their behavior in specific structural configurations to computational modeling in solid mechanics. The lab also worked on the design, fabrication, and testing of micro-electromechanical systems (MEMS), along with their associated materials and processes.

Lagacé was widely recognized for his research in response and failure of composite structures, and the development of composite structures technology and the safety of aircraft structural systems. He was often asked to be an advisor and consultant to industry and government agencies on aspects of structural technology and broader engineering systems. He served as a consultant, expert witness, and member of committees and panels in the investigation of accidents and their implications.

Lagacé was a Fellow of AIAA, the American Society for Composites, and the American Society for Testing and Materials (now known as ASTM International). He served as president of the International Committee on Composite Materials and was recognized as a World Fellow of Composites and Honorary Member of the Executive Council.

In addition to his research, Lagacé taught courses in mechanics of materials and structures with special emphasis on composite materials and their structures. In 1995, he was named a MacVicar Faculty Fellow, an honor that recognizes outstanding classroom teaching, significant innovations in education, and dedication to helping others achieve teaching excellence. He served as co-director of the MIT Leaders for Manufacturing and Systems Design and Management programs. Drawing on his own experience as a first-generation college student, Lagacé was instrumental in launching MIT's First-Generation Program.

Outside of MIT, Lagacé found a way to integrate his love of the Red Sox with his aeronautical knowledge into a real-life problem set for his students. In the early 1990s, Lagacé observed that fewer balls seemed to reach the center field stands. He worked with his undergraduate students to construct a model of Fenway Park, which they then tested in MIT's Wright Brothers Wind Tunnel to simulate the wind and baseball trajectory pathways. He concluded that a recently constructed press box created a wind vortex that prevented baseballs from reaching as far as they used to.

TEXAS A&M UNIVERSITY
Department of Aerospace Engineering

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Tenure-Track or Tenure Review Upon Hire (either)
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The Department of Aerospace Engineering, College of Engineering at Texas A&M University invites applications for a full-time tenured or tenure-track faculty position with a 9-month academic appointment, and the possibility of an additional summer appointment contingent upon need and availability of funds, beginning Fall of 2021. Applicants will be considered for the faculty titles of assistant, associate and full professor. Candidates should have expertise in: reactive flows, computational and numerical: computational combustion, computational propulsion, numerical algorithms and code development; experience using numerical simulations with high-performance computing and computers to understand and study reactive flows; all fluid regimes of interest, studies of fundamental reactive flow and combustion, as applied to energy, safety, and propulsion; experience in flame or shock and detonation physics.

The successful applicants will be required to teach; advise and mentor graduate students; develop an independent, externally funded research program, participate in all aspects of the department's activities, and serve the profession. Applicants must have an earned doctorate in aerospace engineering or a closely related science discipline. Strong written and verbal communication skills are required. Applicants should consult the department's website to review our academic and research programs (**https://engineering.tamu.edu/aerospace**).

Applicants must have an earned doctorate in aerospace engineering or a closely related engineering or science discipline.

Applicants should submit a cover letter, curriculum vitae, teaching statement, research statement, diversity statement and a list of four references (including postal addresses, phone numbers and email addresses) as part of the application package to be submitted for the above position at **apply.interfolio.com/87351**. Full consideration will be given to applications received by November 30, 2021. Applications received after that date may be considered until positions are filled. It is anticipated the appointment will begin fall of 2022. Questions regarding this position should be sent to Kathleen del Mar **kathleendelmar@tamu.edu**

Texas A&M University is committed to enriching the learning and working environment for all visitors, students, faculty, and staff by promoting a culture that embraces inclusion, diversity, equity, and accountability. Diverse perspectives, talents, and identities are vital to accomplishing our mission and living our core values.

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JAHNIVERSE

CONTINUED FROM PAGE 64

other domain, land and sea, before humans traveled routinely, those most resourced led the way. So, praise everyone making space more accessible to more people. However, when we explored land and sea, evidence shows that we did so to the detriment of the environment. So, we must continue to excitedly explore space and concurrently engage in behaviors and activities that maximize environmental protection and sustainability. Additionally, the only way that humanity can extend its expiration date as a species will be to figure out how to thrive elsewhere in the universe. Our expiration date could come as a result of several sources, from being too slow to address climate change, to a rogue asteroid wiping us out like the dinosaurs, or eventually, our sun going boom. Staying on Earth spells a guaranteed end for us, so we all need to get behind environmentally responsible space exploration. ★

EMBRY-RIDDLE Aeronautical University

Faculty Positions in the Department of Aerospace Engineering
Embry Riddle Aeronautical University, Daytona Beach

The Department invites applications for several tenure-track faculty positions at the rank of Assistant Professor or Associate Professor. Successful applicants should demonstrate a potential to establish and grow a strong externally funded research program and to excel at teaching and mentoring graduate and undergraduate students. The preferred areas of expertise are astronautics & space applications, hypersonics & rocket propulsion, experimental aerodynamics as well as composites & additive manufacturing. In addition, the department is looking for potential faculty (possibly non-tenure track-teaching positions) interested in teaching design, i.e. spacecraft, rocket engine, airplane, and jet engine design. However, applicants in all areas of Aerospace Engineering will be considered.

Current research thrust areas of the Department include: astrodynamics, guidance, navigation and control, unmanned and autonomous robotic systems, urban air mobility, computational fluid dynamics, aeroacoustics, rotorcraft aerodynamics, flow control, alternative propulsion, air-breathing hypersonic and rocket propulsion, aeroelasticity, composites, nanomaterials, smart materials, structural health monitoring, computational structural mechanics, and design optimization.

The Aerospace Engineering Department, the largest in the nation with an enrollment of over 2,000 full-time students, offers Bachelor, Master, and Ph.D. degrees, including 42 students in the PhD program. The undergraduate program is currently ranked #8 and the graduate program is ranked #25 (tied) by the U.S. News and World Report. To achieve national prominence, the Department has launched an ambitious agenda focused on expanding the graduate programs, facilities, recruiting talented faculty, and building research infrastructure and capabilities, In support of this agenda, the University has invested in a new 50,000 square foot engineering building, the John Mica Engineering and Aerospace Innovation Complex (MicaPlex), housing several research laboratories (**https://erau.edu/research-park/micaplex/labs**) a state-of-the-art subsonic wind tunnel, and a new Flight Research Center facility, all as part of a Research Park with incubator space and growing number of industry creating an echo system to support innovation and entrepreneurship.

Embry Riddle Aeronautical University (ERAU), the world's largest, fully accredited university specializing in aviation and aerospace, offers more than 70 Baccalaureate, Master, and Ph.D. degree programs in Arts & Sciences, Aviation, Business, and Engineering. ERAU's eastern campus is located at Daytona Beach and serves a diverse student body of approximately 7,500 students.

Candidates should have an earned Doctorate in Aerospace Engineering or a closely related field. For non-tenure track positions, a PhD degree could be replaced by an MS and substantial industrial experience. Women and underrepresented minorities are especially encouraged to apply. Applicants must submit a single document that includes: (1) a cover letter, (2) a Curriculum Vitae, (3) teaching philosophy, (4) a research plan, and (5) the names and contact information of at least three references. For more information about the position and application process, please visit our careers site - **https://careers.erau.edu/** and click on Career Search to find requisition no. R301537. For full consideration, candidates are encouraged to apply before September 15th, 2021. Screening of the applications will start upon receipt and will continue until the positions are filled.

LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1921

1 **Sept. 18** U.S. Army Air Service Lt. J.A. Macready sets a world altitude record when he flies to 34,508 feet in his LePere fighter. E.M. Emme, **Aeronautics and Astronautics, 1915-60**, p. 14.

2 **Sept. 23** The U.S. Army Air Service starts day and night bombing exercises against the USS Alabama in the Chesapeake Bay with Martin MB-2 heavy bombers and DH-4B light bombers. The old battleship withstands all of the attacks on the first day, but eventually succumbs to hits from several 900-kilogram (2,000-pound) bombs. E.M. Emme, **Aeronautics and Astronautics, 1915-60**, p. 14.

3 **Sept. 26** French pilot Joseph Sadi-Lecointe flies his Nieuport Delage ND-29 to a record speed of 205.82 mph (331 kph). He is the first to exceed 200 mph. His aircraft is powered by a Hispano-Suiza 42 V-8 engine. David Baker, **Flight and Flying: A Chronology**, p. 140.

1946

Sept. 1 British European Airways Corp. begins its London-Copenhagen service flying a Vickers Viking carrying 14 passengers plus a crew. The flight takes three hours and 25 minutes. Other new BEA routes that begin this month include London-Oslo and London-Amsterdam. **The Aeroplane**, Sept. 6, 1946, p. 288, and Sept. 18, 1946, p. 312.

4 **Sept. 7** E.M. Donaldson, a British Royal Air Force Group captain, breaks the world speed record with a 1,000 kph (615 mph) flight in an improved Gloster Meteor IV jet near Rustington, Sussex, England. F.K. Mason and M. Windrow, **Know Aviation**, p. 52.

Sept. 17 An experimental solid-fuel booster for the Nike-Ajax anti-aircraft missile is tested for the first time at White Sands Proving Grounds in New Mexico. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 54.

Sept. 22 Invited by Argentina's secretariat of aeronautics, the British Royal Air Force sends a Coastal Command de Havilland Mosquito Mk.34 to Buenos Aires on a goodwill mission as part of celebrations to mark the first Argentine Aeronautical Exhibition. **The Aeroplane**, Oct. 4, 1946, p. 381.

5 **Sept. 27** Geoffrey de Havilland Jr., son of the British aircraft designer and chief test pilot of the company, is killed while piloting a de Havilland DH-108 Swallow sweptback research jet in an attempt to exceed the speed of sound. While attaining the plane's highest speed in level flight, the Swallow breaks up over the Thames Estuary in England. **The Aeroplane**, Oct. 4, 1946, p. 380; F.K. Mason and M. Windrow, **Know Aviation**, p. 52.

Sept. 29-Oct. 1 A new nonstop world distance flight record of 11,235 miles (18,000 kilometers) is set by the "Truculent Turtle," a U.S. Navy Lockheed P2V Neptune flown by Cmdr. Thomas Davis and a crew of four from Perth, Australia, to Columbus, Ohio. Gordon Swanborough and Peter Bowers, **United States Navy Aircraft Since 1911**, p. 284.

Sept. 30 A group of engineers, instrument technicians and technical observers is ordered to temporary duty from the National Advisory Committee for Aeronautics' Langley Lab to the Air Force test facility at Muroc, California, to assist in the flight of the Bell X-1 rocket research aircraft. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60,** p. 54.

1971

Sept. 1 Preliminary results of the experiments conducted during the Apollo 15 mission are reported at a Marshall Spaceflight Center briefing in Alabama. Among these, the Apollo 15 seismometer network detected 30 events including "the most significant" one yet recorded on the moon. This is a moonquake occurring 800 kilometers beneath the surface and at a far greater depth than any quake found on Earth. It was centered about 400 km west of the Tycho crater. The data also reveals swarms of quakes occurring more intensely and regularly than on Earth. **Washington Post**, Sept. 2, 1971, p. A1.

6 **Sept. 1** The second flight model of the Lunar Roving Vehicle is delivered by Boeing to NASA's Kennedy Space Center in Florida for the upcoming Apollo 16 mission. NASA, **Marshall Spaceflight Center Release 71-166**.

Sept. 2-11 The Soviet Union launches its Luna 18 uncrewed probe to the moon. It reaches the moon's surface on Sept. 11 near the Sea of Fertility although the Tass news agency announces that communications ceased at 3:48 a.m. Eastern time indicating the probe crash-landed. NASA, **Astronautics and Aeronautics, 1971**, p. 246.

Sept. 4 The Anglo-French supersonic Concorde 001 prototype transport aircraft leaves Toulouse, France, for Cayenne in French Guiana on the initial leg of its first transatlantic test flight to Rio de Janeiro. NASA, **Astronautics and Aeronautics, 1971**, p. 248.

Sept. 5-11 The first U.S.-Soviet conference on Communication with Extraterrestrial Intelligence is held at the Byurakan Astrophysical Observatory in Armenia. It is sponsored jointly by the U.S. and Soviet Academies of Science and organized by Soviet astronomer Iosif Shklovsky and Cornell University astronomer Carl Sagan. The scientists conclude that civilization in another solar system "a few hundred light years away" might be trying to communicate with other bodies, including Earth. They also recommend coordinated worldwide efforts to attempt to detect such efforts with powerful radio-telescopes. **New York Times**, Sept. 19, 1971, p. 4.

Sept. 6 The Soviet supersonic Tu-144 transport aircraft flies to Bulgaria on its second flight outside the Soviet Union. The aircraft first appeared outside the country when it was taken to France for the Paris Air Show. During its return flight it reaches a speed of 2,300 kph. **New York Times**, Sept. 7, 1971, p. 62.

Sept. 8 The U.S. and Soviet Union agree to replace the Washington-to-Moscow teletype "hot line" link with a communications satellite service capable of providing an instantaneous link between the capitals in any crisis. Preliminary arrangements were worked out by U.S. and Soviet communications experts at one of the Strategic Arms Limitation Talks in Helsinki. The system will use existing communications satellites by both countries. **Washington Post**, Sept. 8, 1971, p. 3.

Sept. 8-10 NASA and the United Cerebral Palsy Research Foundation sponsor a joint conference at NASA's Ames Research Center in California on people with neurological problems. Scientists, physicians and engineers discuss applications of space age technology to neurological disorders. **NASA Release 71-161**.

Sept. 17 The age of Apollo 15's "Genesis rock" is announced to be about 4.15 billion years by scientists of the State University of New York. The anorthosite sample brought back by the Apollo 15 mission of July 26 -Aug. 7 is the oldest lunar rock found on any of the Apollo missions so far. **New York Times**, Sept. 18, 1971, p. 25.

Sept. 28-Oct. 3 The Soviet Union's uncrewed Luna 19 is launched from the Baikonur Cosmodrome in Kazakhstan toward the moon. By Oct. 3, the spacecraft enters lunar orbit and continues to provide panoramic images of the mountainous regions of the moon and conducts extensive studies on the shape and strength of the lunar gravitational field. After a year of operation and 4,000 orbits of the moon, communications will be lost Nov. 1, 1972. NASA, **Astronautics and Aeronautics, 1971**, p. 267 and 1972, pp. 337-338.

7 **Sept. 28** Japan launches its third satellite, Shinsei (New Star), which is also the country's first scientific satellite. The 26-sided, 75-centimeter-diameter solar cell-powered spacecraft is designed to study cosmic rays and solar electric waves. **Washington Post**, Sept. 29, 1971, p. A14.

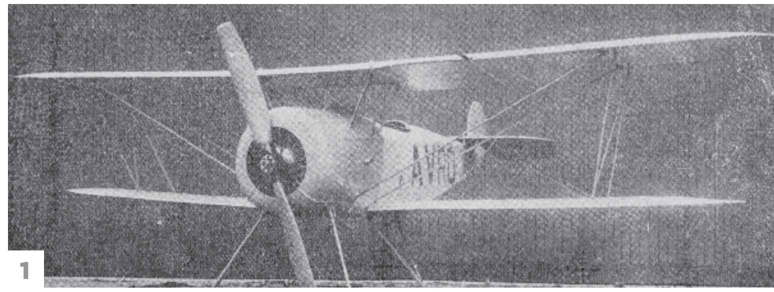
1996

8 **Sept. 7** U.S. astronaut Shannon Lucid breaks the endurance record for women in space, exceeding cosmonaut Elena Kondakova. The record is broken when Lucid's time in space is extended because of delays in launching the space shuttle Atlantis. When she returns from the Mir space station on Sept. 26, Lucid will have logged 188 days in space. NASA, **Astronautics and Aeronautics, 1996-2000**, pp. 35, 36.

Sept. 12 NASA's Goddard Space Flight Center in Maryland receives the first high-quality images from the Total Ozone Mapping Spectrometer, an instrument on board the Japanese Advanced Earth Orbiting Satellite. The images are among the first to explore the ozone hole over Antarctica. NASA, **Astronautics and Aeronautics, 1996-2000**, pp. 35.

Sept. 16 Space shuttle Atlantis, STS-79, is launched into orbit from Cape Canaveral in Florida. It carries 2,000 kilograms of supplies to replenish the stores on the Mir space station. It is the fourth docking mission to Mir and the 17th flight of Atlantis. NASA, **Astronautics and Aeronautics, 1996-2000**, pp. 35 - 36.

Sept. 30 Scientists at NASA's Goddard Spaceflight Center in Maryland deactivate the International Ultraviolet Explorer satellite. Launched in 1978, the satellite was expected to last for just three years. Almost two decades later, it has gathered important data for more than 2,000 researchers, resulting in the publication of 3,200 scholarly papers. NASA, **Astronautics and Aeronautics, 1996-2000**, pp. 37.



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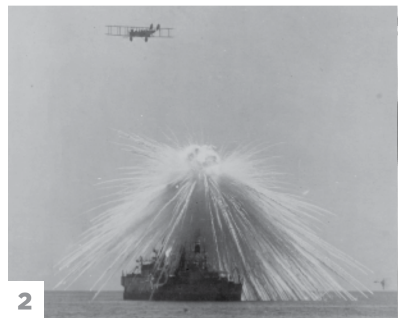
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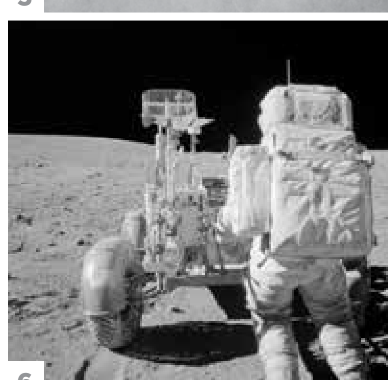
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8

Why going to space doesn't always make you an astronaut

BY MORIBA JAH

We'll know we're a space-faring species when rockets and spacecraft become normalized as modes of transportation on the same list with planes, trains and automobiles. July's historic space tourism flights could go down in history as steps toward that normalization, provided we can quickly settle the question of who should get to call themselves astronauts.

Minutes after landing, Richard Branson famously declared he and his fellow passengers were now astronauts, going so far as to have former Canadian astronaut Chris Hadfield pin Virgin Galactic astronaut wings onto each one of them. Likewise, Jeff Bezos declared himself and his passengers as astronauts.

So are they?

Not in my view. They are spaceflight passengers, and there should be no shame in that. I have many friends who are airline pilots, and when they aren't flying the aircraft, they sit somewhere in the cabin with people like me, as passengers. If you are an astronaut by trade, nothing precludes you from being a passenger at times too, such as when riding to and from the International Space Station on an automated craft.

In this debate, I'm not suggesting that we shake our fists at the sky, because billionaires have achieved yet another thing in exclusivity, and now they want the astronaut title too. We should celebrate these flights as steps on the natural path toward space travel becoming commonplace.

So "booya" to Branson, Bezos, their families, friends and employees for these important steps. But if you go to space on a joy ride, that does not make you an astronaut. The FAA, which has the power to award "Commercial Space Astronaut Wings" to space flyers, seems to hold a similar view. Effective July 20, which happened to be the day of Bezos' flight, recipients must have conducted "activities during flight that were essential to public safety, or contributed to human space flight safety," the FAA said.

Though perhaps it's not discussed as much as it should be, being an astronaut comes with serious responsibilities. The Outer Space Treaty of 1967, considered the Magna Carta Libertatum of International Space Law, states that "astronauts shall be regarded as the envoys of mankind." An envoy is defined as an official representative of one entity or organization to another. Personally, I would find it a stretch to regard billionaires as official representatives of humanity regarding our extraterrestrial activities.

The treaty's wording about astronauts and their responsibilities should not be taken lightly. Governments, not private citizens, bear legal liability for how people behave and conduct operations in space.

You might have noticed that I haven't addressed what altitude one must reach to become an astronaut. That's because altitude is much less important than what one does in space. Jeff Bezos and the New Shepard passengers crossed the Kármán line 100 kilometers (62 miles) above mean sea level, the invisible boundary recognized by the Fédération Aéronautique Internationale as the start of space. That feat does not make them any more astronaut-like than the Branson passengers who settled for crossing the 50 mile (80 km) threshold recognized in the United States as the start of space.

I hope being called a passenger doesn't dissuade more rich people from taking these trips. In every

Moriba Jah is an astrodynamicist, space environmentalist and associate professor of aerospace engineering and engineering mechanics at the University of Texas at Austin. He holds the Mrs. Pearlie Dashiell Henderson Centennial Fellowship in Engineering and is an AIAA fellow. He also hosts the monthly webcast "Moriba's Vox Populi" on SpaceWatch.global.

CONTINUED ON PAGE 61

FALL COURSE OFFERINGS

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AIAA online short courses help you stay sharp while strengthening your knowledge base. We're committed to assisting in your professional development and maximizing your success year-round. This fall AIAA is offering 12 new courses featuring a variety of technical areas including hypersonics and cybersecurity.

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Advanced Space Propulsion
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22 September–15 October | 16 Total Hours

Turbomachinery for Emerging Space Applications: Liquid Rocket Propulsion
22 September–29 October | 24 Total Hours

Satellite and SmallSat Thermal Control Engineering
29 September–22 October | 16 Total Hours

Spacecraft Design, Development, and Operations
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Understanding Cybersecurity in the Space Domain
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7–28 October | 8 Total Hours

Hypersonic Propulsion Concepts: Design, Control, Operation, and Testing
12 October–4 November | 16 Total Hours

Space Architecture: Designing a Lunar Habitation System
19 October–11 November | 9 Total Hours

Aviation Cybersecurity
26 October–18 November | 16 Total Hours

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