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?

MYSTERY SIGHTINGS

Examining explanations for the strange phenomena encountered by U.S. Navy pilots. PAGE 26

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AEROSPACE AMERICA

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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.

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Christine Fisher

Christine writes about technology, space and science. Her work can also be found on Engadget.com.

PAGE 9

Tom Jones

Tom Jones flew on four space shuttle missions and is an adviser to the Coalition for Deep Space Exploration. He has a doctorate in planetary sciences.

PAGE 18

Jan Tegler

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

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Debra Werner

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

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DEPARTMENTS

Don't say "UFO"

For this month's cover story, we decided to walk readers through the possible explanations for the unidentified aerial phenomena, to use the U.S. Navy's preferred term, spotted by F/A-18 pilots, their radars and cameras and also off-board sensors.

My inspiration for suggesting this storytelling approach came from entirely unrelated works of journalism, such as "The Body in Room 348" in the April 2013 issue of Vanity Fair and "What really happened to Malaysia's Missing Airplane" in the July issue of the Atlantic.

As our reporting got underway, it quickly became clear that there would be a key distinction from those sorts of articles. By the end of "Room 348," we learn that the explanation for this mysterious death was hidden in the evidence all along. Likewise, the absence of a question mark on the headline of the Atlantic story is no accident. The author lays out the evidence related to the disappearance of flight MH370, and the reader follows the clues to what seems like the only logical conclusion.

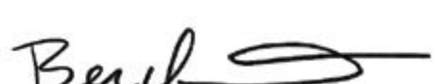
We can't steer you to an explanation for these Navy sightings or even point to a most likely answer. We let the facts tell the story, and the facts point to an ongoing mystery.

We do think we managed to dig into the science and technology related to the accounts in a thought-provoking way. Tone was important, because as entertaining as this topic is, it's also serious. Americans count on the U.S. Navy, among other agencies, to divine the capabilities of potential adversaries and be ready to win against them. The Navy seems as mystified as anyone by these fast, highly agile phenomena that sparked words of amazement from its pilots.

My hope is that one day someone will find one of these craft, if indeed these strange blurs are aircraft. I can picture the object hauled ashore at a boat ramp, in front of spectators and their smartphones. Or, if someone in the U.S. or abroad is keeping a secret, perhaps the reasons for that secret will fade and the time will become right to reveal the explanation for these phenomena. When that happens, I plan to look back on this article in search of signs that we were at least getting warm. ★

▲The U.S. Navy is investigating encounters with fast-moving, highly agile shapes like the one between the targeting lines in this screen grab from the "Gimbal" cockpit video shot in 2015 by the infrared camera on an F/A-18F.

U.S. Navy



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

Misusing "Mach 1"

I enjoy Aerospace America each month for all the interesting articles, but this month's cover [October 2019] shocked me with your statement about "Mach 1" passenger jets. Whoever wrote that ought to get a brief education on supersonic flight.

No aircraft company would build a jet designed to cruise right at Mach 1. In the transonic speed range (from roughly the high Mach 0.8s to around 1.1), there are many areas of mixed subsonic and supersonic air flow over the airframe, and following the localized supersonic flow there are shock waves. These shocks tend to be unsteady because of the shock/boundary layer interactions, and they tend to dance around over the control surfaces. If you stay at this speed, it can be a bumpy ride, so in supersonic flight operations, the aircraft prefers to punch through the transonic regime, and the ride gets smoother and the drag decreases once you're fully supersonic. I'm sure you've heard that the supersonic aircraft in development right now are all designed to cruise at Mach 1.4 or above. If you're going to go through the trouble of making an aircraft have supersonic capability, one would not stay at Mach 1. I would have just called them supersonic passenger jets on your cover. ★

Don Durston
AIAA senior member
Sunnyvale, California

Editor's note: Our economy of words failed us in this case. We indeed understand that supersonic passenger jets would fly faster than Mach 1.

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FLIGHT PATH

Connecting Corners of the World in Minutes

Speed is the next frontier in flight.

How do we better connect the world and allow interactions on a more rapid scale? Can we get from point A to B in minutes instead of hours or days and save time, one of our most valuable commodities? Can red-eye flights be eliminated from our hectic lives?

In short, can we go faster?

In 1976, the Concorde started to pave the way, but money and technical limitations got in the way. Supersonic flights were just too expensive, and the plane was unpopular and could never reach its full potential because of the sonic boom it created. The last flight occurred in 2003. Can we do better today?

Much of the sonic boom problem is being mitigated thanks to decades of research and improved aircraft shaping. But solving that problem doesn't get past one of the biggest barriers—informing the public about the design improvements that make the sonic boom weak enough to be acceptable. The AIAA community can play a key role in public outreach by working to share research in this realm and communicating progress to lawmakers.

The remaining problem is advancing supersonic and hypersonic technology to the point that it can cross the barrier from military applications to the commercial sector. Extensive research in the past decade is making hypersonic flight a reality for the military.

But how do we cross the barrier to commercial flight?

One piece of that puzzle is education, primarily workforce development. There is a current rise in hypersonic research interest and funding, but a dire shortage in qualified researchers for the work. This is a direct result of hypersonics funding, which has historically gone through many peaks and valleys, usually on a 15-year cycle. Much of our hypersonics expertise resulted from the Apollo program and the ballistic missile programs that were prevalent in the 1960s and 1970s. There was a resurgence in the late 1980s and early 1990s with the National Aerospace Plane, but that ended around the same time as the end of the Cold War. With each valley, many of the talented researchers moved on to other areas or retired. A few organizations and universities have maintained their hypersonic expertise and are now shouldering the burden of re-educating the workforce. The more young minds we can interest in hypersonics and have them invest their time in the field, the faster we will advance as a community. Again, AIAA can play a major role in encouraging young minds to pursue careers in high-speed flight by showing career opportunities and the exciting challenges of flying faster.

Hypersonic flight will also, of course, require financial investment in people, prediction codes, and test capabilities, but more importantly, the acceptance of failure. Initial tests might fail repeatedly, but we as a community should be OK with unmanned test flight failures. In fact, we should celebrate failure as an opportunity to push beyond our current limits. AIAA too can work to share this mentality with the lawmakers and the community at large. For example, look at the recent success of the SpaceX reusable launch system development program. SpaceX was willing to accept repeated losses of their first stage Falcon 9 rocket but now has demonstrated the ability to recover it. Without a cycle of testing, success and failure, feedback and learning, we as a society will not make commercial supersonic and hypersonic flight a reality.

Only by investing in public outreach and aerosciences education and by being willing to try and fail will we be quicker to succeed in going faster. ★

Katya Casper, Ph.D.
Principal Member of the Technical Staff, Sandia National Laboratories
Winner, 2019 AIAA Lawrence Sperry Award

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

Conundrum of the canards

Q. Explain why the following is true or false: The Dassault-built Rafale fighter and NASA's X-59 low-boom design each have canards in front of their wings for the same aerodynamic reason.

Draft a response of no more than 250 words and email it by midnight Nov. 11 to aeropuzzler@aiaa.org for a chance to have it published in the December issue.

FROM THE OCTOBER ISSUE

LIGHTSAILS AND LIGHT SPEED: Not withstanding Einstein, we asked you whether a lightsail could crack the speed of light if given enough time to accelerate, given that Earthly sailboats often go faster than the wind. Your responses were reviewed by retired U.S. Air Force Brig. Gen. Pete Worden, an astronomy Ph.D. and executive director of the Breakthrough Starshot initiative.

WINNER: No, for many reasons. If "notwithstanding Einstein" means neglecting Relativity, photons have no mass and cannot impart momentum to the lightsail, so you will not accelerate. With Relativity, as the lightsail approaches the speed of light, it gains relativistic mass, dampening any force's acceleration to asymptotically approach, but not exceed, light speed. In the interest of aeronautics, let's go with "just applying classical physics." A sailboat traveling less than a right angle off where the wind is coming from uses its sail as an airfoil, not a parachute. The force of water against the keel cancels the perpendicular portion of lift. As the boat accelerates upwind, to the sail, the wind appears to accelerate, increasing lift. The sailboat keeps accelerating until the sail's lift in the direction of motion is countered by drag. For the lightsail, photons pass through each other, so there is no pressure differential to create lift. The photons' change in momentum when reflecting off the lightsail provides the force. The shallower the reflection, the less force is imparted, so the best you can do is have your light source directly behind you. The amount of energy imparted by a photon is proportional to frequency. As a lightsail accelerates towards the speed of light, a photon approaching from behind will be red-shifted (from the Doppler effect) towards having zero energy, reducing its effective force to nothing, so a lightsail can never accelerate beyond the speed of light.

Jeffrey J. Mach
Santa Clara, California
Mach works for Sierra Lobo Inc. as a site manager at the Thermophysics Facilities Branch of NASA's Ames Research Center.

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

Targeting methane sources from space

BY CHRISTINE FISHER | christine@cfisherwrites.com

Raising cattle and collecting and processing oil and natural gas are messy affairs. About 75 million metric tons of methane gas escape into the atmosphere each year worldwide, according to the U.S.-based Environmental Defense Fund. That's a problem for Earth's climate, because methane could be responsible for as much as a quarter of the warming seen in recent years.

Historically, finding specific sources of methane emissions has required businesses and regulators in the U.S. and abroad to travel to scattered sites to take measurements with hand-held spectrometers.

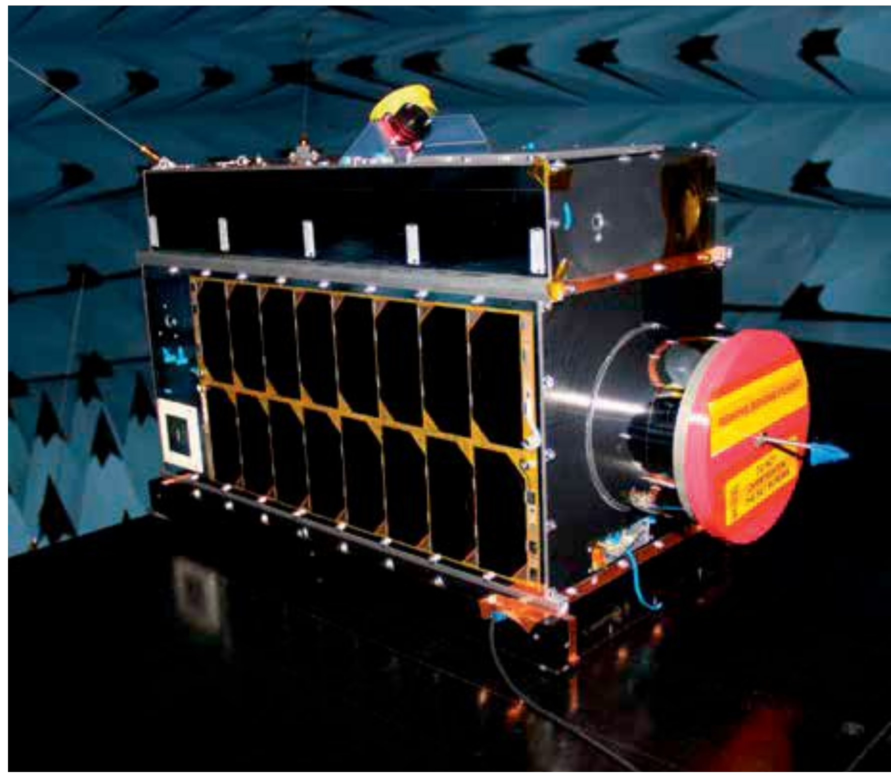
That is changing, in part because of work by GHGSat Inc., a satellite startup in Montreal that in 2016 launched its Greenhouse Gas demonstration satellite, which has been measuring methane emissions from oil and gas facilities, coal mines, animal feedlots and other sources in the U.S. and Canada since shortly after its launch.

Next year, the company's two GHGSat C1 and C2 nanosatellites (they're about the size of microwave ovens) are set to join the demonstration satellite, known as GHGSat-D and nicknamed Claire, after a team member's daughter to symbolize that it was built with future generations in mind.

With a telescope on one end, Claire collects sunlight reflected from Earth's surface and directs the light to an internal spectrometer that measures the brightness of various wavelengths. Because methane blocks certain wavelengths, Claire can determine how much methane is present in the atmosphere over specific sites along each 90-minute orbit. Because the instrument is not attempting to measure global emissions, the spectrometer can be small, capturing a 12-kilometer-by-12-kilometer swath, with each pixel representing a 25-meter-by-25-meter square.

By contrast, the European Space Agency's TROPOspheric Monitoring Instrument or Tropomi, for short, measures methane and other greenhouse gases, but on a broader scale. It has a field of view that's approximately 2,600 km wide, and each pixel represents a 7-km-by-3.5-km rectangle, so it needs a larger spectrometer. Tropomi rides on the Sentinel-5 Precursor satellite and weighs 200 kilograms compared to 15 kg for Claire.

GHGSat's mission is "a similar problem, but we're designing to a different requirement," says GHGSat President Stéphane Germain.



▲ **GHGSat Inc. plans** to launch its second methane-monitoring microsatellite, GHGSat-C1, next year. The pink cap covers the aperature where light enters the telescope.
GHGSat

Others in the private sector are planning to measure methane emissions too. In September, MethaneSAT LLC, a California subsidiary of the Environmental Defense Fund, chose Ball Aerospace to build the dual-spectrometer instrument for its first 350-kg satellite.

"Existing satellites can either map methane emissions across large areas or measure them at predetermined spots," the MethaneSAT company said in a press release. "MethaneSAT will do both."

The findings will be shared free as open-source public data.

Another startup, Bluefield Technologies, plans to launch a methane-monitoring microsatellite in late 2020 or 2021. Meanwhile, California Gov. Gavin Newsom and billionaire Michael Bloomberg announced a partnership with the Earth-imaging company Planet to monitor greenhouse gases including methane over the state.

Germain says he's not worried. "When there's competitors coming in that means everybody sees it as a real market, and that means things are looking good for us," he says. ★

Simon Weeks at AIAA's Propulsion and Energy Forum.

Britain's innovation architect

In some respects, the British view of society's future in flight is similar to that here in Aerospace America's home country of the United States. But spend a few minutes with Simon Weeks, and a stark contrast becomes apparent. Clean, quiet flight is in high public demand in the United Kingdom, and those who fall short make easy targets for critics. As chief technology officer of the Aerospace Technology Institute, or ATI, a government and industry joint venture that directs U.K. research spending, Weeks spends much of his time scouting for ideas worthy of receiving funds through a formal solicitation process. I interviewed Weeks at The Hub during AIAA's Propulsion and Energy Forum in Indianapolis. — *Cat Hofacker*

SIMON WEEKS

POSITIONS: Chief technology officer of United Kingom's Aerospace Technology Institute, or ATI, since 2014; head of aerospace research and technology at Rolls-Royce Corp., 2010-2014; technical director of EuroJet Turbo GmbH, a joint venture between Rolls-Royce in the U.K. and European companies, 2001-2004.

NOTABLE: Joined Rolls-Royce as a combustion engineer in 1990; in 2014, became the inaugural chief technology officer at ATI. During his time at Rolls, oversaw all engineering of the EJ200 turbofan engine developed for the Eurofighter Typhoon, which entered service in 2003 and is flown by air forces in Europe and the Middle East.

AGE: 57

RESIDENCE: Ashby-De-La-Zouch, Leicestershire, U.K.

EDUCATION: Master of Arts in chemistry and Doctorate of Philosophy in the electrochemistry of fuel cells, both from Oxford University, 1987

Scan this QR code to read the complete transcript online.

IN HIS WORDS

ATI's role

Working with U.K. industry, we've put together a national technology strategy for the U.K., a bit like NASA's got a technology strategy for aerospace. We do talk internationally to people, so we know NASA quite well and work with them to gather their thoughts on where the world of aerospace should be going. We are working on a budget at the moment of about £4 billion ($4.8 billion) for over a number of years. So we're investing about £300 million a year jointly of government and industry money, and the big priorities are the future generations of propulsion, investing in the latest technologies for composite wind technology, and a huge focus on electrification. We check that proposed projects fit with that strategy. Did we think that the program that's been proposed is ambitious enough, it's challenging enough and it's bringing through novel, new technologies, and then down the line will actually deliver some economic benefit in the U.K., which is one of the reasons our government have put a large amount of money in — the economic importance of aerospace industry in the country.

Jet engine technology

Certainly, our biggest area of work is future propulsion. Propulsion is a big part of our program in the U.K., with much of it led by Rolls-Royce. The focus is on developing technologies for large ultra-high bypass ratio engines. It's the biggest engine architecture change for large engines that Rolls-Royce has done in many decades. It's totally new architecture, huge amount of new technology, very challenging technology. So there's a huge amount of exciting stuff there.

Collaborating

The U.K. is putting together some unique collaborations with people who don't necessarily naturally come together. We pulled together about 13 different groups on the program to bring through radical new ways of developing safety-critical software. You have all these people suddenly realizing, not surprisingly, there are other companies out there working on software, and they developed a very openly collaborative way of working and brought through certain phenomenal improvements on how quickly you can develop software. That's hugely important because the cost of software development for aerospace is rocketing. We're building more and more complexity, and so the cost is going up and up with each generation of products we develop. In fact, some of the work that we did with Rolls-Royce awhile back showed that within the back 20 years, the biggest cost element of developing an engine is the control system software, which is a bit scary, isn't it?

Bringing back supersonic flight

I think the environmental impact would be a key issue. Supersonic aircraft will use several times as much energy. Going fast takes energy, and if you were to go hypersonic, you're sitting on top of a huge flying fuel tank. So will there be a commercial market and passengers for supersonic? I think maybe for the very rich — few can afford it because it's going to always be expensive — but I don't see a mass market for it. If we're all trying to fly supersonically, that will not be great for the environment either. So I think the market will be there, but it'll be small, probably for very high-end small-business jets. Of course, as an aerospace enthusiast, it's very exciting, but we do need to think about the environment. What we see over in Europe is a real upswell of public opinion on the environment, and aerospace is an easy target. You can see lots of aircraft flying around, and so I think it's going to be a powerful factor in what sort of stuff we could do in the future. Already in some countries, if you look in Sweden where this young woman Greta Thunberg is already leading this environmental challenge, the demand for civil flights has dropped by something like 15% since the campaigning started a few months back. It's having real impact; people are making decisions on whether they fly.

> **As an aerospace enthusiast, supersonic flight is very exciting, but we do need to think about the environment. What we see in Europe is a real upswell of public opinion on the environment, and aerospace is an easy target.**

Lowering emissions

Today, the way in which we manage air traffic leads to aircraft staying in the air for much longer than they need to get from A to B, burning more fuel and generating more emissions. There's almost 10% emissions improvement to come if we could fly every aircraft on the most fuel-efficient course, without waiting on hold in the air for a landing slot. That's possible; the technology is there to do that now. Funny enough, it's more the speed of the politics around aviation that hold up progress. If you look at the European environment, there are many, many separate air control authorities, and they will need to decide to adopt effectively the same system. And actually, you don't need as many air traffic control centers as there currently are. I think it's where the U.S. could move a lot faster because it's a single air transport authority across the whole country, and it's a very big country. So I think there's an opportunity there for the U.S. to come lead the way.

Public perception

Noise is a hugely emotive issue; it's quite interesting. If you asked the public, their concerns are, "There's more aircraft; they're getting bigger and getting noisier." It's a kind of human perception issue, and that perception kind of ratchets up over time so people's expectation changes. This is a huge challenge for urban aviation, air taxis. They've got to have almost negligible noise impact on their

▲ **Development of the E-Fan X,** a joint venture of Airbus, Rolls-Royce and Siemens, is partially funded by the Aerospace Technology Institute in the U.K.
Airbus

Batteries will be actually key to smaller aircraft, and the power density needs to at least double from where we are today.

surroundings, otherwise there will be a public perceptibility issue. I was at the Paris Air Show, and Pipistrel [in Slovenia] is a company making small battery-powered trainer aircraft, which is proving quite popular, and you could hardly hear that fly. Normally with a little [general aviation aircraft], you hear the engine. So I think electric vehicles will stay quiet, but they won't be noiseless. If you move air, you're going to make some noise.

Achilles heel for electric flight

The problem with batteries is you can't store very much energy compared with kerosene. I've been using gas turbine power in combination with electrical power, so using the gas turbine to generate electrical power and using that electrical power to drive electric propulsors may give you a lot more flexibility to make more aerodynamically efficient aircraft. I think one of the real challenges with the battery-powered aircraft would be how much endurance you get. At the moment, once you take battery deterioration and emergency reserves into account, for an eVTOL air vehicle, you might only be able to do short flights before recharging — can you make a commercial business from that?

Unlocking electrification

I think that electrification is all-around power density, and it's the power density of how you would store or generate that power. Batteries will be actually key to smaller aircraft, and the power density needs to at least double from where we are today. The batteries, electrical machinery, motors, generators need to hit much lighter, more power dense than they are today. And all of the electronic units you need to manage that power need to have smaller power than that's there today. So, power density is a key issue and the systems integration around what could be actually quite complex for integrating those electrical propulsion systems, possibly with autonomous flight systems, particularly for small air taxis. I think there will be a market there, and one of the things that's driving it is increasing congestion around our societies. I think the cost of just traffic jams in the U.K. is at least £9 billion a year, so well over $10 billion a year, and that's just the tip of the iceberg. Commute times are going up and up and up. So does the air offer you a realistic way to block some of that? Actually, if you can allow autonomous flights or, say, electrified aircraft in the airspace, you could deliver a whole range of other different services: survey machines, transport of parcels. The construction industry is starting to look at using drones for the construction of buildings. There's a whole world that starts to get unlocked. Electrification is part of it, and autonomy. The ability to allow huge numbers of small air vehicles to operate in the same airspace could well transform the ability to get things from A to B and offer services in the air. So I think it's a really exciting potential future.

Braced for Brexit

The aerospace companies that I'm aware of in the U.K. have been very proactive, putting a lot of measures into place to ensure that the supply chains and logistics keep flowing. I think that's the biggest concern because I think there were various already agreements in place that limit customs duty and all those sorts of things, charges for going across borders. The key thing is: Will Brexit make the whole process of getting from A to B across Europe, or between mainland Europe and the U.K., much more difficult? As far as I'm aware, most countries have done something to try alleviate that. I think there'll be a few bumps in the road, but I'm pretty confident the industry will rally rank and find a way to get around it. Interestingly, Theresa May, before she finished as prime minister, committed the U.K. to zero emitted carbon by 2050, which I think is the first government internationally to do that. That's a hugely ambitious target, so we were trying to figure out: Could we actually do that? If so, how do you do that? It's not just the air vehicles; it's the transport system; it's the fuel that we use as well. How do we get more low carbon impact fuel into aircraft? And again, the solution there is partially political. These politicians need to do something to start the market to make alternative fuels affordable with respect to fossil fuels. There's a lot that can be done to do that, but I think that push to low emissions will continue in respect to the Brexit.★

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Quest for 90,000 feet

Creating a piloted glider that can soar into the stratosphere on waves of air rising over the Andes required some creative safety innovations. Keith Button tells the story of Perlan 2.

BY KEITH BUTTON | buttonkeith@gmail.com

▲ **Perlan 2 glides over** Lago Argentino as it returns to El Calafate International Airport, Argentina.
Airbus

Flights of the Perlan 2 glider in August and September were not for naught, even though pilots failed to beat the glider altitude record they set last year when Perlan 2 climbed to 76,124 feet over Argentina.

Design improvements over the original Perlan aircraft worked as planned, and the Nevada-based Perlan Project, which is funded mainly by Airbus, will try again next year to reach its ultimate goal of 90,000 feet, the pilots and engineers say.

The conclusion of this year's flights marked the first time in Perlan 2's four-year history that the team hasn't returned from Argentina with a long to-do list, says Morgan Sandercock, chief engineer for the project. "We don't have a big sheet of paper filled with: 'Fix this; repair that; upgrade that.' We've got it flying pretty much perfectly how we want it to fly now," he says.

Getting to this point required overcoming some life-and-death engineering challenges.

Bad vibrations

The team conducts its flights in late winter in the Southern Hemisphere to take advantage of Antarctica's powerful polar vortex, which pushes wind over the Andes. When some of these winds rush down the backsides of the mountains, they rebound forcefully and, under the right conditions, can rise as high as 130,000 feet and persist for days. These stratospheric waves are what the Perlan 2 pilots ride into the stratosphere once they are released by their tow plane at an altitude of about 45,000 feet.

Steering a carbon-fiber glider with a 26-meter wingspan through the stratosphere at the climb rate of an airliner can be hairy. The two pilots in their pressured cockpit and heated flight suits must avoid severe wing flutter, which are vibrations that can be catastrophic.

"We know that flutter will get worse as we climb higher," says Sandercock, one of the co-pilots who rotates on the Perlan 2 flights.

The thinning atmosphere provides less of a damping effect to smooth vibrations that can become flutter. Also, the risk of flutter increases with rising airspeed, and the glider must accelerate as altitude increases to maintain lift in the thinning air. As Sandercock notes, every aircraft has a red line on its airspeed indicator, "and if you exceed that red line, then bad things happen, like the wings fall off."

Obviously the team can't let that happen.

Below the stratosphere, staying under the indicated airspeed limit is part of the strategy for avoiding flutter. But in the stratosphere, the indicated airspeed doesn't tell the whole story. That's because pitot-tube sensors measure airspeed by sensing the pressure of air flowing by. Since the air in the stratosphere is thinner, this means the indicated airspeed from the pitot sensor remains at a constant figure while the glider's true airspeed in fact increases to maintain lift at higher and higher altitudes. If the glider were to reach a recording-setting 90,000 feet, for example, its true airspeed might have to soar to 370 kph for adequate lift, Sandercock says.

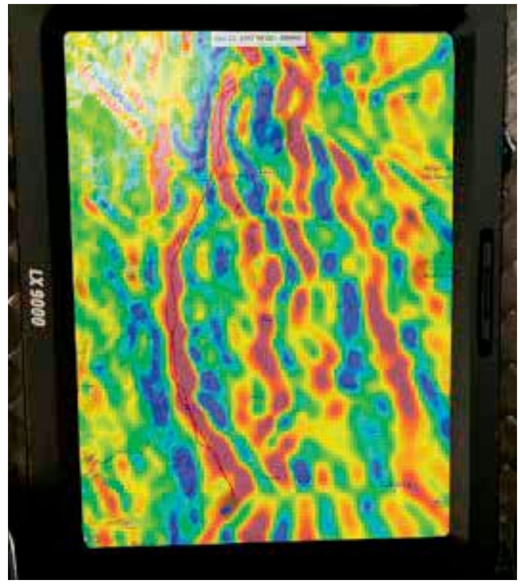
They needed to be confident that Perlan 2 would not succumb to flutter in those conditions.

The team members realized after ground vibration tests on Perlan 2 in 2015 that they would need to test for vulnerability to dangerous flutter in real time during each flight. The tests showed that unsafe flutter conditions could result if the plane flew too fast, outside its flight envelope, and a confluence of conditions occurred. Those conditions could include certain bolts loosening plus mechanical connections coming apart plus damage to the glider's skin. The extreme cold at high altitudes could also create flutter from unexpected sources — cold grease in a hinge creating more friction, for example.

So Sandercock built a flutter test system that fits in the wingtips. It consists of motors that vibrate six weights of about 170 grams each (that's about the weight of a cellphone) to see if vibrations of certain frequencies begin to produce signs of flutter. Also, four accelerometers measure vibration, twisting and bending in the wing. Perlan 2's pilots activate the flutter test system during every flight. Measurements of the frequency responses and damping are routed to the team's flight test engineers at El Calafate airport, Perlan 2's Argentina base. When the glider climbs to an altitude where it has never before flown, the measurements are also routed to engineers with ATA Engineering in San Diego who confirm that flutter conditions are not present before giving the go-ahead for the glider pilots to continue climbing.

The pilots do this about every 5,000 feet during a record attempt.

The Perlan 2 team also tests for Dutch roll, which is an oscillating rolling and yawing movement that could create unnecessary drag and slow the glider's climb. These tests also are done every 5,000 feet as an untested altitude is reached. The team initially believed it might have to install an active damping device to control Dutch roll, but the pilots so far have determined they can control the condition without damping.



◀ **The red in this screen** shot from the wave visualization system shows rising air. Perlan 2 pilots ride such stratospheric waves in their altitude-record attempts. This is a photo illustration.

Airbus

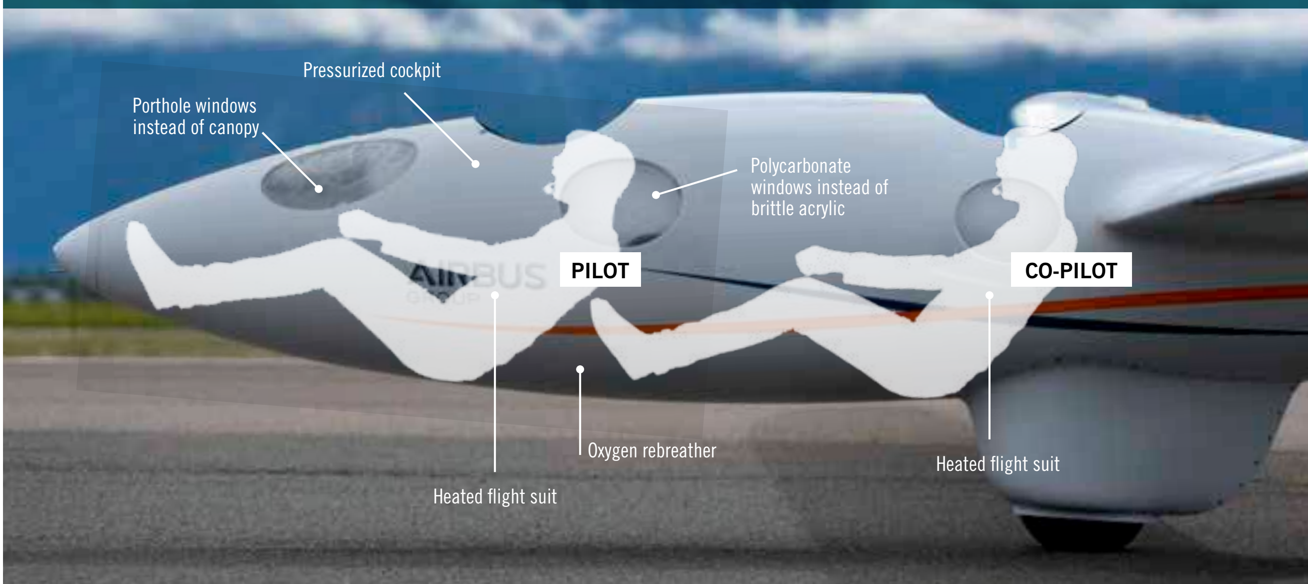
The team hoped to soar as high as 90,000 feet during the 2019 flights. But this year, a sudden stratospheric warming event, or SSW, disrupted the polar vortex by mixing in warm air and diminishing the vortex wind speeds. The last strong SSW in the Southern Hemisphere occurred in 2002, and this year's was the strongest ever, according to the project team. During this year's highest flight, to 65,000 feet, the stratospheric wave generated lift of 30 to 60 meters per minute, compared to 240 to

▼ **Pilot Jim Payne** helps lift the hatch after a mission.

Airbus

PERLAN 2: SURVIVING THE STRATOSPHERE

Like its predecessor, the second iteration of the experimental stratospheric glider needed numerous innovations compared to conventional gliders.



QUICK LOOK

- **Altitude record (glider):** 76,124 feet over Argentina, Sept. 2, 2018
- **Wingspan:** 26 meters
- **Length:** 10 meters
- **Weight (empty/gross):** 680/907 kilograms*
- **Built:** 2015 by Windward Performance and RDD Enterprises of Oregon
- **Designer:** Greg Cole of Windward Performance in Bend, Oregon

* Compare to 1,000 kg gross weight of Cessna 172

Sources: Staff research, Perlan 2

300 meters per minute during last year's record flight, says Jim Payne, chief pilot for the Perlan 2.

If all goes well, they'll try again next year. Sandercock says there is a practical limit to how high Perlan 2 or any glider can fly. Cracking 100,000 feet would require flying at Mach 0.7 or Mach 0.8, and "giant amounts of thrust" would be required to push the aircraft through the transonic drag of those speeds, he says. "We don't believe it will ever be possible for any glider to fly above 100,000 feet."

Combating cold

Another potential high-altitude danger the team had to prepare for was extreme cold. The temperatures in the atmosphere above 50,000 feet could dip to minus 78 degrees Celsius, threatening to crack materials or cause mechanical parts to jam.

Business jets and commercial airliners cruise in temperatures almost that cold, but designers of these aircraft have an advantage that glider designers don't have: combustion engines. "They just run a little duct out there and put some hot air in and there you go; you've solved the problem," Sandercock says.

The only possible sources of warming power aboard Perlan 2 are its batteries.

Engineers needed to find out how much warming would be needed, so they tested glider components on the ground by lowering their temperature to minus 68 Celsius with frozen carbon dioxide, better known as dry ice. They discovered that the oxygen regulators on each pilot's breathing apparatus would need to be heated to minus 40 degrees.

They also discovered that the performance of Perlan 2's lithium batteries dropped off sharply below minus 10 degrees Celsius. They decided to attach heaters to the batteries and divert a few percent of each battery's energy to them.

Next year

In addition to shooting for altitude records, Perlan 2 collects meteorological data and conducts experiments requested by scientists and students. The glider flights provide controlled access to specific spots in the stratosphere that isn't possible with weather balloons and sounding rockets.

The Perlan team has not announced its plans for next season, but Airbus says it will continue to sponsor the program until Perlan 2 reaches 90,000 feet, which would set the altitude record for all winged-aircraft, not just gliders. ★

Inside NASA's moon suit plan

A NASA spacesuit engineer wears a prototype spacesuit during a test of the Portable Life Support System 2.0.
NASA

The current International Space Station spacesuit, designed 40 years ago for extravehicular activities from space shuttle orbiters, would frustrate any moonwalker. Veteran spacewalker Tom Jones looks at how NASA will build a moon suit in time for the planned 2024 lunar return.

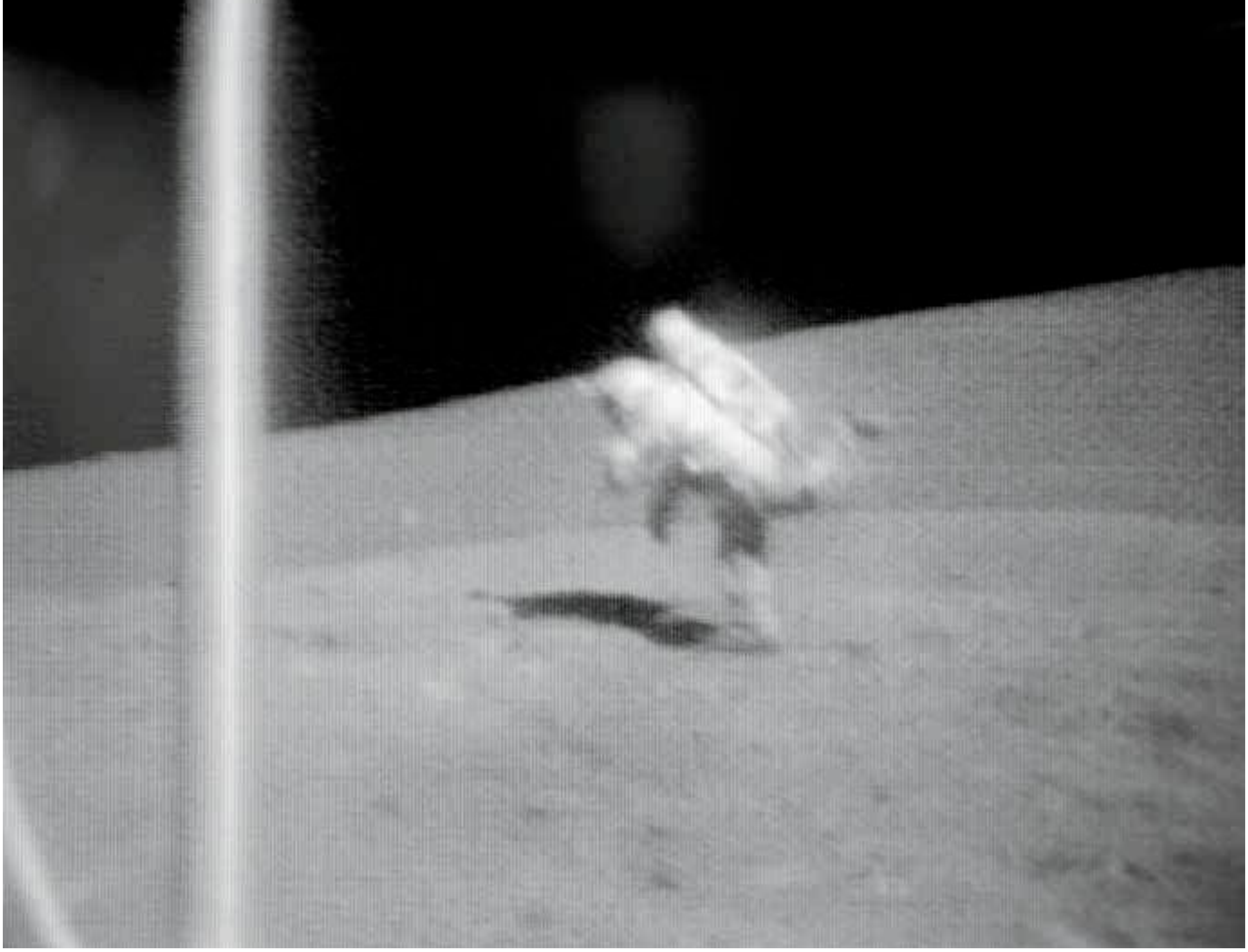
BY TOM JONES | skywalking1@gmail.com
www.AstronautTomJones.com

Neil Armstrong's and Buzz Aldrin's A7L spacesuits enabled the first moon walk, but exhibited significant shortcomings in flexibility, internal comfort, glove utility and life support capacity. Armstrong, in a technical debriefing after landing, was specific: "We should clear that suit so that you could go down to your knees, and we should work more on being able to do things on the surface with your hands," he said.

If NASA's Artemis program succeeds in returning astronauts to the moon, those explorers will need a new and capable suit design, one benefiting from Apollo and shuttle experience and incorporating the fruits of over two decades of NASA technology investment. Work on the lunar suit is accelerating at NASA's Johnson Space Center in Houston.

This is great news. The current Extravehicular Mobility Unit, or EMU, was designed in the late 1970s for spacewalking outside the space shuttle orbiters.

Having worn an EMU during three spacewalks on the International Space Station, I can attest that the design is rugged, but it's stiff and affords limited mobility. An EMU with a 73-kilogram (160-pound) astronaut inside weighs 145 kilograms. This mass is still present in space, and an astronaut



▲ **Apollo 17 astronaut** Harrison Schmitt loses his balance and heads for a fall while working on the moon in 1972. This is a screenshot taken from a NASA video.

must get it all moving and then stop it at a worksite. Beyond that, the suit's legs were not designed for walking; at ISS, they serve merely as anchors in foot restraints. And the exterior fabric and life support systems were designed to function in the vacuum of empty space, not on a dusty moon or planetary surface.

The xEMU

So, NASA's goal is "to develop an exploration-class spacesuit," says Liana Rodriggs, the xEMU project manager at Johnson, by email. Variants of the design will enable Artemis astronauts to walk on the moon or work outside the planned lunar Gateway or today's ISS. The agency plans to build three xEMU suits in-house at Johnson in time for testing on ISS and the 2024 lunar return.

The xEMU will capitalize on lessons from Apollo, decades of EMU experience on shuttle and at ISS, and lab and field tests of surface suit concepts dating back to at least 1989. The new design will remedy the ISS EMU's deficiencies, incorporate mobility and life support advances, and be maintainable in orbit or at a lunar outpost.

The xEMU Phase I design will be for ISS or the lunar Gateway. Its upper torso will be a machined aluminum shell with a rear-entry hatch, like the rear entry feature of Russia's Orlan EVA suit. Rear entry reduces the contortions necessary to don the suit, and the shoulder bearings are canted forward, lining up more naturally with an astronaut's shoulders and upper arms. By contrast, today's EMU must be donned by wriggling up from below, forcing the shoulder bearings to face more to the left and right, an orientation that contributed to long-term shoulder injuries among astronauts.

The Phase I xEMU will introduce a redesigned helmet with better downward visibility and a built-in mic and speaker system, eliminating the sweaty "Snoopy cap" that always seemed to slip down over my eyes. For missions far from Earth, the helmet may also incorporate projected infographics displaying life support parameters, procedures and reference material.

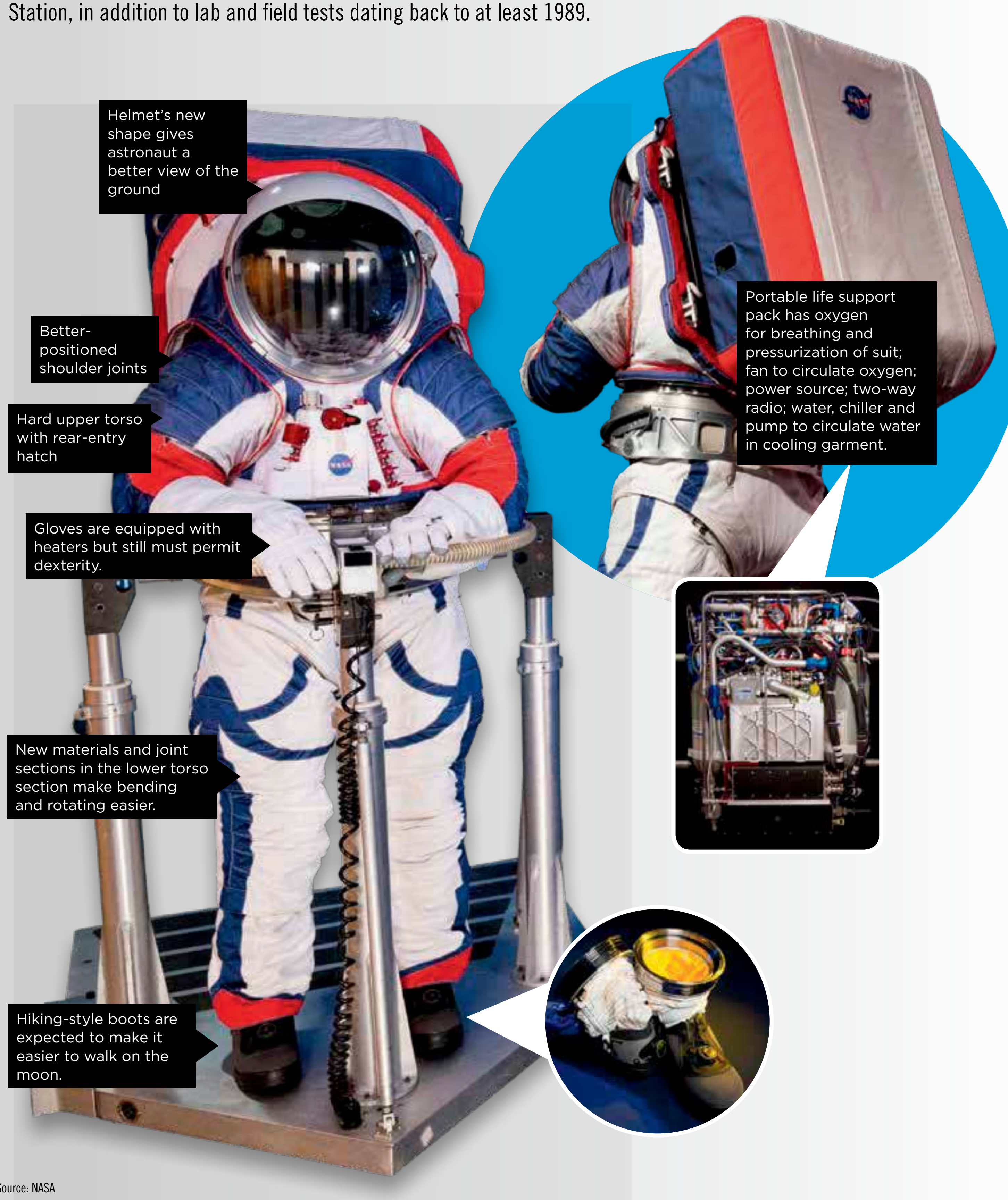
Amy Ross, the xEMU pressure garment subsystem lead at Johnson, tells me that the Phase I suit will get its first test outside the ISS in mid-2023. This test suit will be a hybrid, incorporating the new torso and life support system, but with gloves, legs and boots transferred from today's EMUs. An astronaut in the xEMU will put the new suit through its paces while shepherded by a crewmate in the standard ISS EMU.

Stayin' alive in deep space

Astronauts can't survive and work effectively outside their spacecraft without a portable life support system to supply oxygen, battery power, cooling

SUITING UP FOR THE NEXT MOON LANDING

The xEMU will capitalize on lessons from Apollo, the space shuttle and the International Space Station, in addition to lab and field tests dating back to at least 1989.



Source: NASA

▲ **Cosmonaut Yuri** Gidzenko wears a thermal undergarment as he is about to put on an Orlan space suit at a test center in Russia. A similar rear-entry hatch will be incorporated into NASA's xEMU.
NASA

and CO_2 removal from the suit's atmosphere. Today's PLSS backpack traps CO_2 by circulating air through a canister of silver oxide particles. The canister can remove CO_2 for up to eight hours. Back inside ISS, a heating chamber forces the reusable cartridges to give up their CO_2, which is vented overboard. By contrast, the new PLSS will have a constantly renewable absorber consisting of a pair of chemical beds containing amine, organic compounds containing nitrogen. "One [bed] is always absorbing [CO_2] and one is always desorbing to vacuum," explains Ross. The beds swap functions periodically so that one will "continue to remove CO_2 for the duration of the EVA," eliminating the current EMU's limit on EVA endurance.

Then there is the matter of cooling. Today's EMU PLSS pumps cooling water through an inner garment laced with thin tubes. The water circulating around the torso and limbs absorbs heat generated by an astronaut's work and cellular metabolism. This warmed water circulates through a sublimator unit in the backpack, where a separate water supply trickles into a porous metal block, where it cools and freezes as it sublimes directly into vapor in the space vacuum. This sublimation-formed ice bed chills the warmed suit water, which then recirculates to cool the astronaut.

However, this sublimator's tiny pores and air-water separator are sensitive to water impurities; clogging can cause loss of cooling and even force water into the helmet.

The xEMU PLSS resolves this contamination susceptibility and avoids the need for a separate water supply by letting some of the water from the cooling garment evaporate directly into space through a permeable membrane. The device is called a spacesuit water membrane evaporator, or SWME, and is pronounced "swimmy." The SWME "has already gone hundreds of hours in testing and is not nearly as sensitive to water quality," Ross says. If her team can achieve the required manufacturing quality, the SWME should be a reliable, rugged cooler that works at vacuum and in Mars' thin atmosphere.

To the moon

The Phase II surface suit is being developed in parallel with the Phase I xEMU. The NASA-industry team plans to adapt the Phase I design for the surface by adding a lower-body pressure garment, known as the lower-torso assembly, that will provide much greater surface mobility than the Apollo design. "We've been working on prototype suits since at least 1989 that give us a good idea about how to put those components together for the lower [suit]. We'll be building on what we have — probably a two-bearing hip with soft goods [fabric] between the two bearings that allows you to walk the way you want to," Ross says.

Moonwalkers should be able to walk, lope, skip, crouch, bend over and even kneel on the lunar surface. But Ross says that "putting a shell on a human and asking him to move like a human is a big challenge. We're probably never going to be able to do backward handsprings."

In addition to lunar legs, a surface xEMU will need an environmental protection garment, an external layer to protect the wearer from thermal extremes, micrometeoroids and dust intrusion. The Apollo suits were quickly degraded by jagged, microscopic dust grains infiltrating their joint bearings and mechanisms.

The current EMU's white outer protection layer consists of Ortho-Fabric, a blend of Gore-Tex, Kevlar and Nomex. Ross says Ortho-Fabric is a woven material full of holes — not what you want for dust repulsion. Her team is looking to textured, bio-inspired coatings, like the tiny, self-cleaning hairs on gecko feet, to help repel dust.

The ISS EMU's Phase VI gloves, like those I wore at the station, are not perfect, but they have enough dexterity for early lunar missions. Transferring them to the new suits means adding an extra outer layer for lunar dirty work. As for the boots, years of field testing on prototype suits have given the team a leg up on their design.

Tight schedule

In 2023, the xEMU project must deliver three flight units: two for the first Artemis lunar landing in 2024 and one to demonstrate the new suit on the ISS. Rodriggs, the project manager, says the 2023 ISS tests could "extend up to a year in order to perform a series of EVAs to prove out the xEMU's capabilities." She says the two xEMU suits for working on the moon will be complete by early 2023, in time to be launched to the Gateway to await the first landing crew.

To meet that schedule, Rodriggs leads approximately 45 civil servants and 170 contractors, a team that will continue to grow next year to incorporate the new suit capabilities and meet the Artemis deadline. Already, dozens of companies spread across the country are developing xEMU components. After tests in orbit and the initial lunar return mission, NASA plans to seek an industry partner, or partners, from this team to build a fleet of suits and maintain them at ISS and on future lunar and Mars expeditions.

NASA has tried for a couple of decades to field a new spacesuit, efforts that have stalled for lack of funding. Money is still the critical factor, as it is for Artemis as a whole. Today, though, says Ross, "our financial situation has changed. The budget box is opening up, [and] we have resources enough to give us confidence in meeting the schedule. NASA is serious about doing this — and doing this in time."

During my August visit to Johnson's advanced spacesuit laboratory, I got a close-up look at prototypes of the xEMU's sleek, aluminum hard upper torso and rear-entry hatch, redesigned shoulder bearings and joints, and wrap-around bubble helmet. Rodriggs, Ross and their xEMU team will develop flight hardware from these, provided they receive healthy Artemis funding from Congress to capitalize on decades of research. "We did the technology development work in a meaningful way," Ross says, and now the team is "ready to move toward flight with some confidence. We have a lot of support at all layers of NASA management. We can move on this." ★

▼ **The new upper torso** for NASA's xEMU will let astronauts easily roatate their arms, reach across their bodies and lift objects over their heads.
NASA

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SHAPING THE FUTURE OF AEROSPACE

MYSTERY OF THE "DAMN THINGS"

In a handful of incidents that go back to 2004, U.S. Navy fighter pilots and weapons officers have reported detecting strange objects maneuvering quickly with unheard of agility around their aircraft. The Navy professes to be as mystified as anyone. Jan Tegler and Cat Hofacker went searching for possible explanations. Here is what they found.

BY JAN TEGLER | wingsorb@aol.com and CAT HOFACKER | catherineh@aiaa.org

During training flights off the East Coast of the U.S. in 2014 and 2015, unidentified gauzy blobs showed up on the cockpit displays of F/A-18 jets so often that U.S. Navy pilots gave them a nickname. "Usually we'd just say, 'we're seeing one of those damn things again,'" Ryan Graves, a former Navy lieutenant and F/A-18F pilot, told us in a September phone interview.

Graves is one of three F/A-18 pilots who have publicly described encounters with small, featureless objects that, depending on the account, descended and ascended with incredible mobility before accelerating and vanishing. Graves and colleagues were not the first to see mysterious objects on their cockpit displays or, in at least two other reported cases, with human eyes. The first sighting, as far as the public record shows, occurred in 2004 when a pilot reported seeing a fast-moving object about 40 feet (12 meters) long whose shape resembled, of all things, a Tic Tac mint.

The U.S. Navy this year began publicly emphasizing how seriously it is taking such accounts by its flyers. The Navy's determination to help solve the mystery is understandable, given that each of the possible explanations that we explore in this article is unsettling in its own way.

Spearheading the Navy's investigation is the Office of the Deputy Chief of Naval Operations for Information Warfare, where the job is to make sure the Navy outperforms its adversaries on the intelligence, cyberspace and electronic warfare fronts. Representatives of the office began fanning out to the service's F/A-18 strike fighter squadrons earlier this year "to encourage our aviators to report any observations of UAPs." That's shorthand for unidentified aerial phenomena. The Pentagon borrowed the term from the United Kingdom partly because the phrase does not "pre-judge the results of any investigation," the office of the DCNO for Information Warfare says. The Navy declined to discuss the direction of its investigation, but the word "phenomena" to us suggests that the Navy wants to leave open the possibility that whatever the pilots are seeing might not be objects at all. The term also handily sidesteps the culturally freighted term "UFO."

We are deeply curious about possible explanations for the sightings, and so we conducted our own investigation. The Navy declined our request to interview its investigators, so we sent written questions. We also interviewed Graves, other current and former Navy pilots, a military analyst and scientists.

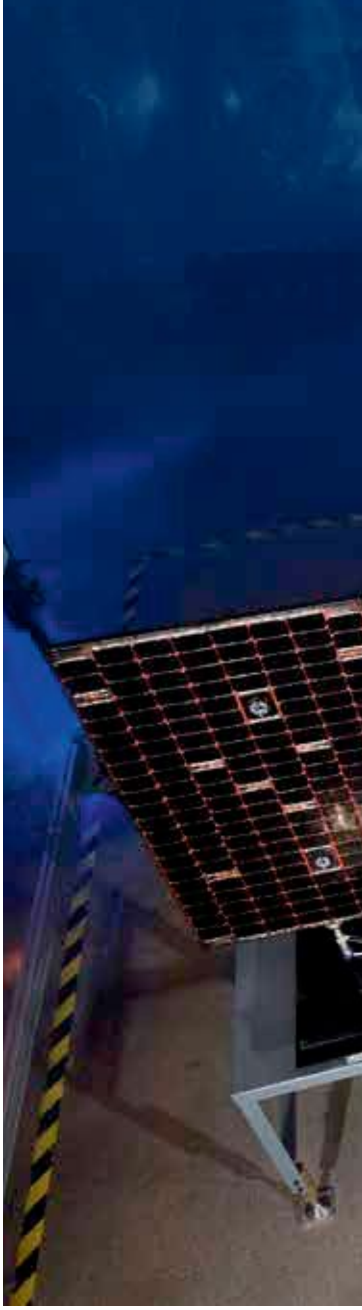
It's not E.T. — we don't think

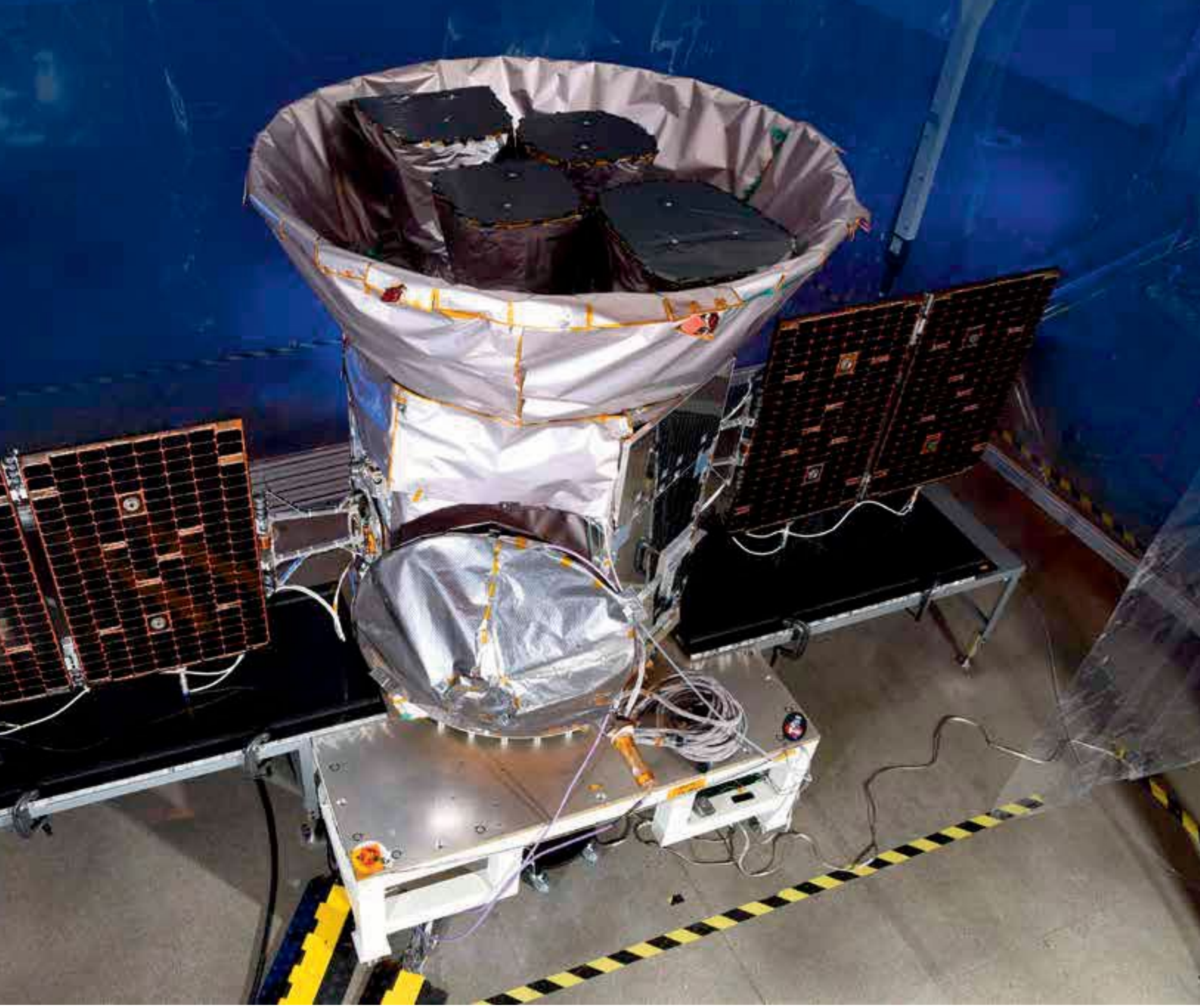
Because we know it's on all our minds, let's first consider the unlikely but gobsmacking possibility of extraterrestrial visitation.

From what exoplanet scientists know at this time, a giant leap of faith would be required to conclude that humanity is not alone. As of October, NASA's Exoplanet Archive lists 4,073 confirmed exoplanets identified by scouring graphs of star intensities gathered mainly by NASA's Kepler space telescope before its mission ended in 2018 and now also its successor TESS, short for Transiting Exoplanet Survey Satellite. When the intensity of a star dips slightly and at regular intervals, this indicates that a planet is passing in front of the star.

Astronomers believe 55 of those exoplanets could be habitable, because each orbits its star at a distance that makes the surface temperatures right for liquid water. The term "habitable" does not tell us whether life exists, or if it does, whether the life consists of microbes or a civilization. If we assume that intelligent life requires conditions similar to those on Earth, proving the existence of those conditions would require direct observations of the planet's atmosphere, probably with the aid of a coronagraph inside a space telescope or a free-flying starshade positioned ahead of the telescope to block the blinding light from the host star. Those technologies are still years away from deployment.

That's where matters stand today, but in fairness, astronomers are just at the beginning of their exo-





▲ **TESS, NASA's** Transiting Exoplanet Survey Satellite, is searching for exoplanets that could support life.
NASA

planet hunt. Consider the Drake equation created in 1961 by astronomer Frank Drake of California, now an emeritus trustee at the Search for Extraterrestrial Intelligence, or SETI, Institute he co-founded in 1984. His equation estimates how many communicating civilizations might exist in our galaxy. Astronomers feed variables into the equation, including what's known about the rate of star formation in the Milky Way and estimates of the number of stars hosting planets that could support life. The Drake equation has spit out numbers ranging from thousands of communicating civilizations to none. "Each number might as well come with an asterisk next to it, given how little we really know about our own galaxy, let alone the universe," says astrophysicist Erin Macdonald, host of "Dr. Erin Explains the Universe" on YouTube. "That said, it's still good to think of all the probabilities that would need to be considered to assess the possibility of life, so as a thought experiment, it's a great start."

That still leaves the distance problem. Kepler stared at star systems up to 3,000 light-years away, and only a handful of the confirmed exoplanets are less than 100 light-years from Earth. The closest exoplanet, spotted in 2016 by telescopes at the La Silla Observatory in Chile, is Proxima b at 4.2 light-years away. Assume that a spacecraft equivalent to NASA's Parker Solar Probe, which is the fastest human-made object, were to leave Proxima b tomorrow. It would need at minimum 6,500 years to reach Earth.

Crossing such a vast distance would require traveling at close to the speed of light or finding a shortcut through space-time.

In any case, scientists are not optimistic that Proxima b is a good candidate for life, even though it's within its star's habitable zone. The planet has been subjected to "much harsher radiation than the Earth ever was," says astrophysicist Scott Engle of Villanova University in Pennsylvania, who's published papers on the planet's habitability. That's not to

▲ **An APG-79 radar** installed in the nose of a U.S. Navy F/A-18F Super Hornet undergoes maintenance. Pilots whose radar detected unusual flying objects at first thought the APG-79 was malfunctioning.

Raytheon

entirely rule out life: "It's also possible that higher radiation could challenge life and through natural selection it could have evolved to adapt," Engle says.

He has watched the mysterious objects in the videos "perform aerial maneuvers that would be impossible to do with anything we have," but he still doesn't buy that we've been E.T-ed. He can't see a motive: "Why are they doing this?"

Still, the idea of visitation has tantalized even the staid and cautious defense industry. We contacted Raytheon, hoping to learn whether one of the company's executives was serious in a 2017 press release when he said that the Raytheon-made video targeting pod on a Navy F/A-18 Super Hornet "might be the system that caught the first evidence of E.T. out there." The press release came after a December 2017 New York Times exposé on the front page of its Sunday paper about the history of a Pentagon organization assigned to investigate the phenomena witnessed by F/A-18 pilots. The Raytheon executive was referring to the fuselage-mounted Advanced Targeting Forward Looking video pod that was implicated in the 2004 incident off San Diego described in an article accompanying the exposé. Raytheon declined to connect us with the executive or answer any questions about his comment, however.

Unexplained digital phenomena

Could the sightings result from a persistent sensor or computing malfunction of some kind or a unique vulnerability to spoofing? Supporting this theory is the fact that, as far as we could learn, only Navy pilots have had such encounters and all involved the Super Hornet version of the F/A-18. Consider the encounters by Graves and his colleagues in VFA-11, a strike fighter squadron based out of Naval Air Station Oceana in Virginia. The squadron flies F/A-18Fs, the version of the Super Hornet with a pilot and weapons systems officer. The squadron's first sightings came in mid-2014, not long after its aircraft were upgraded with Raytheon's APG-79 radar, a flat panel of transmitters and receivers shrouded inside the nose of the plane to electronically scan the sky.

Graves, who left the Navy in June, and his fellow flyers initially thought the detections must have been a "malfunction of some sort" with their new radars, given that the symbols were maneuvering with agility they had never seen. The APG-79 can track multiple targets dozens of kilometers ahead, but it cannot image a radar reflection or identify what is producing it. So, the pilots closed in until the targets were in range of their video pods, called the Advanced Targeting Forward Looking Infrared or ATFLIR (pronounced A-T-FLIR) system consisting of an electro-optical camera that senses visible wavelengths and an infrared camera to sense heat. A pilot or weapons systems officer in the two-seat version of the Super Hornet can cycle between EO and IR views from the ATFLIR nestled next to the plane's left engine intake. These are the pods referenced by the Raytheon executive.

Once the ATFLIRs locked on, "that kind of took away some of the uncertainty for us," Graves says. "We're getting them on radar and then picking them up on the FLIR." What appeared on the cockpit display was not the distinct outlines of an aircraft that one would normally see; typically, says Graves, "you can almost see the rivets." One of Graves' colleagues, pilot Danny Accoin, said in a History Channel documentary this year that each "had no distinct wings, no distinct tail, no distinct exhaust plume." The objects seemed to have an aura, prompting speculation by outside observers that perhaps a bright infrared emission was obscuring the shape. Graves doesn't think this is so, based on his experience with the cameras. "Perhaps I would get a bit of loss of resolution staring at a streetlight on a road from 25K feet above," he says, "but at relatively close ranges in A/A [air-to-air] mode, I would expect to see individual ripples of fire coming out of the back of an exhaust can," he says, using pilot slang for an engine nozzle.

In fact, the lack of exhaust has flabbergasted Graves and his fellow pilots.

Could the lack of exhaust indicate that the phenomena are not in fact tangible objects? A lot would have to go wrong for that to be true. Radars and multiple ATFLIR cameras would have to lock onto a mirage or some other phenomena. Also, the pilots had a situational awareness or SA page on their cockpit displays that fuses offboard radar and FLIR detections with those of their own aircraft. Some of the encounters were corroborated this way, which is why, in the leaked "Gimbal" video of a Jan. 21, 2015, encounter off the East Coast, the pilot talks about a fleet of these things on the SA page. That video was publicized in 2017 by the California research organization To the Stars Academy of Arts and Science together with one of the 2004 incident that had been leaked years earlier. The nickname "Gimbal," in some tellings, refers to how the object seems to rotate similar to how a video camera rotates on its gimbal.

Whatever they were, the sightings became commonplace. Graves recalls a VFA-11 pilot

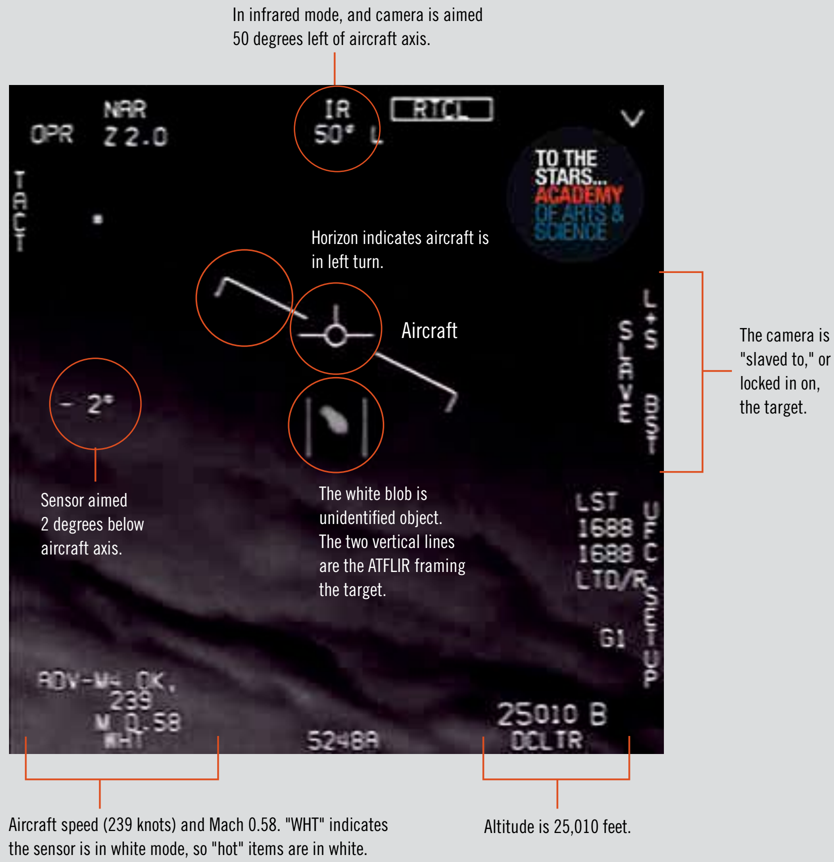
COCKPIT VIDEOS

For years, footage of U.S. Navy pilots' encounters with mysterious objects has coursed over the internet under catchy nicknames, capturing pilots' exclamations of disbelief about the nondescript blobs on their cockpit displays. Here's a primer on those videos, all captured aboard F/A-18F Super Hornets. — *Cat Hofacker*

NAME	DATE	LOCATION	PILOT	PUBLISHED BY	SIGNIFICANCE
FLIR1 Named for the jet's ATFLIR pod, short for Advanced Targeting Forward Looking Infrared.	Nov. 14, 2004	Naval training range off San Diego	Commander David Fravor	Separately by the New York Times and To the Stars Academy*	This was the first encounter to reach the public record. We see the plane's infrared camera locking onto a gauzy object that accelerates suddenly out of view.
Gimbal Named for the component that rotates a video camera.	Jan. 21, 2015	Naval training range off the U.S. East Coast	Unknown	Separately by The New York Times and To the Stars Academy*	The object rotates while flying, prompting the pilot or perhaps the weapons systems officer to exclaim "Look at it fly!"
Go Fast Refers to the speed of the object.	Jan. 21, 2015	Naval training range off the U.S. East Coast	Unknown	To the Stars Academy*	The object zips across the cockpit display several times before the pilot and weapons systems officer lock onto it with their infrared camera.

PILOTS' VIEW

In this screenshot from the Gimbal video, Jan Tegler decodes the nomenclature on the display.



**To the Stars Academy is a California research organization that studies unexplained aerial phenomena and futuristic technologies.*

walking into the squadron ready-room and exclaiming, "I almost hit one of those damn things!"

This time, the pilot reported seeing the object with his own eyes, not just via his cockpit display or helmet visor display, Graves says. If this account is correct, human corroboration should be added to the onboard and off-board radar and infrared detections. That seems to suggest that whatever was out there could not have been a result of spoofing, malware or a design malfunction.

The pilot, according to Graves, described the object as a partially transparent sphere with a cube inside. It should be noted that this description does not mesh very well with the shape observed by then-Super Hornet pilot and Navy Cmdr. David Fravor in the 2004 incident. Fravor, on the "Joe Rogan Experience" YouTube show in October, referred to a "Tic Tac-looking object" that was "about the size of a Hornet fuselage."

Balloon sleuth

Are there any Earthly craft out there today that look like what the pilot in the near-collision described?

We're not sure, but journalist Tyler Rogoway who writes The War Zone blog for The Drive website thinks there might be. This year, he uncovered and wrote about two U.S. patents, including one granted in 1949 that described how a cube-shaped reflector could be installed inside a high-altitude balloon to solve one of the more annoying drawbacks of balloons. At the time, meteorologists and atmospheric scientists could only track their balloons by slinging radar reflective panels beneath them. If the reflector could be installed inside the balloon, that would avoid aerodynamic drag. We don't know if such balloons were ever made, but we do recall that DARPA from 2004 to 2014 funded a project called Integrated Sensor is Structure, or ISIS. A surveillance radar was to be installed inside a football-field-length airship to double as the craft's internal support, although ISIS never flew.

Could the pilot in the near collision have streaked by a balloon or a spinoff of the DARPA project? There are problems with this hypothesis. If the object were indeed a balloon, we would have to accept that either the plane's radar was not operating, the pilot did not heed it or his radar failed to detect a reflector whose expressed purpose was to make the balloon easy to spot. Also, there remain the other encounters in which pilots described (or their cockpit videos captured) maneuvers not expected from balloons or perhaps miniature airships.

Black program

Graves' immediate response to the near collision

▼ **A U.S. Navy F/A-18F** Super Hornet pilot from the aircraft carrier USS Nimitz in 2004 reported detecting a fast-moving unidentified object.

U.S. Navy

> "IT WOULD BE SOMEWHAT SURPRISING TO ME IF THE AIR FORCE OR OTHER AGENCIES WERE WILLING TO ALLOW THIS KIND OF CONFUSION ON THE PART OF NAVY PILOTS TO GO UNCORRECTED FOR LONG."
>
> — **Steven Aftergood**, Project on Government Secrecy of the Federation of American Scientists

suggests another possibility. "The last thing we wanted to do was lose an aircraft over what logic was telling us was potentially someone else's drone program," he says. He filed a hazard report with the Naval Safety Center in late 2014 fearing that sooner or later a Super Hornet would collide with one of the objects. Also, the Navy had not yet fanned out to the squadrons to encourage flyers to report such sightings, and Graves did not know how else to draw the attention of Navy leadership.

If the objects weren't another country's handiwork, we questioned whether perhaps they were a product of a secret or "black" U.S. technology program, one so highly classified that even the Navy pilots and the DCNO for Information Warfare have yet to be read in. That's "at least a hypothetical possibility," says Steven Aftergood, director of the Project on Government Secrecy of the Federation of American Scientists, a Washington, D.C., think tank. But he sees a major weakness in this theory. "It would be somewhat surprising to me if the Air Force or other agencies were willing to allow this kind of confusion on the part of Navy pilots to go uncorrected for long," he says.

Historically speaking, there is no perfect analog to the Navy sightings. UFO conspiracy theories were born in the decades after World War II. Today, about half of all UFO reports from the 1950s and 1960s can be accounted for as U.S. reconnaissance flights by the high-altitude U-2 jets flown by the CIA and U.S. Air Force, according to the CIA website.

In that era, UFO reports from the public provided convenient cover for such flights. "But misleading the public, including foreign audiences, is different than misleading the Navy," Aftergood says.

Range incursions

Let's look at the question of another country's drones. The DCNO for Information Warfare provided an intriguing statement when we asked about news reports of unidentified aircraft entering U.S. military-controlled ranges and airspace. "Consistent with the wide proliferation and availability of inexpensive unmanned aerial systems, sightings of this nature have increased in frequency from 2014 until now," the office said.

If that was a reference to consumer drones, it seems unlikely to us that these could be what the pilots are seeing. It's true that consumer drones don't emit exhaust, but they also lack the range to penetrate naval ranges off both coasts, and they can't fly at 80,000 feet, the altitude of a sighting reported by a Navy ship, according to one pilot account.

The objects, it seems, would require a propulsion breakthrough of some kind. For one, the objects reportedly flew fast. Fravor, in a New York Times article accompanying the exposé, said he tried to intercept the Tic Tac object, but it "accelerated like nothing I've ever seen." This year, in an appearance on the "Joe Rogan Experience" on YouTube, he said the object "disappeared in like a second."

Remember, the pilots consistently report being mystified by the lack of exhaust. High-speed flight without exhaust doesn't yet exist as far as we know, but researchers are working on it. In 2017, physicists at NASA's Eagleworks Laboratories at Johnson Space Center in Houston reported circulating microwaves in a cone-shaped test article and moving the article by 4 to 10 micrometers, or considerably less than the width of a human hair. Writing in AIAA's Journal of Propulsion and Power, the authors noted several possible sources of error and emphasized the need for further testing of their EmDrive, short for electromagnetic propulsion drive. Indeed, in 2018 German scientists published a study that suggested the NASA findings could be explained by "some electromagnetic interaction" from the magnetic fields leaking through the cables.

So, could the pilots be seeing the latest in Chinese or Russian drones?

Carlo Kopp, an Australian-based defense analyst and AIAA associate fellow, doesn't think so.

PRESSING THE NAVY ABOUT "UNIDENTIFIED AERIAL PHENOMENA"

In July, U.S. Rep. Mark Walker, R-N.C., asked the Navy secretary if the Navy was continuing to track and investigate reports from its pilots of unusual objects. Thomas B. Modly, under secretary of the Navy, responded below. The yellow highlights are ours.

Congress of the United States
Washington, DC 20515

July 16, 2019

Honorable Richard Spencer
Secretary of the U.S. Navy
1300 Navy Pentagon
Washington, DC 20350

Based on pilot accounts, encounters with these UAPs often involved complex flight patterns and advanced maneuvering, which demand extreme advances in quantum mechanics, nuclear science, electromagnetics, and thermodynamics. If the accounts are true, the unidentified crafts could pose a serious security risk to our military personnel and defense apparatus. They could also represent a tremendous opportunity for advancements in science and technology that can contribute to the public good.

has the Department continued to both log reports/sightings and fully investigate the origins of the accounts? Does the Department continue to dedicate resources to tracking and investigating the claims? If so, to what measure? Has the Department found physical evidence or otherwise that substantiates these claims?

Lastly, does the Department have any information regarding private companies or foreign nations who have made significant advancements in aero physics?

THE UNDER SECRETARY OF THE NAVY
WASHINGTON DC 20350-1000

31 JUL 2019

The Honorable Mark Walker
U.S. House of Representatives
Washington, DC 20515

Dear Representative Walker:

Thank you for your July 16, 2019 letter regarding the unidentified aerial phenomena (UAP) featured in recent media reports.

There have been a number of reports of unauthorized and/or unidentified aircraft entering various military-controlled training ranges and designated air space in recent years. The Department of the Navy (DON) takes these reports very seriously and continues to log sightings and fully investigate the accounts. The wide proliferation and availability of inexpensive unmanned aerial systems (UAS) has increasingly made airspace de-confliction an issue for our aviators. Naval aircrews have been provided reporting guidance to determine the frequency and location of UAS operating in training areas. The guidance supports objective, data-driven analysis of incursions. The DON continues to dedicate resources to the tracking and investigation of reports that could affect the safety of our aircrews.

Kopp says there's "no evidence to date" of Russian or Chinese drones that are "more technologically advanced" than the latest U.S. technology. Specifically, he knows of no Chinese or Russian drones that "are large enough to provide the unrefueled operating radius to reach the CONUS" — meaning the military ranges off the continental U.S. coast — "loiter on station, and conduct high-energy expenditure maneuvering near the target." He doesn't think the sightings could be Russia's S-70 Okhotnik (a purportedly stealthy unmanned combat vehicle), a similar Chinese unmanned combat vehicle, or a supersonic drone China has teased. Additionally, there's no evidence as of yet that China or Russia have the technology to refuel an unmanned aircraft in flight, Kopp adds.

What about submarines? Perhaps China or Russia are carrying flocks of drones into range on submarines and releasing them to somehow fool pilots and sophisticated sensors into concluding that they are accelerating to hypersonic speeds. Some indirect evidence for this hypothesis exists in the Fravor account. He reportedly saw the Tic Tac hovering just above the water before it climbed and vanished.

Some countries, including the United States, have worked on concepts for launching unmanned aircraft from submarines, notes Steven Zaloga, who studies unmanned aerial vehicles and missiles for the Teal Group in Virginia.

In 2016, the U.S. Navy permitted AeroVironment, the California drone-maker, to announce that some Navy submarines and unmanned underwater vehicles would be equipped with the company's Blackwing small surveillance and communications-relay aircraft. "You fire it out the torpedo tube or from another dedicated launcher and you can pop up a hard-to-detect small unmanned aircraft to snoop around," Zaloga says.

Zaloga does not mean to suggest these could be what the pilots are seeing. A Blackwing weighs just 1.8 kilograms and its tubular fuselage and angular wings look nothing like Tic Tacs or spheres with cubes inside them. The point is that launching aircraft via submarine is a research thrust. Also, on the Rogan show, Fravor reported seeing a cross-shaped object "about the size of a 737" under the surface of the water that seemed to be associated with the flying object.

Perhaps China or Russia have developed a submarine-launched drone. If they have, Zaloga questions whether either country could send a submarine from its waters all the way to Navy training ranges without being detected. Even if this were possible, each drone would have to transmit observations back to the vessel that deployed it. "So it should be detectable," Zaloga notes.

▲ **The yellow** display in this F/A-18 cockpit trainer is the situational awareness screen. The dark screen with white text in the upper left corner is the Advanced Targeting Forward Looking Infrared, or ATFLIR, display. Pilots report seeing strange objects on the displays.
Boeing

Hypersonic weapons

What if the craft could fly so fast and far that they didn't need to be delivered by submarine? China, in particular, is working vigorously on weapons that maneuver to their targets at many times the speed of sound, and has publicly displayed a new anti-ship missile. In 2018, the Pentagon's Michael Griffin, under secretary of defense for research and engineering, told lawmakers about China's development of hypersonic weapons that could strike U.S. aircraft carriers, "and we don't have defenses against those systems." That same year, Russian President Vladimir Putin during his state of the nation address in Moscow described a series of what he called "hypersonic systems," according to a translation, ranging from torpedoes to cruise missiles to a wedge-shaped hypersonic glide weapon. Putin paused to show a cartoonlike video of a rocket taking off and releasing the wedge-shaped craft to fall toward Earth. It weaves and porpoises over the globe, surrounded by a translucent orange cloud. Putin cautioned that he couldn't show "what it really looks like."

Nothing Putin showed seems to maneuver in the manner described by the Navy pilots. The Chinese weapons alluded to by Griffin and described at a trade show do not bear obvious resemblance to what the pilots have described.

What we can say for certain is that each explanation explored in this piece should be disconcerting. ★

Adam Hadhazy contributed to this report.

SUPE

NASA's Low Boom Flight Demonstration Program could help pave the way for supersonic air travel, provided U.S. populations and ultimately those abroad agree that the X-59's thump instead of a boom is quiet enough.

BY JAN TEGLER | wingsorb@aol.com

RSONIC
THUMP

Charted over time, the pressure wave of a sonic thump would resemble an electrocardiogram, or EKG, readout.

If you live in the United States, you may be among the first people in the world to hear a "sonic thump," that being the only audible indication that NASA's X-59 Quiet Supersonic Technology jet is passing 55,000 feet overhead. NASA doesn't highlight the following about QueSST, but the plane could even define the conditions that will produce no perceptible sound at all.

Also known as the Low Boom Flight Demonstrator, the piloted X-59, now in construction at Lockheed Martin Skunk Works in Palmdale, California, will cruise at 1,500 kph over a variety of locations around the United States from 2023 to 2025 to test the reaction of people to the sound. This community response study will include day and night flights over a variety of geographic and cultural settings ranging from urban to rural. The goal is to give FAA and international aviation regulators the survey data they will need to craft a global standard for en-route supersonic aircraft noise. In the U.S., this standard would end the ban on supersonic civilian flights over land that has been in place since March 1973, a factor that contributed to making the trans-ocean Concorde supersonic flights from 1976 to 2003 untenable in the long term.

The issue now is whether NASA can prove that a thump from a passing jet will be acceptable to the public in the U.S., and possibly abroad. This achievement would go a long way toward clearing the way for supersonic passenger travel, although cruise noise is far from the only factor in the environmental-acceptance equation that could still prevent commercial supersonic passenger travel from ever taking off. Others are working to resolve questions about damage to the stratosphere, plus the subsonic noise of takeoffs, departures, approaches and landing.

Sweet spot

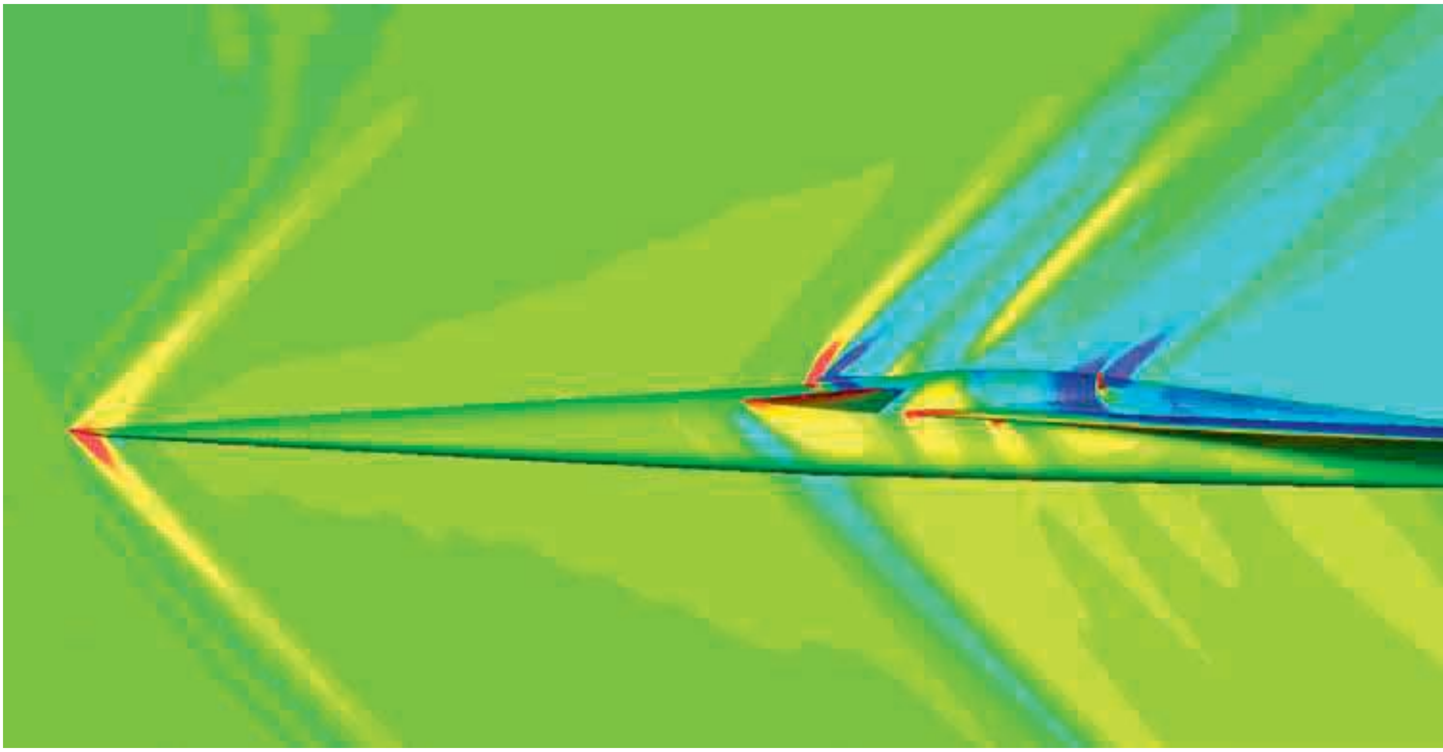
Supersonic aircraft are in the works today, but not the kind NASA hopes to open the door to. The U.S.-based companies Aerion Supersonic, Boom and Spike want to reel in well-heeled business travelers mainly by flying over oceans. NASA has in mind overland flights and a much broader vision for supersonic flight.

"Our goal is to make it available for the average person eventually, not just the business jet" traveler, says NASA's Dave Richwine of Langley Research Center in Virginia.

As the deputy project manager in charge of technology for the X-59 Low Boom Flight Demonstrator, his job is to make sure the technical work unfolds in a fully integrated manner from the current construction phase to acoustic validation flights in Phase 2 through the community response study in Phase 3.

A milestone will come next May, if all goes well, when the X-59's forebody, its wing assembly and tail section or empennage are joined. "It starts to look like an airplane," Richwine says.

Today's supersonic pioneers have a basic sense of what's needed for regularly scheduled passenger flight. Cruising at Mach 1.6 to potentially as high



as Mach 1.8 (1,963 kph to 2,205 kph) will be "the sweet spot for supersonic air travel," says David Richardson, director of air vehicle design and technologies at Skunk Works. At that speed, supersonic airliners could roughly halve the flight time needed to travel between New York and Los Angeles or Seattle and Miami.

The spot would be sweet for another reason, too, adds Richwine. Above Mach 1.6, "you start to get heating in your inlet and your engine, and all your control surface edges, and places where you have to do some heat mitigation measures that start to have a weight penalty," he explains.

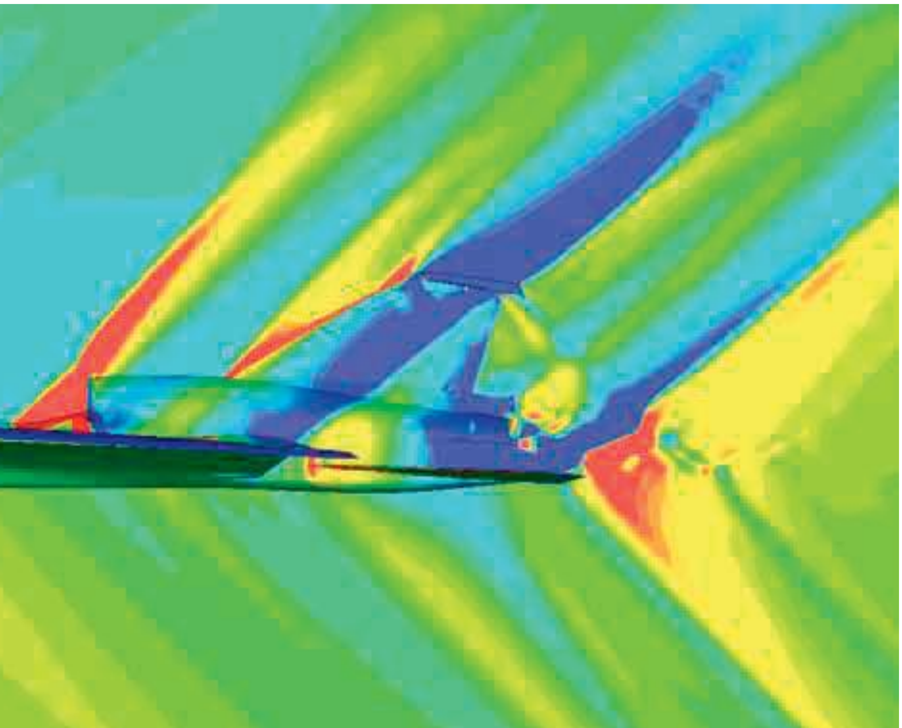
The X-59 won't quite reach the sweet spot for a simple reason. It doesn't need to. Some of the low-boom innovations, if not the basic X-59 design, might someday be adopted by commercial designers, but that is not the main mission. The top goal is to nail down the acceptable level and kind of noise for someone in a backyard or at a playground or on a hike, or "going about their daily lives," as Richwine's boss, Peter Coen, the low-boom mission manager, puts it.

Key is that the theorized thump reach the ground. That only requires flying at Mach 1.4, Richwine says. "It wouldn't sound any different than it would at 1.6," he explains. "We don't have to have a lot of bypass and bleed, and all these other things that would drive the cost of the airplane up."

Not overbuilding the plane is one strategy NASA is employing to control the cost of the $582 million effort.

NASA understands that any future standard for supersonic overland flight noise "will need to be an internationally agreed to standard."

— Peter Coen, NASA



▼ **A computational** fluid dynamics image of the X-59. Red represents areas of highest pressure, then, in descending order, orange, yellow, green, light green, light blue, dark blue.

NASA

NASA plans to collect dose-response data from average people and deliver that to the FAA's Office of Environment and Energy and to the International Civil Aviation Organization's Working Group 1, a panel of interested parties including Coen and representatives from U.S. and international aircraft companies.

Going worldwide

This initiative is presently the only effort to assess public acceptance of a low-boom supersonic aircraft. A consortium of European aviation manufacturers, academia and scientific research groups known as the Regulation and Norm for Low Sonic Boom Levels, or Rumble, aims to study human response to simulated sonic booms. The group has no plan to fly a low-boom research aircraft over Europe where overland supersonic flight is also banned and where environmental policies are increasingly strict.

Could international differences of opinion on the noise of supersonic aircraft lead to separate regulations instead of a global standard for cruise noise?

"There is always a possibility that U.S. standards could differ from standards eventually adopted by ICAO, but that is not a desired outcome," the FAA replied. Responding to the same question, ICAO said only that "should such an analysis be conducted then the data would be considered by ICAO."

Coen says NASA understands that any future standard for supersonic overland flight noise "will need to be an internationally agreed to standard." That's why NASA is reaching out to engage international regulators and researchers in the planning process for the X-59 flights "so that the test and survey plans are as internationally applicable as possible." He also says NASA is open to "discussion of using the X-59 for community response testing in locations outside the U.S."

If NASA were to formally make such an offer, ICAO says it would give the idea "due consideration."

Such flights could help speed the process of rulemaking for supersonic aircraft — a category the U.S. is keen to promote.

The U.S. Department of Transportation's emphasis on innovation includes the FAA "taking steps to advance the development of supersonic aircraft," according to the FAA's "Supersonic Flight" fact sheet. The document also notes that the FAA Reauthorization Act of 2018 encourages the FAA administrator to "exercise leadership" in creating federal and international regulations and standards for certification and operation of civil supersonic aircraft.

Stretch goal

NASA says the X-59's first flight is scheduled for some time in 2021. Phase 1 includes an approximately nine-month Flight Clearance stage to clear the way for acoustic validation and the community response phases, Coen says.

In the Phase 2 acoustic flights, a pilot will fly the X-59 at supersonic speeds over microphones arrayed across the desert floor of the range surrounding Edwards Air Force Base, California. "The purpose is to validate that the acoustic signature performance — how loud the airplane is as heard from the ground — matches our predictions for the full range of flight conditions that we expect to use in the community testing," Coen explains.

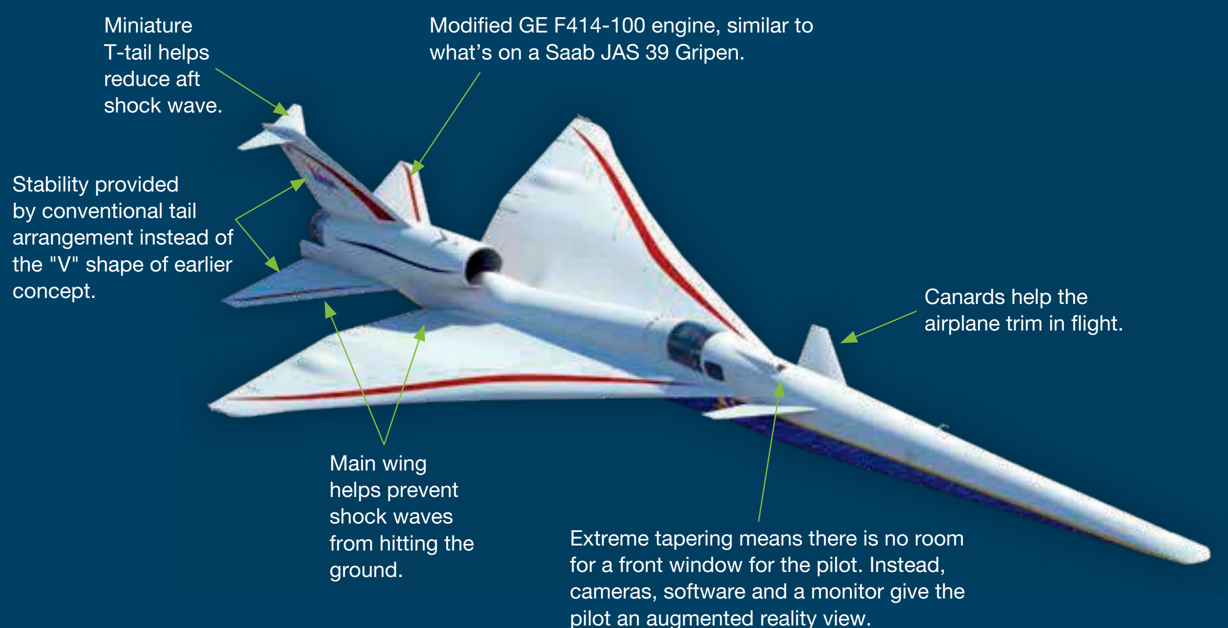
The X-59 is designed to register 75 perceived level decibels, a unit of measure that takes into account the judgment of an average listener, according to Dictionary.com. Because the decibel scale grows louder logarithmically, this would be a significant improvement over the 100-plus decibel sonic booms typical of jet fighters and the Concordes.

▼ **NASA's X-59 Quiet** SuperSonic Technology, or QueSST, aircraft won't have a forward-facing window. Its cockpit will have a 4K ultra-high-definition monitor as part of the aircraft's eXternal Visibility System, or XVS, whose computer stitches together images from two cameras with terrain data.

NASA

LOWERING THE "BOOM"

From the hollow nose to its miniature T-tail, the 30-meter-long X-59 is designed to reduce the shock waves, or pressure, rolling off its frame in flight, reducing sonic booms to thumps.



Source: Staff research, NASA

NASA might even be able to do better than 75 PLDB. "We'd like to get data down as low as 70, and we can do that a couple different ways through certain flight test maneuvers," Richwine says. "We're pretty convinced that there's no one on this planet that could hear 70."

Coen says that these bold goals are critical: "If we weren't doing extraordinarily better than a sonic boom there would be no reason to build an airplane and conduct these community tests."

Mapping the boom carpet

If Phase 2 goes as hoped, NASA will capture the sound over the entire boom carpet, meaning the swath of ground that's exposed to the aircraft's predicted sonic thump.

The microphone array on the desert floor will measure the sound at the ground level, and a NASA F-15 will probe the pressure waves that build up around airplanes in supersonic flight. Richwine explains that NASA wants to chronicle the waves that form under specific atmospheric conditions all the way from the region near the aircraft to below 15,000 feet. Of particular concern is wind turbulence below 10,000 feet, which can either soften a wave or make it louder. "We're thinking that a rounded sonic boom wave, much like ours, which is more like a sine wave, would not suffer that kind of amplification or dampening. It would be less impacted by turbulence, which is a good thing."

As an airplane accelerates past Mach 1, waves created by the nose collapse into a single shock wave, and the airplane's tail also creates its own shock wave. This is why when the space shuttle orbiters landed, people on the ground typically heard two booms in close succession. Richwine expects things to play out differently with the X-59. "For an airplane that is in that 100- to 150-foot category," like the X-59, "you're not going to be able to perceive a double boom," or in the X-59 case, a double thump.

NASA wants to subject the public to a range of perceived decibel levels and gather opinions about each. The Phase 2 flights are important because "we'll learn if we are producing the range of acoustic levels that we need to be successful in our community testing," Coen says.

Planning for Phase 3 community response testing is already underway. When those flights start in 2023, the first ones will be from NASA's Armstrong Flight Research Center (co-located with Edwards Air Force Base). The X-59 will be flown to

a population center to-be-decided, probably somewhere in the Southwest. It must be "a community that doesn't hear sonic booms," Coen says.

Test flights over the same area will last as long as a month and a half with three to nine "exposures" per day, as NASA calls them, including nighttime flights to cover as many variables as possible.

X-59's U.S. tour

After that, NASA plans to fly the X-59 from various locations around the country. This will assure "a robust database," Coen says.

Those sites are to-be-decided. For sure, each home facility for the X-59 must have a 100-foot hangar. "I've heard stories of guys had their airplane out in Oklahoma that got hit in a hailstorm, and it damaged the airplane. We don't want that," Richwine says.

Also, because the X-59 is an experimental plane, it will be equipped with an emergency restart device sparked by hydrazine. "They don't want you showing up to mom and pop's airport with that."

NASA has determined that its X-plane will fly from military facilities in the regions where these deployed tests will be conducted. Air Force and Navy airfields have the kind of support equipment the X-59 needs, Coen explains. Another benefit is that people around military bases tend to be accustomed to jet noise, and the X-59 won't stand out as much during takeoffs and landings.

"That minimizes the concern of contaminating results for en-route noise with landing and takeoff

▲ **NASA researchers** test a subscale Learjet engine nozzle in the Aero-Acoustic Propulsion Laboratory at Glenn Research Center. The curved truss at the top of the dome carries microphones that measure noise from a simulated flyover. NASA's Commercial Supersonic Technology project is concerned about such noise during takeoff and landing in addition to sonic booms or thumps.

NASA/Alcyon Technical Services

▲ **NASA's X-59 Quiet** Supersonic Technology airplane, including parts of its wing, is under construction at the Lockheed Martin Skunk Works factory in Palmdale, California. The yellow and green parts at the top are the aft-wing structure; in the center is the mid-wing structure. The silver is tooling.

Lockheed Martin

The top goal is to nail down the acceptable level and kind of noise for someone in a backyard or at a playground or on a hike, or "going about their daily lives."

— **Peter Coen**, NASA

noise," Coen says. "We'll probably start our supersonic runs a considerable distance from whatever base we use," he adds.

Flying an X-plane over populated areas is unusual. Although NASA will self-certify the X-59, the agency is keeping the FAA closely apprised, Richwine says.

NASA is still working on exactly how to gather input from the public. Last November, the agency conducted a rehearsal of sorts. This Quiet Supersonic Flight campaign employed a NASA F/A-18 Hornet to make repeated dives at supersonic speed off the coast of Galveston, Texas. The Hornet's boom diminished to a thump by the time it reached the 500 residents who volunteered to participate in a survey assessing the level of noise they perceived.

The campaign provided lessons for how to engage a large community in the X-59 flights, especially how to share information about the program with the public without introducing bias in their views about booms versus thumps. NASA also worked on developing a survey, recruiting participants, fielding equipment to measure acoustics in an urban area and conducting operations far away from the aircraft's home base.

Perception — past and present

Public objection to the sound of supersonic flight goes back more than 60 years. As the jet age accelerated and supersonic Cold War military aircraft proliferated, Americans became acquainted with sonic booms. Some accepted the noise as a feature of modern life. Others protested, complaining that supersonic thunderclaps rattled their windows, jangled their nerves and startled livestock. By 1964, supersonic noise complaints caused the FAA to stage Operation Bongo II, also known as the Oklahoma City sonic boom tests to measure the booms' effect

▲ **A subscale X-59 model** undergoes testing in the 12-Foot, Low-Speed Wind Tunnel at NASA's Langley Research Center in Virginia.

NASA/David C. Bowman

"Our goal is to make [supersonic flight] available for the average person eventually, not just the business jet" traveler.

— **Dave Richwine**, NASA

on structures and public attitude, and develop standards for boom prediction and insurance data.

Over a six-month period beginning that February, 1,253 sonic booms were generated by U.S. Air Force F-104 Starfighters and B-58 Hustler bombers, breaking windows in the city's two tallest buildings and energizing protests from civic groups. A report on the tests by the University of Chicago's National Opinion Research Center concluded that the majority of those exposed to the flights "felt they could learn to live with the numbers and kinds of booms experienced." But FAA mishandling of complaints led to a class-action lawsuit against the U.S. government. The bad publicity may have influenced the cancellation of Boeing's B2707 supersonic airliner project in May 1971. Two years later, the FAA banned overland supersonic flight.

With such history and greater modern sensitivity to noise, NASA knows the X-59 will have to gather "unbiased" public response. "We want to get as much data as possible to be representative of people's responses in different societal groups, different weather conditions and different climatology," Coen says.

Just the start

Lockheed Martin's Richardson says the X-59's extremely long, thin design, which dulls the supersonic boom to a thump by breaking up supersonic shockwaves via careful placement of features including its horizontal stabilators, a small T-tail that sits atop the vertical stabilizer, its engine inlet, and its lack of a canopy with natural forward visibility, "should scale very well to larger-size aircraft."

He thinks the X-59's design "is a perfect niche for an airliner," not a supersonic business jet.

Lockheed Martin's Quiet Supersonic Technology Airliner, a concept for a twin-engine 40-seat transport the company presented at AIAA's Aviation Forum in June, "leverages X-59's design."

Advancements in the Skunk Works' ability to model and predict shock waves and shock interaction accurately over the last 20 years are crucial enablers in damping the boom Richardson says, adding that Lockheed is confident that the X-59 will be a success. ★

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Calendar

6–10 JANUARY 2020

Orlando, FL

Hear from industry experts on how aerospace is driving solutions for global challenges. Whether it's delivering life-saving supplies via unmanned vehicles to remote rural villages or combating climate change via Earth-observation satellites, aerospace technology inspires and supports the betterment of people and our planet.

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DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2020			
4–5 Jan	3rd Sonic Boom Workshop	Orlando, FL	
4–5 Jan	Design of Experiments: Improved Experimental Methods in Aerospace Testing Course	Orlando, FL	
4–5 Jan	Design of Electrified Propulsion Aircraft Course	Orlando, FL	
4–5 Jan	Fundamentals of Drones: UAV Concepts, Designs and Technologies Course	Orlando, FL	
4–5 Jan	Integrated CubeSat Engineering	Orlando, FL	
4–5 Jan	Integrating Program Management, Systems Engineering, and Six Sigma	Orlando, FL	
4–5 Jan	Missile Guidance Course	Orlando, FL	
4–5 Jan	Systems Thinking for Modern Aerospace Complexity	Orlando, FL	
5 Jan	75+ Years of Hypersonics Development: History, Resources, References, and Insights	Orlando, FL	
5 Jan	Additive Manufacturing: Structural and Material Optimization Course	Orlando, FL	
5 Jan	Introduction to Digital Engineering Course	Orlando, FL	
5 Jan	Space Standards and Architecture Course	Orlando, FL	
5 Jan	A Unified Approach for Computational Aeroelasticity Course	Orlando, FL	
6 Jan	Class of 2020 AIAA Associate Fellows Induction Ceremony	Orlando, FL	
6–10 Jan	AIAA SciTech Forum	Orlando, FL	11 Jun 19
14–16 Jan*	2nd IAA Conference on Space Situational Awareness	Washington, DC (icssa2020.com)	

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.).

21–23 Jan*	International Powered Lift Conference (IPLC 2020)	San Jose, CA (vtol.org/events/2020-transformative-vertical-flight)	19 Aug 19
25–28 Jan*	Aircraft Noise and Emissions Reduction Symposium (ANERS)	Bordeaux, France (Contact: aerospace-europe2020.eu)	31 July 19
27–30 Jan*	66th Annual Reliability & Maintainability Symposium (RAMS®)	Palm Springs, CA (www.rams.org)	
7–14 Mar*	2020 IEEE Aerospace Conference	Big Sky, MT (aeroconf.org)	
10–12 Mar*	23rd AIAA International Space Planes and Hypersonic Systems and Technologies Conference	Montréal, Québec, Canada	22 Aug 19
18 Mar	AIAA Congressional Visits Day	Washington, DC	
23–25 Mar*	55th 3AF Conference on Applied Aerodynamics — "Turbulent Flows in Aerodynamic Applications"	Poitiers, France (http://3af-aerodynamics2020.com)	18 Nov 19
16–19 Apr	AIAA Design/Build/Fly Competition	Wichita, KS (aiaa.org/dbf)	
5–7 May	AIAA DEFENSE Forum	Laurel, MD	8 Oct 19
19 May	2020 AIAA Fellows Dinner	Crystal City, VA	
20 May	2020 AIAA Aerospace Spotlight Awards Gala	Washington, DC	
25–27 May*	27th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (elektropribor.spb.ru/en/conferences/142)	
15–19 Jun	AIAA AVIATION Forum	Reno, NV	7 Nov 19
13–14 Jun	1st AIAA CFD Transition Modeling Prediction Workshop	Reno, NV	
13–14 Jun	6th AIAA Workshop on Benchmark Problems for Air Frame Noise Computations (BANC-VI)	Reno, NV	
14 Jun	2nd AIAA Workshop for Multifidelity Modeling in Support of Design and Uncertainty Quantification	Reno, NV	
23–26 Jun*	ICNPAA 2020: Mathematical Problems in Engineering, Aerospace and Sciences	Prague, Czech Republic (icnpaa.com)	
15–22 Aug*	43rd Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events (COSPAR 2020)	Sydney, Australia	14 Feb 20
24–26 Aug	AIAA Propulsion and Energy Forum	New Orleans, LA	11 Feb 20
14–18 Sep*	32nd Congress of the International Council of the Aeronautical Sciences	Shanghai, China (icas.org)	15 Jul 19
26–27 Sep*	CEAS-ASC Workshop 2019 on "Advanced Materials for Aeroacoustics"	Rome, Italy	
12–16 Oct*	71st International Astronautical Congress	Dubai, UAE (mbrsc.ae/iac2020)	
29 Oct–1 Nov*	37th International Communications Satellite Systems Conference (ICSSC 2019)	Okinawa, Japan (kaconf.org)	15 May 19
16–18 Nov	ASCEND	Las Vegas, NV (ascend.events)	

● AIAA Continuing Education offerings

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

AIAA Announces Class of 2020 Associate Fellows

AIAA is pleased to announce its Class of 2020 Associate Fellows, who will be formally honored and inducted at the AIAA Associate Fellows Induction Ceremony on Monday, 6 January 2020, at the Hyatt Regency Orlando in Orlando, Florida, during the 2020 AIAA SciTech Forum.

"Aerospace is constantly evolving to solve problems and push the boundaries of the possible," said John Langford, AIAA president. "The newest class of Associate Fellows is building on the great work that has come before them to push us faster and farther here on Earth as well as in space. Congratulations to the Class of 2020 Associate Fellows!"

The grade of Associate Fellow recognizes individuals "who have accomplished or been in charge of important engineering or scientific work, or who have done original work of outstanding merit, or who have otherwise made outstanding contributions to the arts, sciences, or technology of aeronautics or astronautics." To be selected as an Associate Fellow an individual must be an AIAA Senior Member in good standing, with at least twelve years professional experience, and be recommended by a minimum of three current Associate Fellows.

"I am proud to welcome the these newly minted Associate Fellows to the esteemed roster of aerospace professionals," said Dan Dumbacher, AIAA executive director. "Their dedication to aerospace, from making meaningful contributions to their field to mentoring students and young professionals, inspires us all."

The Class of 2020 AIAA Associate Fellows are:

Ragini Acharya, CFD Research Corporation

Sumanta Acharya, Illinois Institute of Technology

Mark Alber, Sikorsky, A Lockheed Martin Company

Roberto Albertani, Oregon State University

Brian Biswell, Raytheon Company

Ken Blackburn, Air Force Research Laboratory

Matthew Borg, Air Force Research Laboratory

Gillian Bussey, U.S. Department of Defense

Christian Carpenter, SpaceX

Jeffrey Cerro, NASA Langley Research Center

Animesh Chakravarthy, University of Texas at Arlington

Jacqueline Chen, Sandia National Laboratories

Maenghyo Cho, Seoul National University

Kung-Ming Chung, National Cheng Kung University

Tracy Copp, Ball Aerospace & Technologies Corporation

Scott Crawford, Raytheon Company

Darrell Crowe, Air Force Research Laboratory

Kevin Cunningham, NASA Langley Research Center

Craig Day, American Institute of Aeronautics and Astronautics

Marcelo J.S. de Lemos, Instituto Tecnológico de Aeronáutica

Anton de Ruiter, Ryerson University

Steve Denker, Lockheed Martin Space

Dianne DeTurris, California State Polytechnic University

Simonetta Di Pippo, United Nations Office for Outer Space Affairs

Diego Donzis, Texas A&M University

Jay Dryer, NASA Headquarters

Umut Durak, German Aerospace Center (DLR)

Karl Edquist, NASA Langley Research Center

Barbara Esker, NASA Headquarters

George Flowers, Auburn University

Gary Fogel, Natural Selection, Inc.

David Folta, NASA Goddard Space Flight Center

Joseph Footdale, Ball Aerospace & Technologies Corporation

John Foster, University of Michigan

Hiroshi Furuya, Tokyo Institute of Technology

Richard Gaffney, NASA Langley Research Center

Dave Gallagher, Jet Propulsion Laboratory, California Institute of Technology

Mehdi Ghoreyshi, U.S. Air Force Academy

Starr Ginn, NASA Armstrong Flight Research Center

David Gonzalez, Naval Surface Warfare Center

Kenneth Granlund, North Carolina State University

Melissa A. Green, Syracuse University

Anant Grewal, National Research Council Canada

Jason Hartwig, NASA Glenn Research Center

Stefan Heinz, University of Wyoming

Philip Henderson, L3Harris Technologies, Inc.

Michael Henson, Lockheed Martin Corporation

Georg Herdrich, Stuttgart University

Mark Hilburger, NASA Langley Research Center

James Hileman, Federal Aviation Administration

Timothy Hinerman, Blue Origin

Nathan Hines, The Boeing Company

Warren Hoburg, NASA

Frank Holzäpfel, German Aerospace Center (DLR)

William Hoskins, Aerojet Rocketdyne

Robert Howard, Arnold Engineering Development Complex

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David Lockard, NASA Langley Research Center

Andrew Lofthouse, U.S. Air Force

Todd Magee, Boeing Research & Technology

Barrett McCann, U.S. Air Force Academy

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Todd Michal, The Boeing Company

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Xingqun Zhan, Shanghai Jiao Tong University

Dan Zhao, University of Canterbury, New Zealand

Celebrate the Class of 2020 AIAA Associate Fellows

AIAA Associate Fellows Induction Ceremony and Reception

Monday, 6 January 2020

Hyatt Regency Orlando in Orlando, Florida

The Class of 2020 Associate Fellows will be officially inducted for their accomplishments in engineering or scientific work, outstanding merit, and contributions to the art, science, or technology of aeronautics or astronautics.

Join us in recognizing these exemplary professionals during the Associate Fellows Induction Ceremony followed by a reception, to be held in conjunction with the 2020 AIAA SciTech Forum at the Hyatt Regency Orlando on Monday evening, 6 January.

Tickets to this celebrated event are available on a first-come, first-served basis and can be purchased for $85 at aiaa.org/SciTech/registration or onsite (based on availability).

For more information about the Class of 2020, please visit
aiaa.org/AssociateFellows2020

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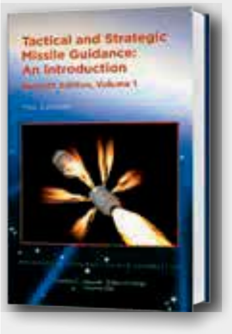

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AIAA-Sponsored Series Launches Curiosity — And a Project to Space

Photos by Christina Tyler Wenks

This year's Higher Orbits *Go For Launch!* Apollo series sponsored by AIAA hosted more than 130 students who conceptualized and proposed research projects that compete for development and launch to the International Space Station.

"This renewed my passion for pursuing space as a career," said Ankur Gatupa of Sterling, Virginia, who attended the Arlington event at the Lockheed Martin Space Experience Center in August—one of several events throughout the country.

Higher Orbits is an educational nonprofit organization that uses space to promote STEM, leadership, teamwork, and communication. Since 2016, more than 1,200 students have participated in 50 *Go For Launch!* events. Eight projects traveled to the International Space Station. Two more launch by the end of the year, and several more are being developed.

This year, Higher Orbits competitively selected the only five Americans attending the two-week Harry Messel International Science School at the University of Sydney in Australia.

"We are limited by what we are allowed to do in a classroom," said Colorado high-school senior Zach Pickerel. "Higher Orbits opens mental doors. Without it, I would never have learned about microbiology at the level I wanted. I realize now what I am capable of."

"I've always believed in giving back," says AIAA Associate Fellow, former astronaut trainer and Higher Orbits founder Michelle Lucas remarked, "The only reason I can do what I do is because of those who support me professionally, who enable me to chase the passion into the nonprofit world."

AIAA Executive Director Dan Dumbacher said he hopes the AIAA Apollo Series *Go For Launch!* will encourage students to consider aerospace as a career.

"It's a simple fact—we need more aerospace professionals, engineers of all disciplines, financial analysts, legal experts, business people, and many other backgrounds," Dumbacher said. "Aerospace is an incredibly meaningful field and Higher Orbits gives students a glimpse of how much it has to offer."

For more information about AIAA's educational activities, including making a donation, please contact Foundation Director Merrie Scott, merries@aiaa.org or visit aiaa.org/foundation.


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5

1 Astronaut Mike Foreman explains to NBC4 that science is everywhere and for everyone and why ideas of youngsters matter.

2 At the AIAA Arlington event, Michael Milkiewicz, Grace Schvodian, Caroline Wenks and Misha Somogyi teamed to form Team Hyperion, researching the viability of flatworms' ability to combat radiation.

3 Astronaut Mike Foreman poses with a *Go For Launch!* Space Coast team who were being recognized for their participation in the event.

4 Higher Orbits founder Michelle Lucas shared her personal story and how she found her tribe among science enthusiasts, as she encourages the next generation of scientists.

5 Students at *Go For Launch!* Spring Grove, in partnership with Scot Forge, build teamwork and communication skills with a space-inspired activity.

2019 Best Professional and Student Technical Papers

AIAA technical committees (TCs) and integration and outreach committees (IOCs) have selected the best professional and student technical papers presented at recent AIAA forums. With a standard award criteria and selection process from the respective committees, the following technical papers were selected as the "best," and the authors were presented with a Certificate of Merit. The papers can be found online at the AIAA Aerospace Research Central (arc.aiaa.org).

BEST PROFESSIONAL PAPERS

2017 AIAA Spacecraft Structures Best Paper

"Flight Qualification Testing of a Meter-class CubeSat Deployable Boom" (AIAA 2017-0621) by JoAnna Fulton, University of Colorado Boulder; Sungeun Jeon, LoadPath LLC; and Thomas Murphey, Roccor LLC.

2018 AIAA Aerospace Power Systems Best Papers

"An Intelligent Autonomous Power Controller for the NASA Human Deep Space Gateway" (AIAA 2018-4634) by Jeffrey Csank, James Soeder, Jeffrey Follo, Matthew Muscatello, Yu Hin Hau, and Marc Carbone, NASA Glenn Research Center.

"The Kilopower Reactor Using Stirling TechnologY (KRUSTY) Nuclear Ground Test Results and Lessons Learned" (AIAA 2018-4973) by Marc A. Gibson, James Sanzi, and Maxwell H. Briggs, NASA Glenn Research Center; David I. Poston and Patrick McClure, Los Alamos National Laboratory; and Thomas Godfroy, Vantage Partners, LLC.

2018 AIAA Aircraft Design Best Paper

"HALE Multidisciplinary Design Optimization Part I: Solar-Powered Single and Multiple-Boom Aircraft" (AIAA 2018-3028) by Dorian Colas, Nicholas H. Roberts, and Vishvas S. Suryakumar, Facebook, Inc.

2018 AIAA Air Transportation Systems/ Aircraft Operations Best Papers

"Fairness Metric-Based Trajectory Negotiation for Merging Air Traffic Management" (AIAA 2018-3039) by Sang Gyun Park, Parikshit Dutta, and P. K. Menon, Optimal Synthesis Inc.

"Testing Enabling Technologies for Safe UAS Urban Operations" (AIAA 2018-3200) by Andrew Moore, Swee Balachandran, Steven D. Young, Evan T. Dill, Michael J. Logan, Louis J. Glaab, Cesar Munoz, and Maria Consiglio, NASA Langley Research Center.

2018 AIAA Astrodynamics Best Paper

"Applied Reachability Analysis for Spacecraft Rendezvous and Docking with a Tumbling Object" (AIAA 2018-2220) by Costantinos Zagaris and Marcello Romano, Naval Postgraduate School.

2018 AIAA Atmospheric and Space Environments Best Paper

"Experimental Studies of Ice Crystal Accretion on an Axisymmetric Body at Engine-Realistic Conditions" (AIAA 2018-4223) by Alexander Bucknell, University of Oxford, Oxford, UK.

2018 AIAA Atmospheric Flight Mechanics Best Paper

"Rapid Load Calculations Using an Efficient Unsteady Aerodynamic Solver" (AIAA 2018-3621) by Daniel Kharlamov, Jernej Drofelnik, Andrea Da Ronch, and Scott Walker, University of Southampton, Southampton, UK.

2018 AIAA/Colliers-HyperSizer Research Best Structures Paper

"Steering of Carbon Fiber/Thermoplastic Pre-preg Tapes Using Laser Assisted Tape Placement" (AIAA 2018-0478) by Gearoid Clancy, Daniel Peeters, Vincenzo Oliveri, Ronan O'Higgins, David Jones, and Paul Weaver, University of Limerick, Ireland.

2018 AIAA Electric Propulsion Best Paper

"In-Flight Verification and Validation of Colloid Microthruster Performance" (AIAA 2018-4643) by John Ziemer, Colleen Marrese-Reading, Curt Cutler, Charles Dunn, Andrew Romero-Wolf, Shahram Javinda, Thanh Le, Irena Li, and Phil Barela, NASA Jet Propulsion Laboratory, California Institute of Technology; Nathaniel Demmons and Vlad Hruby, Busek Company, Inc.; Jacob Slutsky, James Ira Thorpe, Peiman Maghami, Oscar Hsu, and James O'Donnell, NASA Goddard Space Flight Center.

2018 AIAA Fluid Dynamics Best Paper

"Evaluation of Thermoacoustic-based Forcing for Control of Dynamic Stall" (AIAA 2018-3683) by Stuart I. Benton and Miguel R. Visbal, Air Force Research Laboratory, Wright-Patterson AFB.

2018 AIAA Gas Turbine Engine Best Paper

"Active Turbine Tip Clearance Control Trade Space Analysis of an Advanced Geared Turbofan Engine" (AIAA 2018-4822) by Jonathan L. Kratz and Jeffreys W. Chapman, NASA Glenn Research Center.

2018 AIAA Guidance, Navigation and Control Best Technical Paper

"Efficient Prioritization in Explicit Adaptive NMPC through Reachable-Space Search" (AIAA 2018-1847) by Vishnu Desaraju and Nathan Michael, Carnegie Mellon University.

2018 AIAA High Speed Air Breathing Propulsion Best Papers

"Supersonic Isolator Shock-Train Dynamics: Simple Physics-Based Model for Closed Loop Control of Shock Train Location" (AIAA 2018-1618) by Leon Vanstone, Joe Lingren, and Noel Clemens, University of Texas at Austin.

"Sustained Combustion Limits of a Central Dump Solid Fuel Ramjet Combustor at High Altitude Operational Conditions" (AIAA 2018-4449) by Ronald G. Veraar and Wolter Wieling, TNO Defence Security and Safety, Rijswijk, The Netherlands.

2018 AIAA History Best Paper

"Unlikely Partners: German-Soviet Aeronautical Cooperation, 1919-1933" (AIAA 2018-1612) by Richard Hallion, Florida Polytechnic University (retired).

2018 AIAA Hybrid Rockets Best Paper

"Investigation of Graphite Nozzle Erosion in Hybrid Rockets Using O2/C2H4" (AIAA 2018-4531) by Landon T. Kamps, Shota Hirai, Kazuhito Sakurai, and Tor Viscor, Hokkaido University, Sapporo, Japan; Yuji Saito, Tokoku University, Sendai, Japan; Raymond Guan, University of Alberta, Edmonton, Canada; Hikaru Isochi and Naoto Adachi, Uematsu Electric Co., Akabira, Japan; Mitsunori Itoh, IHI Corporation, Yokohama, Japan; and Harunori Nagata, Hokkaido University, Sapporo, Japan.

2018 AIAA Liquid Propulsion Best Paper

"Computational Analysis of Supercritical and Transcritical Flow in Cooling Channels with Rough Surface" (AIAA 2018-4465) by Hideyo Negishi, Yu Daimon, and Hideto Kawashima, Japan Aerospace Exploration Agency.

2018 AIAA Meshing, Visualization and Computational Environments Best Paper

"Generation of Anisotropic Adaptive Meshes for the First AIAA Geometry and Mesh Generation Workshop" (AIAA 2018-0658) by Todd Michal, Joshua Krakos, and Dmitry Kamenetskiy, The Boeing Company.

2018 AIAA Modeling and Simulation Best Papers

"A Modeling, Simulation and Control Framework for Small Unmanned Multicopter Platforms in Urban Environments"" (AIAA 2018-1915) by Corey Ippolito and Kalmanje Krishnakumar, NASA Ames Research Center; Sebastian Hening and Shankar Sankararaman, Stinger Ghaffarian Technologies, Inc.

"Differential Adaptive Stress Testing of Airborne Collision Avoidance Systems" (AIAA 2018-1923) by Ritchie Lee and Ole Mengshoel, Carnegie Mellon University; Anshu Saksena, Ryan Gardner, Daniel Genin, and Jeffrey Brush, Johns Hopkins University Applied Physics Laboratory; and Mykel Kochenderfer, Stanford University.

"Human-in-the-Loop Study on Angle-of-Attack Indicator Effectiveness for Transport Category Airplanes" (AIAA 2018-2938) by Angela Campbell, Somil Shah, and Mark Reisweber, Federal Aviation Administration; and Lisa R. Le Vie, NASA Langley Research Center.

2018 AIAA Multidisciplinary Design Optimization Best Paper

"Efficient Multi-Resolution Approaches for Exploration of External Aerodynamic Shape and Topology"(AIAA 2018-3952) by Laurence Kedward, Alexandre Payot, Thomas Rendall, and C.B. Allen, University of Bristol, Bristol, UK.

2018 AIAA Nuclear and Future Flight Propulsion Best Paper

"Consideration of Low Enriched Uranium Space

Reactors" (AIAA 2018-4673) by David L. Black, Westinghouse Electric Corporation (retired).

2018 AIAA Plasmadynamics and Lasers Best Paper
"Parallel Vortex Body Interaction Enabled by Active Flow Control" (AIAA 2018-3521) by Andre Weingaertner, Philipp Tewes, and Jesse C. Little, University of Arizona.

2018 AIAA Pressure Gain Combustion Best Paper
"Characterization of Detonation Wave Propagation in a Rotating Detonation Rocket Engine using Direct High-Speed Imaging" (AIAA 2018-4688) by John W. Bennewitz and Blaine R. Bigler, ERC, Inc.; William A. Hargus and Stephen A. Danczyk, Air Force Research Laboratory; and Richard D. Smith, GHKN Engineering, LLC.

2018 AIAA Propellants and Combustion Best Paper
"Complete Determination of the Velocity Gradient Tensor upstream of the Flame Front with High-Speed Tomo-PIV/Dual-Plane-PIV/OH-PLIF Measurements" (AIAA 2018-0153) by Tongxun Yi, Christopher A. Fugger, Naibo Jiang, Josef Felver, Mikhail N. Slipchenko, and Sukesh Roy, Spectral Energies, LLC; Travis Smith, Jamie Lim, Matthew Sirignano, Benjamin L. Emerson, and Tim C. Lieuwen, Georgia Institute of Technology; Benjamin R. Halls and James R. Gord, Air Force Research Laboratory.

2018 AIAA Sensor Systems and Information Fusion Best Paper
"Information Exchange Considerations for Effective Fusion among Heterogeneous Network Participants" (AIAA 2018-0710) by Thomas Frey Jr., and Kent Engebretson, Lockheed Martin Aeronautics; and Nelson Rasmussen, Lockheed Martin Rotary and Mission Systems.

2018 AIAA Solid Rockets Best Paper
"An Analytical Model for Acoustic Induced Heat Release Disturbances from Aluminum Combustion in Solid Rocket Motors" (AIAA 2018-4788) by Aurélien Genot CNES DLA, Paris, France; Stany Gallier ArianeGroup, Vert-le-Petit, France; and Thierry Schuller, Laboratoire EM2C, Toulouse, France.

2018 AIAA Thermophysics Best Papers
"Uncertainty Analysis of Coaxial Thermocouple Calorimeters used in Arc Jets" (AIAA 2018-3770) by David M. Driver, Daniel Philippidis, and Imelda Terrazas-Salinas, NASA Ames Research Center.

"Conjugate Analyses of Ablation in the HIPPO Nozzle"(AIAA 2018-3271) by Peter G. Cross, Naval Air Warfare Center Weapons Division; and Iain D. Boyd, University of Michigan.

2018 AIAA Space Architecture Best Paper
"Recommendations for Next Generation Crew Quarters" (ICES 2018-106) by Brandon W. Maryatt, NASA Johnson Space Center; Michael J. Van Wie, KBRwyle; and Toni A. Clark, Leidos, Inc.

2018 ASME/Boeing Best Paper
"Nonlinear Computational Aeroelasticity Using Structural Modal Coordinates" (AIAA 2018-1447) by Renator Medieros and Carlos Cesnik, University of Michigan; and Etienne Coetzee, Airbus Operations.

2018 ASME Propulsion Best Paper
"Additive Manufacturing of Liquid Rocket Engine Combustion Devices: A Summary of Process Developments and Hot-Fire Testing Results" (AIAA 2018-4625) by Paul Gradl, Sandy E. Greene, Christopher Protz, Brad Bullard, James Buzzell, Chance Garcia, Jessica Wood, and Kenneth Cooper, NASA Marshall Space Flight Center; James Hulka, Jacobs Technology, Inc.; and Robin Osborne, ERC Incorporated.

2019 AIAA Aerodynamic Measurement Technology Best Technical Paper
"Evaluation of Wavelet-Based Optical Flow Velocimetry from OH Scalar Fields in Reacting Turbulent Flows" (AIAA 2019-0270) by Bryan E. Schmidt and Jeffrey A. Sutton, Ohio State University; Colin A. Towery and Peter Hamlington, University of Colorado.

2019 AIAA Applied Aerodynamics Best Paper
"Multipoint Aerodynamic Shape Optimization for Subsonic and Supersonic Regimes" (AIAA 2019-0696) by Marco Mangano and Joaquim Martins, University of Michigan, Ann Arbor.

2019 AIAA Terrestrial Energy Systems Best Paper
"Impact of Alternative Fuel on Gas Turbine Noise, Vibration and Instability" (AIAA 2019-0240) by Charith J. Wijesinghe and Bhupendra Khandelwal, University of Sheffield, Sheffield, South Yorkshire, UK.

BEST STUDENT PAPERS AND STUDENT PAPER COMPETITIONS

2018 AIAA Aerospace Power Systems Best Student Paper
"The SPACE Computer Code for Analyzing the International Space Station Electrical Power System: Past, Present, and Future" (AIAA 2018-4635) by Sara G. Miller, Brandon T. Klefman, Steven Korn, Terrian Nowden, Ann M. Delleur, and David McKissock, NASA Glenn Research Center.

2018 AIAA Atmospheric Flight Mechanics Student Paper Competition
"An Experimental Investigation of Tractor and Pusher Hexacopter performance" (AIAA 2018-2983) by Prashin Sharma and Ella Atkins, University of Michigan, Ann Arbor

2018 AIAA Hybrid Rockets Best Student Paper
"Hypergolic Ignition and Relights of a Paraffin-based Hybrid Grain" (AIAA 2018-4661) by Alicia Benhidjeb-Carayon, Jason Gabl, and Timothee L. Pourpoint, Purdue University.

2018 Plasmadynamics and Lasers Best Student Paper
"Radar REMPI Diagnostic for Low Neutral Density Measurements of Xenon in Helium Buffer Gas: Experiments and Modeling" (AIAA 2018-3435) by Christopher A. Galea, Mikhail N. Shneider, and Arthur Dogariu, Princeton University; Tat Loon Chng, École Polytechnique; and Richard B. Miles, Texas A&M University.

2018 AIAA Solid Rockets Best Student Paper
"Overview of a Supersonic Probe for Solid Propellant Rocket CCP Collection" (AIAA 2018-4882) by Stefania Carlotti, Filippo Maggi, Riccardo Bisin, Stefano Dossi, and Luciano Galfetti, Politecnico di Milano, Italy; Dominik Saile and Ali Gülhan, German Aerospace Center, Germany; Christopher Groll and Tobias Langener, European Space Agency, Noordwijk, The Netherlands.

2018 Space Architecture Best Student Paper
"MARSH: Multi-Mission Artificial-Gravity Reusable Space Habitat" (AIAA 2018-5100) by Dale Martin, Melissa Adams, Spencer Aman, Derek Bierly, Andrew Delmont, Caleb Fricke, Simon Hochmuth, Nicholas Levitsky, Neel Patel, Aseel Syed, Skylar Trythall, Peter Wight, and David L. Akin, University of Maryland.

2018 AIAA Thermophysics Best Student Paper
"Aerothermodynamic Modelling of Meteor Entry Flows in the Rarefied Regime" (AIAA 2018-4180) by Federico Bariselli, Vrije Universiteit Brussel; Stefano Boccelli and Aldo Frezzotti, Technical University of Milan; Thierry Magin, von Kármán Institute for Fluid Dynamics; and Annick Hubin, Vrije Universiteit Brussel.

2019 American Society of Composites Best Student Paper
"Effects of Fiber Surface Treatment and Nozzle Geometry in Structural Properties of Additively Manufactured Two-Phase Composites" (AIAA-2019-0407) by Easir Arafat Papon, University of Alabama.

2019 Harry H. and Lois H. Hilton Student Paper Award in Structures
"Structural Modelling of Compliance-Based Morphing Structures under Transverse Shear Loading" (AIAA-2019-0229) by Andres E. Rivero, University of Bristol, Bristol, UK.

2019 Jefferson Goblet Student Paper Award
"Modeling of Laminated Reinforced Composite with Carbon Nanotube Interlayers to Estimate Structural Damping in a Rotorcraft Blade" (AIAA-2019-1511) by Keerti Prakash, Pennsylvania State University.

2019 Lockheed Martin Student Paper Award in Structures
"A Three-Dimensional Constitutive Modeling for Shape Memory Alloys Considering Two-Way Shape Memory Effect and Transformation-Induced Plasticity" (AIAA-2019-1195)

Student Author: Lei Xu, Texas A&M University.

2019 Southwest Research Institute Student Paper Award in Non-Deterministic Approaches
"Probabilistic Failure Analysis for ICME Using An Adjoint-based Lattice Particle Method" (AIAA-2019-0970) by Yi Gao, Arizona State University

Thank you to the technical committees who took the time to judge these papers and recognize the ongoing advancement of our aerospace community!

News

Utah Section Attends FanX 2019

In early September, the AIAA Utah Section, the larger Utah Engineers Council, and Hill AFB STEM partnered to showcase STEM at FanX, Salt Lake City's biannual Comic Convention, which draws more than 100,000 guests. The goal was to reach young people, educators, and parents in the local community and stimulate an interest in future STEM careers.

The volunteers contributed swag from Hill AFB STEM, displayed the A-10 simulator cockpit from the Hill Aerospace Museum as a photo-op, and exhibited an awesome interactive topographical sandbox that adjusted the projected map onto the sand as you played with it. The booth also had several FIRST robotics teams at multiple levels demonstrating their expertise to other kids their own age.

Multiple kids told volunteers that the STEM booth was their favorite event at the convention, which speaks highly of the volunteers and the great service they provided. It was a highly successful event, and the section looks forward to participating in this collaborative outreach effort again in the future!

AIAA Savannah Section Participates in Girls Engineer It Day

In mid-September, the Society of Women Engineers along with other organizations, including AIAA, hosted Girls Engineer It Day. More than 180 participants signed up to participate in various engineering activities. Some even attended an aircraft design course taught by Jessica Swann of the AIAA Savannah Section! It was a fun and successful event.

L to R. Linda and Joe Frietag celebrate with Mr. Thalmeier.

Thalmeier Receives the 13th Freitag Award

By Joe Freitag, AIAA Associate Fellow

On 18 September, **Jonas Thalmeier** received the Joseph Frietag, Sr. Award. Thalmeier is a graduate of the Daimler-Benz Training School, which provides apprentice training for metal working and robotic technician professions. Many of them like Thalmeier engage in special projects during their training and go on to universities to get their bachelor of engineering degrees.

This year, Thalmeier, 21, stood out from the two dozen applicants because of his innovative ideas and the automotive mechatronics engineering computer programs he had written. His academic performance was excellent and he assisted fellow classmates when they needed academic help. In addition to his own project that required oversight from two mentor teachers, he participated "brilliantly" on a team project by constructing and soldering circuitry. He enjoys motor biking with friends and on his summer holidays he has been a supervisor in the children's sports camp for the last five years.

While previous awardees pursued bachelor degrees in mechanical engineering, Thalmeier discovered he was quite good in the field of electronics and he was accepted by the University of Graz, Austria, to study of electrical engineering.

Following the award ceremony, Thalmeier, his family, members of the selection committee and some past award winners joined Joe Freitag and his wife Linda for dinner in Esslingen, Germany.

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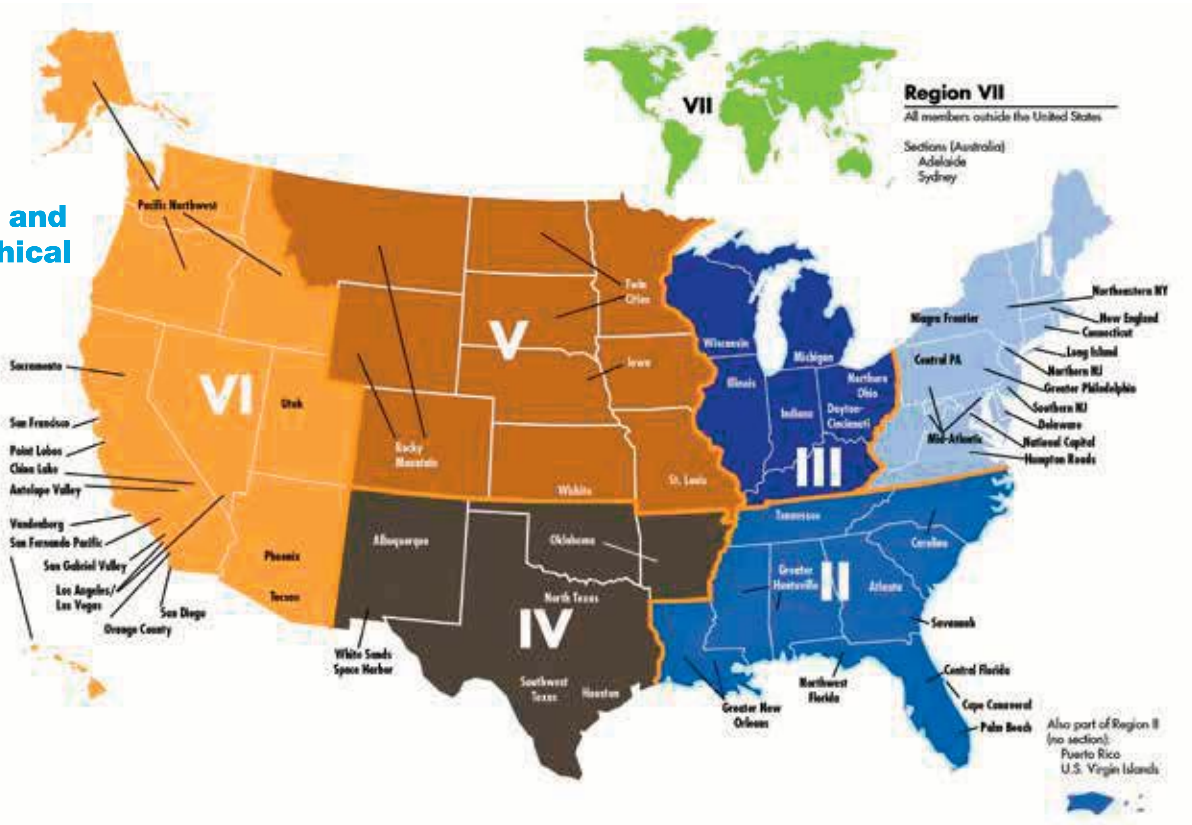

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Erin Tesny *Membership Officer*
Edmond Wong *Communications Officer*

Wisconsin

Michael Carkin *Chair*
Trent Cybela *Vice Chair*
Robert Michalak *Young Professional Officer*
Todd Treichel *STEM K-12 Officer*

REGION IV - SOUTH CENTRAL

Sarah Shull *Director*
Edgar Bering *Deputy Director, STEM K-12*
Alexander Foster *Deputy Director, Young Professionals*
David Fox *Deputy Director, Public Policy*
Svetlana Hanson *Deputy Director, Membership*
Edward Laverdure *Deputy Director, Education*
Mark Melanson *Deputy Director, Honors & Awards*
James Walker *Deputy Director, Finance*
Douglas Yazell *Deputy Director, Communications*

Albuquerque

Ben Urioste *Chair*
Terry Caipen *Secretary*
Mark Fraser *Public Policy Officer*
Andrea Loper *Career and Professional Development Officer*
Robert Malseed *Treasurer and Newsletter Editor*
William McCasland *Corporate Liaison*
Nicholas Morley *Programs Officer*
Erin Pettyjohn *Membership Officer*
Elfego Pinon *STEM K-12 Officer*
Svetlana Poroseva *University Liaison Officer*
Stephen Seiffert *Honors & Awards Officer*
Humberto Silva *Education Officer*

Houston

Irene Chan *Chair*
Edgar Bering *STEM K-12 Officer*
Thomas Bryan *Treasurer*
Shen Ge *Publicity Officer*
Ami Halbur *Technical Officer*
Svetlana Hanson *Chairman Emeritus*
Michael Martin *Education Officer*
William O'Neill *Secretary*
Wayne Rast *Public Policy Officer*
Patrick Rodi *Vice Chair, Technical*
Laura Sarmiento *Programs Officer*
Elizabeth Sheridan *Council Member*
Sarah Shull *Council Member*
Wanda Sigur *Council Member*
Jackelynne Silva-Martinez *Technical Officer*

North Texas

James Sergeant *Chair*
Mike Fox *Advisory Committee*
Dana Johnson *Treasurer*
Donald Kaderbek *Advisory Committee*
Justin Kanarick *Secretary*
Kevin Kramer *Advisory Committee*
Ian Marks *Vice Chair*
Paul Park *Advisory Committee*
Erasmo Pinero *Advisory Committee*
Michael Smith *Advisory Committee*
Robert Wetherall *Advisory Committee*

Oklahoma

Alfred Striz *Chair*
Andrew Arena *Secretary and Website Editor*
Michael Frey *Programs Officer*
Richard Gaeta *Vice Chair*
Subramanyam Gollahalli *Honors & Awards Officer*
Jamey Jacob *Newsletter Editor*
Prakash Vedula *Treasurer*

Southwest Texas

Gaurav Kumar *Chair.5*
Pablo Bueno *Treasurer*
James Crean *Membership and Public Policy Officer*
George Hindman *Technical Officer*
Joan Labay-Marquez *STEM K-12 Officer*
Thomas Moore *Secretary*

White Sands Space Harbor

Stephen McDougle *Chair*
Joe Bullington *Programs Officer*
Robert Cort *Education Officer*
Robert Cort *Honors & Awards Officer*

REGION V - MID WEST

Rusty Powell *Director*
Andrew Carlson *Deputy Director, Honors & Awards*
Karolyn Evans *Deputy Director, STEM K-12*
Cristin Finnigan *Deputy Director, Public Policy*

Kristen Gerzina *Deputy Director, Finance*
John Grace *Website Editor*
James Horkovich *Deputy Director, Technical*
Barrett McCann *Deputy Director, Education*
Gary White *Deputy Director, Membership*

Iowa
John Moore *Chair*
Vinay Dayal *Programs Officer*
Michael Gries *Treasurer*
Sridher Kaminani *Secretary*
Albert Ratner *Programs Officer*
Theodore Sieffert *Vice Chair*

Rocky Mountain
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Mohammed Ali *Career and Professional Development Officer*
Paul Anderson *Chairman Emeritus*
Tracy Copp *Public Policy Officer*
Tracy Copp *Vice Chair*
Stacey DeFore *Honors & Awards Officer*
Gene Dionne *Chairman Emeritus*
Alexandra Dukes *Young Professional Officer*
Erik Eliasen *Vice Chair, Montana*
Donna Gerren *Council Member*
John Grace *Website Editor*
Brian Gulliver *Chairman Emeritus*
Joseph Hackel *Website Editor*
Susan Janssen *Education Officer*
Wesley Kenison *Technical Symposium Chair*
Mark Kettles *Vice Chair, Wyoming*
Marshall Lee *Membership Officer*
Taylor Lilly *Treasurer*
John Marcantonio *Vice Chair and STEM K-12 Officer*
Kevin Mortensen *Secretary*
Adrian Nagle *Newsletter Editor*
Todd Nathaniel *Vice Chair*
Durga Niroula *Council Member*
James Paradise *Education Officer*
John Reed *TC Liaison*
Sean Zeeck *Council Member*
Christopher Zeller *Programs Officer*

St. Louis
James Guglielmo *Chair*
Jackie Blumer *STEM K-12 Officer*
Samuel Butler *Other*
Stephen Clark *Young Professional Officer*
Raymond Cosner *Retirees Section Officer*
Robert Dowgwillo *Programs Officer and Advisor*
Chelsea Fuller *Honors & Awards Officer*
Srikanth Gururajan *Advisor*
Alec Herzog *Treasurer*
Mark Kammeyer *Vice Chair*
Andrea Martinez *Publicity Officer*
Nicholas Moffitt *Membership Officer*
David Peters *Advisor*
Thomas Rehmeier *Website Editor and RAC Representative*
Benjamin Reuter *Secretary*
John Schaefer *Technical Officer*
Abigail Sevier *Newsletter Editor*
Bradley Sexton *Special Projects Officer*
Charles Svoboda *Education Officer*
Chris Tavares *Advisor*
Colin Thiele *History Officer*
Frank Youkhana *Public Policy Officer*

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Andrew Carlson *Website Editor*
James Casler *State Representative - North Dakota*
Jeffrey Doom *State Representative - South Dakota*
Cristin Finnigan *Public Policy Officer*
Frank Hoffmann *Treasurer*
Nicholas Janak *Vice Chair*
Michael Ward *Technical Officer*

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Minisa Childers *STEM K-12 Officer*
Alexis Fitzpatrick *Secretary*
John Franken *Student Liaison*
Eddie Irani *Programs Officer*
Vicki Johnson *Membership Officer*
Linda Kliment *Education Officer*
Jonathan Latall *Treasurer*
Robert Stuever *Honors & Awards Officer*
Dustin Tireman *Vice Chair and Professional Society Liaison*

REGION VI - WEST
John Rose *Director*
Matthew Angiulo *Deputy Director, Public Policy*
L. Jane *Hansen Deputy Director, Finance*
Elishka Jepson *Deputy Director, STEM K-12*
Jeffrey Jepson *Deputy Director, Honors & Awards*
Bradley Williams *Deputy Director, Young Professionals*
Oleg Yakimenko *Deputy Director, Education*

Antelope Valley
Jason Lechniak *Chair*
Keerti Bhamidipati *Treasurer*
Michael Bociaga *Young Professional Officer*
Patrick Clark *Secretary and Public Policy Officer*
Chris Coyne *Publicity Officer*
Dean Davis *Education Officer and STEM K-12 Officer*
Joshua Hundley *Programs Officer*
Robert Jensen *STEM K-12 Officer*
Joseph Piotrowski *Young Professional Officer*
Kasthuri Sivagnanam *University Liaison Officer*

China Lake
Michael Petersen *Chair*
Steven Goad *Public Policy Officer and RAC Representative*
Edward Jeter *Secretary and Website Editor*
Ying-Ming Lee *Membership Officer and Newsletter Editor*
Jeffrey Scott *Website Editor*
William Sturgeon *Treasurer*

Los Angeles-Las Vegas
Chandrashekhar Sonwane *Chair*
Jordan Chilcott *Public Policy Officer*
Ian Clavio *Student Liaison*
Robert DeLosSantos *Newsletter Editor*
Robert Friend *RAC Representative*
Lisa Kaspin-Powell *Communications Officer*
William Kelly *Treasurer*
Kenneth Lui *Programs Officer*
Aldo Martinez *Martinez Honors & Awards Officer*
Gary Moir *Aerospace Alumni Chair*
Gary Moir *Technical Officer*
Seth Potter *Professional Society Liaison*
Clay Rumsey *STEM K-12 Officer*
Moises Seraphin *Young Professional Officer*
Kenneth Varghese *Public Policy Officer*
Mohana Venkat *Programs Officer*
Marty Waldman *Las Vegas Chapter Representative*
Dennis Wonica *Enterprise Program*

Orange County
Lotfi El-Bayoumy *Chair*
Zachary Annala *Young Professional Officer*
Jonathan Hart *Website Editor*
Joseph Justin *Secretary*
Erol Kilik *Career and Professional Development Officer*
James Martin *Programs Officer*
Philip Ridout *Council Member*
Dino Roman *Technical Officer*
Philip Schulze *Chairman Emeritus*
Philip Schulze *Young Professional Officer*
Kamal Shweyk *Public Policy Officer*
David Sutton *Treasurer*
H. Welge *Membership Officer and RAC Representative*

Pacific Northwest
Adriana Blom-Schieber *Chair*
Roberto Albertani *State Representative - Oregon*
Emmanuel Domingo *Honors & Awards Officer*
Stanley Ferguson *Membership Officer*
Grant Funk *State Representative - Alaska*
Megan Harrington *Young Professional Officer*
Riley Harris *Advisor*
Abhiram Krishnan *Secretary-Elect*
Thomas Martig *Chairman Emeritus*
Priscilla Martinez *Vice Chair*
Matthieu Masquelet *Vice Chair Elect*
Brent Pomeroy *Council Member*
Karl Rein-Weston *Liaison*
Patrick Remy *Website Editor*
Christopher Roberdeau *Treasurer*
Simon Shuham *Advisor*
Elana Slagle *STEM K-12 Officer*
Jennifer Treese *Treasurer-Elect*
Paul Vijgen *RAC Representative*
Paul Vijgen *Secretary*

Phoenix
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Dennis Barbeau *Council Member*
Brianna Grembowski *STEM K-12 Officer*
Keith Jenkins *Council Member*
Keith Jenkins *Technical Officer*
Richard Kale *Secretary*
Jeonglae Kim *Council Member*
Eric Nichols *Council Member*
Scott Wertel *Treasurer*
Joseph Scroggins *Vice Chair*
Garrick Williams *Young Professional Officer*

Point Lobos
Giovanni Minelli *Chair*
Daniel Bursch *Treasurer*
Jae-Jun Kim *Website Editor*
Lara Magallanes *Vice Chair*
Stephen Tackett *Secretary*

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Andre White *Chair*
L. Jane *Hansen Council Member*
Brett Hoffstadt *Secretary and Communications Officer*
Brett Hoffstadt *Website Editor*
James Hornick *Chairman Emeritus*
Stephen Reiff *Public Policy Officer*
Perry Stout *Council Member*

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Kimberly Painter *Chair*
Mark Anderson *University Liaison Officer*
Kevin Burns *History Officer*
Nick Candrella *Secretary*
Diego Chavez *Student Liaison*
Abigail Cruz *Membership Officer*
Keith Glassman *Honors & Awards Officer*
Irving Hernandez *Education Officer*
Rich Kenney *STEM K-12 Officer*
Cesar Martin *Public Policy Officer*
Susana Munoz *Treasurer*
Jin Oh *Website Editor*
Joel Perez *Vice-chair, Technical*
Allen Plotkin *University Liaison Officer*
Christopher Root *Vice-Chair, Long-Range Planning*
Lindsey Sweeney *Treasurer*

San Fernando Pacific
L Dean *Miller Chair, Honors and Awards Officer*
Corinne Cho *Website Editor*
Carl Ehrlich *Treasurer, Membership Officer, Technical Officer*
Christine Hansen *State Representative - Hawaii*
Robert Tarn *Secretary*

San Francisco
Eric Wahl *Chair*
Watson Attai *Treasurer*
Christabelle Bosson *Council Member*
Kent Caldwell *Council Member*
Ramuhalli Krishna *Education Officer*
Richard Kwan *Council Member*
Thomas Lombaerts *Programs Officer*
Laura Morejon *Ramirez Student Liaison*
Swati Saxena *Honors & Awards Officer*
Vivek Vittaldev *Secretary*

San Gabriel Valley
Michael Staab *Chair*
Jill Hardash *Young Professional Officer*
Gerald Hintz *Treasurer*
Sevan Kenderian *Programs Officer and Website Editor*
Sevan Kenderian *Website Editor*
Oliver Lam *Student Liaison*
Alejandro Levi *Public Policy Officer*
Angus McRonald *Newsletter Editor*
Natanael Portillo *Membership Officer*
Mar Vaquero *Programs Officer*

Tucson
Michelle Rouch *Chair*
Teresa Clement *Vice Chair*
Rajka Corder *Membership Officer*
Eric Hoffman-Watt *Website Editor*
Michael Hotto *Young Professional Officer*
Jeffrey Jepson *RAC Representative*
Elishka Jepson *STEM K-12 Officer*
Alice Kunkel *STEM K-12 Officer*
Mehrdad Rouhani *Treasurer*
Steven Smith *Secretary*

Utah
Scott Stebbins *Chair*
Catherine Beck *Vice Chair*
Mark Edmonson *Secretary*
Trevor Floyd *Website Editor*
Jacob Hopkins *Young Professional Officer*
John McCrea *Communications Officer*
John Metcalf *Treasurer*
Clay Rumsey *STEM K-12 Officer*
Mark Snaufer *Treasurer*
Collin Wagner *Membership Officer*

Vandenberg
Michelle Itzel *Chair*
Steve Boelhouwer *Newsletter Editor and Website Editor*
Cheyenne Jones *Young Professional Officer*
Eva McLaughlin *Education Officer*
Christopher Menino *Membership Officer*
Kevin Smith *Treasurer*
Thomas Stevens *STEM K-12 Officer*
Anthony Touchette *Programs Officer*

REGION VII - INTERNATIONAL
Cees Bil *Director*
João Azevedo *Deputy Director, South America*
Roelof Vos *Deputy Director, Europe*

Adelaide
Saman Aghdam *Chair*
Mark Bateup *Council Member*
Rey Chin *Treasurer, University Liaison Officer*
RaviTeja Duggineni *Website Editor*
Shane Farrelly *Young Professional Officer*
Warrick Miller *Council Member*
Patrick Neumann *Vice Chair, Membership Officer*
Steven Pietrobon *Secretary*
Mark Ramsey *Chairman Emeritus*
Zoe Rich *Student Liaison*
Melanie Ward *Council Member*

Sydney
Arnab Dasgupta *Chair*
Sudip Bhattrai *Council Member*
Tjasa Boh *Whiteman Council Member*
Edmond Dien *Student Liaison*
Diego Exposito *Brioso Council Member*
Charles Hoke *Vice Chair - Canberra*
David Jarrett *Council Member*
Divya Jindal *Membership Officer and Young Professional Officer*
Nathan Long *Council Member*
Christopher Lowe *Treasurer*
Andrew Neely *STEM K-12 Officer*
Cole Scott-Curwood *Student Liaison*
Nimish Shete *Vice Chair-Sydney and Website Editor*
Michael Spencer *Honors & Awards Officer*
Matthew Vella *Council Member*
Gareth Vio *University Liaison Officer*

MISSOURI S&T

Aerospace Engineering Faculty Positions

Missouri University of Science and Technology, Rolla, Missouri

https://mae.mst.edu/

The Department of Mechanical and Aerospace Engineering at the Missouri University of Science and Technology (Missouri S&T) in Rolla, Missouri is seeking outstanding applicants for multiple tenure-track Aerospace Engineering faculty positions in all areas of aerospace engineering including but not limited to computational and experimental aerodynamics, propulsion, aerospace structures and materials, flight dynamics and control, and astronautics. Preference will be given to applicants who can apply their expertise in the above fields to one or more of the department's research thrust areas in aerospace engineering, which include hypersonics and high-speed aerospace vehicles, space systems (focusing on small satellites), and autonomous aerial vehicles and intelligent systems. The position is open to all ranks with the emphasis on assistant and associate professor levels.

Applicants should have demonstrated excellence in research and evidence of potential for excellence in external funding and teaching. Additionally, candidates for associate and full professor position should have demonstrated excellence in externally funded research and teaching. Successful candidates will be expected to have strong commitments to establishing a strong, externally funded research program and high-quality teaching both at the undergraduate and graduate levels. Applicants must hold a Ph.D. in Aerospace Engineering or a closely related field.

The Department of Mechanical and Aerospace Engineering is currently in a position of strength after seven years of deliberate implementation of its ambitious strategic plan. Both research expenditures and Ph.D. enrollment for the department have doubled in five years, with broad support from federal and industrial sponsors. In addition, multiple junior faculty have received CAREER and DoD young investigator awards and many Ph.D. students have received prestigious fellowships from NASA, NSF, and DoD. The department is the largest department on campus; both Mechanical and Aerospace Engineering programs are the largest in the state of Missouri. It is situated in a state-of-the-art 145,000 ft2 facility and has 27 internationally recognized tenured/tenure-track faculty, 5 teaching faculty, 12 staff, over 250 graduate students (including 128 PhD students), over 1,000 undergraduate students, and over 12,000 living alumni. Further details on the department and the Aerospace Engineering program may be found at: **https://mae.mst.edu/**

Missouri S&T's Department of Mechanical and Aerospace Engineering, the campus, and the greater University of Missouri System are deeply committed to inclusion and valuing diversity and the applicants are expected to contribute to this commitment. Missouri S&T has undertaken a number of initiatives to improve campus life and the work/life balance of its faculty and staff (see **http://hr.mst.edu**). Missouri S&T seeks to meet the needs of dual-career couples.

Interested candidates should electronically submit their application consisting of: 1) a cover letter, 2) a current curriculum vitae, 3) a research statement, 4) a teaching statement, and 5) complete contact information for at least four references to Missouri S&T's Human Resources Office at: **http://hr.mst.edu/careers/academic/** using Reference Number 00030914. Acceptable electronic formats are PDF and MS Word. The review of applications will begin on December 9, 2019 and will continue until the positions are filled. For more information prior to submitting an application, please contact the Search Committee Chair, Prof. Serhat Hosder, at: **hosders@mst.edu**.

Missouri S&T is a leading research university founded in 1870 as one of the first technological institutions west of the Mississippi. Located about 100 miles southwest of St. Louis in the multicultural community of Rolla, Missouri S&T is an accessible, safe and friendly campus located/situated in the beautiful rolling hills of the Ozarks and is close to numerous parks and bodies of water. Missouri S&T has nearly 9000 students enrolled on campus and online and offers 20 Ph.D. programs in the sciences and engineering.

Missouri S&T is an AA/EEO employer and does not discriminate on the basis of race, color, national origin, ancestry, religion, sex, pregnancy, sexual orientation, gender identity, gender expression, age, disability, protected veteran status, or any other status protected by applicable state or federal law. Females, minorities, and persons with disabilities are encouraged to apply. The university participates in E-Verify. For more information on E-Verify, please contact DHS at: 1-888-464-4218.

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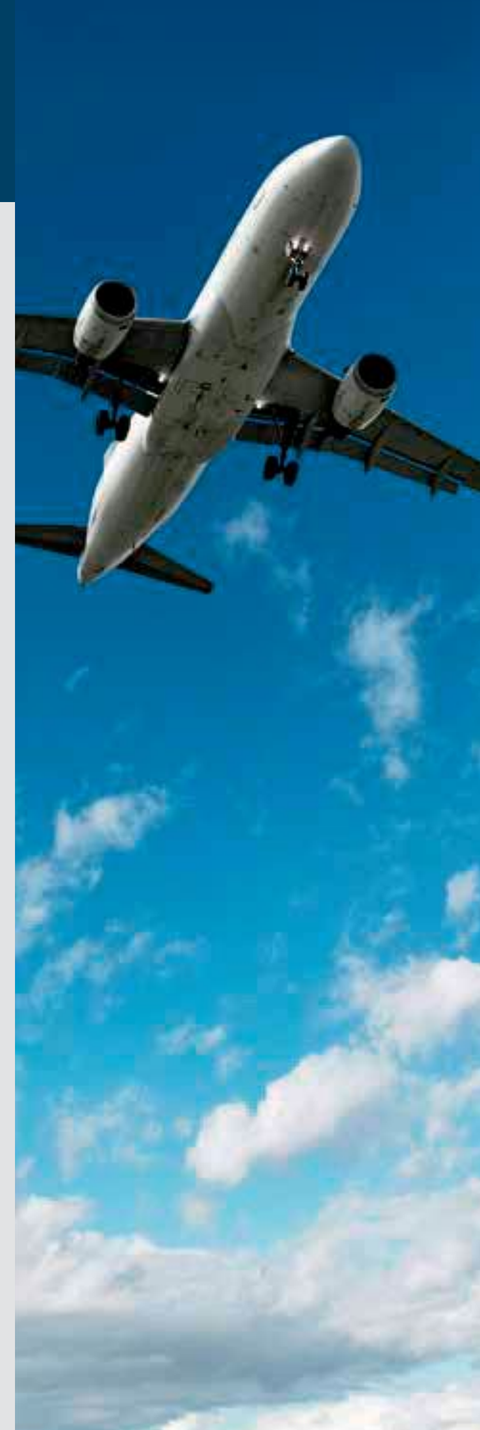

FLORIDA TECH

Faculty Positions in Aerospace Engineering
Department of Aerospace, Physics and Space Sciences
Florida Institute of Technology, Melbourne, FL 32904

The Department of Aerospace, Physics and Space Sciences at Florida Institute of Technology invites applications for multiple full-time faculty positions in Aerospace Engineering with an expected start date of August 2020. Appointments will be either tenure-track or tenured, and will be considered as appropriate at all ranks including Assistant, Associate, and Professor. We are interested in candidates who are committed to teaching at both the undergraduate and graduate levels while conducting cutting edge, externally-funded, research programs in Aerospace Engineering. Candidates are required to hold a Ph.D. in Aerospace Engineering or a closely related field. Those with leading research programs in propulsion, controls, space structures, spaceflight mechanics, and aerodynamics/flight mechanics are especially encouraged to apply.

Information about the Department of Aerospace, Physics and Space Sciences and the College of Engineering and Science can be found at **http://floridatech.edu/apss/**. Our mission is to guide the next generation of engineers and scientists into careers they will love, to understand the physics of the universe, and drive humanity's future in the air and in space. The department has 33 faculty, over 564 undergraduates, and more than 112 graduate students. We are at the heart of the vibrant aerospace community on the U.S. Space Coast and nestled in an area of outstanding natural beauty. Located at the birthplace of American space exploration, the Space Coast is now experiencing an increasing number of launches and sonic booms. Melbourne enjoys a low cost of living, is served by Orlando-Melbourne International Airport, and is consistently ranked as one of the best places to live in the U.S.

In addition to the Kennedy Space Center, the Space Coast is home to Cape Canaveral Airforce Station and Patrick Air Force Base. It is the operational base for the Naval Ordnance Test Unit, the 45th Space Wing, and the 920th Rescue Wing. Aerospace companies in the area include Blue Origin, Boeing, Collins Aerospace, Embraer, SpaceX, OneWeb, L3 Harris, Lockheed Martin, Northrop Grumman, Sierra Nevada Corporation, and United Launch Alliance.

To apply, send a single PDF to **apss-search@fit.edu** containing a cover letter, CV, a statement of research experience and interests, a statement of teaching experience and philosophy, and contact information for at least three references. Strong candidates will articulate a significant collaborative research program that meets the mission of the department. Positions will be open until filled, but applications received by December 31st will be given full consideration.

Florida Tech is an equal opportunity employer.

For further information, interested candidates may contact:
Dr. Daniel Batcheldor
Head of Aerospace, Physics and Space Sciences
dbatcheldor@fit.edu.

Massachusetts Institute of Technology

Department of Aeronautics and Astronautics Tenure-Track Faculty Position

The MIT Department of Aeronautics and Astronautics invites applications for tenure-track faculty positions with a start date of 1 July 2020 or a mutually agreeable date thereafter. The department is conducting a search for exceptional candidates in any discipline related to aerospace engineering, broadly defined, though particular interests are in: the interaction of humans and autonomy, environmental monitoring and mitigation, and human exploration of space.

We are seeking highly qualified candidates with a commitment to research and education. Faculty duties include teaching at the graduate and undergraduate levels, advising students, conducting original scholarly research, developing course materials at the graduate and undergraduate levels, and serving the Institute and the profession.

Candidates should hold a doctoral degree in a field related to aerospace engineering or another relevant science or engineering field by the beginning of employment. The search is for candidates to be hired at the assistant professor level; under special circumstances, however, a senior faculty appointment is possible.

Applications must include a cover letter, curriculum vitae, a 2-3 page statement of research and teaching interests and goals, and names and contact information of at least three individuals who will provide letters of recommendation. Applicants with backgrounds outside aerospace should describe how a substantial part of their work will apply to aerospace problems. Applications must be submitted as a pdf at: https://school-of-engineering-faculty-search.mit.edu/aeroastro/register.tcl. Letters of recommendation must be submitted directly by the recommenders at https://school-ofengineering-faculty-search.mit.edu/letters. To ensure full consideration, complete applications should be received by 1 December 2019. Applications will be considered complete only when both the applicant materials and at least three letters of recommendations are received.

MIT is building a diverse faculty and strongly encourages applications from female and minority candidates.

For more information on the MIT Department of Aeronautics and Astronautics, please visit http://aeroastro.mit.edu/. Applicants may find reading our strategic plan helpful in preparing their application (https://aeroastro.mit.edu/about/strategic-plan). Questions can be directed to faculty search chair Prof. Youssef Marzouk at ymarz@mit.edu.

MIT is an Equal Opportunity/Affirmative Action employer.

http://web.mit.edu

1919

Nov. 6 Aerial flower delivery service starts between Paris and Copenhagen, with an intermediary stop in Holland. Four hundred kilograms of flowers are carried on the first flight. **Aircraft Year Book, 1920**, p. 258.

Nov. 12-Dec. 10 The first intercontinental flight between England and Australia, a distance of 18,000 kilometers, is made in stages by Ross Smith, with a crew of three, in a Vickers Vimy. He leaves from London and arrives at Port Darwin, Australia. Smith and his companions win the Commonwealth Prize, worth about $600,000 today. Smith is also knighted. **Flight**, Dec. 18, 1919, pp. 1,619-1,620.

During November 1919
Airmail service is started in Japan, between Tokyo and Osaka. **Flight**, Nov. 6, 1919, p. 1,452.

1944

Nov. 1-Dec. 7 Representatives from 52 countries attend an international civil aviation conference in Chicago and reaffirm the doctrine of national sovereignty in airspace. They also establish the Provisional International Civil Aviation Organization, which will regulate air commerce. The Chicago Conference becomes the fundamental foundation of postwar international civil aviation. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 48.

Nov. 3 Japan deploys its Fu-Go weapon, a series of balloons carrying incendiaries toward the Western U.S. The balloons, made of rubberized silk, are sent aloft and carried by jet streams across the Pacific Ocean but accomplish little. Robert C. Mikesh, **Japan's World War II Balloon Bomb Attacks on North America**, p. 65.

Nov. 10 A Supermarine Spitfire that flew in the Battle of Britain is presented to the Chicago Museum of Science and Industry. **The Aeroplane**, Nov. 17, 1944, p. 554.

Nov. 9 The Boeing XC-97 Stratofreighter prototype makes its first flight. Based on the airframe of the B-29 bomber, the XC-97 incorporates a large pressurized double-decked fuselage. The civil version becomes the classic Boeing 377 Stratocruiser that flew passengers in great comfort across the Atlantic and Pacific oceans and included an exclusive below-deck lounge. Peter Bowers, **Boeing Aircraft Since 1916**, pp. 353-373.

Nov. 15 The U.S. Army Ordnance initiates the Hermes program for ballistic missile research and development. The prime contract is awarded to General Electric. One of the projects to emerge from Hermes is the RV-A-10, the first U.S. large-scale solid-fuel rocket. This technological breakthrough is the progenitor of all large-scale solid rockets, such as the space shuttle program's solid-fuel boosters and the Scout launch vehicle. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 48.

Nov. 17 The U.S. Navy's Bureau of Aeronautics initiates feasibility studies of the Army's JB-2 version of the German pulse-jet-powered V-1. The Navy version, called the Loon, is later launched from submarines in tests, but never becomes operational. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 48.

Nov. 24 The U.S. Army Air Forces conducts its first major bombing attack on Tokyo, sending 111 B-29 bombers from the Mariana Islands. The main target is the Musashino aircraft plant. K.C. Carter and R. Mueller, compilers, **The Army Air Forces in World War II,** p. 505.

Nov. 30 Kenneth Gatland of the Combined British Astronautical Societies is one of the first to recognize that the German V-2 war rocket has great possibilities for spaceflight. He suggests that if the warhead were replaced with about 45 kilograms of instruments, it could carry them into deep space and to "the moon itself." Some people disagree with his calculations. **Flight**, Nov. 30, 1944, p. 593.

During November 1944
A British Royal Air Force de Havilland Mosquito flies 7,800 kilometers from Great Britain to Karachi, India, in 16 hours, 46 minutes, breaking the speed record set 10 years earlier by Amy Johnson and Jim Mollison. Flown by Flight Lt. J. Linton, the Mosquito's average speed is 506 kph. **The Aeroplane**, Nov. 17, 1944, p. 554.

1969

Nov. 3 Boeing receives a $19 million contract to build four lunar rovers for Apollo missions. Each rover is to be battery-operated and equipped with a color TV camera to send images back to Earth via satellite. It is expected to travel about 11 kph and carry four times its own weight. Eventually, astronauts on Apollo 15, 16 and 17 drive the rovers. **Aviation Week**, Nov. 3, 1969, p. 20.

Nov. 8 The AZUR, or German Research Satellite, West Germany's first scientific satellite and the first of its kind to be developed with the U.S., is launched by a four-stage solid-propellant Scout rocket from Vandenberg Air Force Base, California. The 71-kilogram satellite carries seven scientific experiments provided from five West German research institutes. The main missions of the satellite are to study the Van Allen belts, solar particles and the aurora. **Aviation Week**, Nov. 3, 1969, p. 19; NASA, **Astronautics and Aeronautics, 1969**, pp. 364-365.

Nov. 8 Vesto Slipher, the American astronomer who headed the team that in 1930 discovered the planet Pluto, dies at age 93. The discovery was made by Clyde Tombaugh of the Lowell Observatory, New Mexico, whom Slipher had hired. Slipher was the director of the Lowell Observatory from 1926 to 1952. He had also been the first to observe, in 1912, the shift of spectral lines of galaxies or galactic redshifts; in 1914, he discovered the rotation of spiral galaxies. **Los Angeles Times**, Nov. 10, 1969.

Nov. 9 John B. Oke of CalTech reports the discovery of a new kind of galaxy at the visual edge of the universe and billions of light years away and detected by the 500-centimeter telescope at Mount Palomar, California. **Washington Post**, Nov. 10, 1969, p. A1.

Nov. 14 Apollo 12, the second mission to the moon, launches, carrying astronauts Pete Conrad, Richard Gordon Jr. and Alan Bean. Their Intrepid Lunar Module makes a pinpoint landing Nov. 19 in the moon's Ocean of Storms, only 183 meters from where the Surveyor 3 landed on April 19, 1967. Conrad and Bean will deploy a solar wind composition experiment, a passive seismometer and a lunar surface magnetometer, as well as take numerous photos and collect 43 kilograms of lunar samples. NASA, **Astronautics and Aeronautics, 1969**, pp. 372-378.

Nov. 14 NASA's Lewis Research Center in Cleveland awards a $2.5 million contract to United Aircraft Corp.'s Pratt & Whitney Division to build 18 RL-10 rocket engines for use on Centaur high-energy upper-stage rockets in the early 1970s. Developed in 1958, the RL-10 is the first liquid-hydrogen and liquid-oxygen engine to be flown in space and made its first flight on Nov. 27, 1963, in a test of an Atlas launch vehicle. NASA, **Lewis Research Center Release 69-68**.

Nov. 16 The first public display of an Apollo moon rock opens at the American Museum of Natural History in New York and attracts the largest crowd in the museum's history. The rock weighs 21.1 grams. **New York Times**, Nov. 16, 1969, p. 66.

Nov. 21 Britain's Skynet 1A military communications satellite launches on a U.S. Delta booster from Cape Kennedy, Florida. The 242-kilogram satellite was built by Philco-Ford for the United Kingdom and is one of two planned satellites for the British Skynet military communications satellite network. **Aviation Week**, Nov. 3, 1969, p. 20, and Dec. 8, 1969, p. 50.

Nov. 24 A NASA airborne auroral expedition begins in which a Convair 990 Coronado jet airliner equipped with scientific instruments and also carrying scientists, makes the first of a dozen planned flights from Fort Churchill, Canada, in conducting a study of the aurora in polar regions. The expedition involves 25 university, industry, NASA and other scientists and flies at altitudes up to 12,190 meters. **New York Times**, Nov. 25, 1969, p. 32.

Nov. 27 The prototype of Israel Aircraft Industries' Arava STOL 20-passenger feederliner aircraft makes its first flight with IAI's chief test pilot Avraham Hacohen. The light STOL utility aircraft is designed for operation from rough fields and features rear-door loading. It is also able to be rapidly converted to either passenger or all-cargo configuration. **Aviation Week**, Dec. 15, 1969, p. 24.

1994

Nov. 3 The space shuttle Atlantis blasts into orbit. On board is the Atmospheric Laboratory for Applications and Science, which begins to collect data on the depletion of the Earth's ozone layer. NASA, **Astronautics and Aeronautics, 1991-1995**, pp. 589-590.

Nov. 8 Astronomers map Titan, the largest of Saturn's moons, with the Hubble Space telescope. NASA, **Astronautics and Aeronautics, 1991-1995**, p. 592.

Nov. 30 China launches its latest communications satellite, the Dongfanghong III, on a Long March 3A booster from its base in Xichang. NASA, **Astronautics and Aeronautics, 1991-1995**, p. 601.

During November
A U.S. Air Force B-1B squadron from Ellsworth Air Force Base, South Dakota, completes a readiness test with an 84.6% mission-capable rate. Congress required the six-month Operational Readiness Assessment to settle debate about how much funding the aircraft needed to demonstrate combat effectiveness. **Air Force Magazine**, February 1995.

JONATHAN LANDON, 37

Radio frequency design engineer, L3Harris Technologies

Jonathan Landon was about 10 when he tried to program his family's Atari computer with instructions from a book. The experience was frustrating but he eventually decided to overcome defeat by spending four years in college learning how computers work. Those classes led him to electronics, electromagnetics and antennas. He now designs antennas at L3Harris in Salt Lake City, a maker of antennas for ground vehicles, ships and aircraft.

Attracted to "hard" work ▶ What drew me to engineering was that I heard it was hard. I wondered if I was up to the challenge. Whenever I thought about quitting, I remembered how I felt when I first looked at college course offerings and saw an antenna theory class. It's magical to me that a big piece of metal miles away creates electromagnetic waves that induce tiny electrical currents in my radio.

Signals are the point ▶ At Brigham Young University, I focused more on signal processing because ultimately if there's no signal being received or transmitted, what's the point of the antenna?

Choreographing a mechanical ballet ▶ When I finished undergraduate, I felt like I didn't have enough knowledge to be useful to a company. I stayed for graduate school and got involved in radio astronomy, working with a small radio telescope array on the roof of the engineering building. When you see antennas working in this mechanical ballet to steer and track a celestial object while the Earth rotates under them, it's truly beautiful. I stuck around to get a Ph.D. in electrical engineering.

Special mission ▶ I feel like some people have a negative view toward military aerospace. I want to make a plug for the important work we do. When my friends, neighbors and family members who have the courage to put on that uniform can talk to each other in the field or see video beamed down from an airplane showing dangers on the other side of a hill or building, it keeps them safer and helps ensure they come home.

Autonomous cars preview urban air mobility ▶ In futuristic TV shows, everybody has rocket packs and personal flying vehicles. I would love that to be a reality but I don't think it will be 30 years from now. The basic technology already exists but it is not cost-effective. However, I think we're going to see a lot more self-driving cars and the coordination between those autonomous cars will be directly applicable to coordination of small individually piloted aerial vehicles. Thirty years from now, I think that we're going to be having the kinds of discussions about flyable cars of the future that we're having right now about self-driving cars. ★

BY DEBRA WERNER | werner.debra@gmail.com

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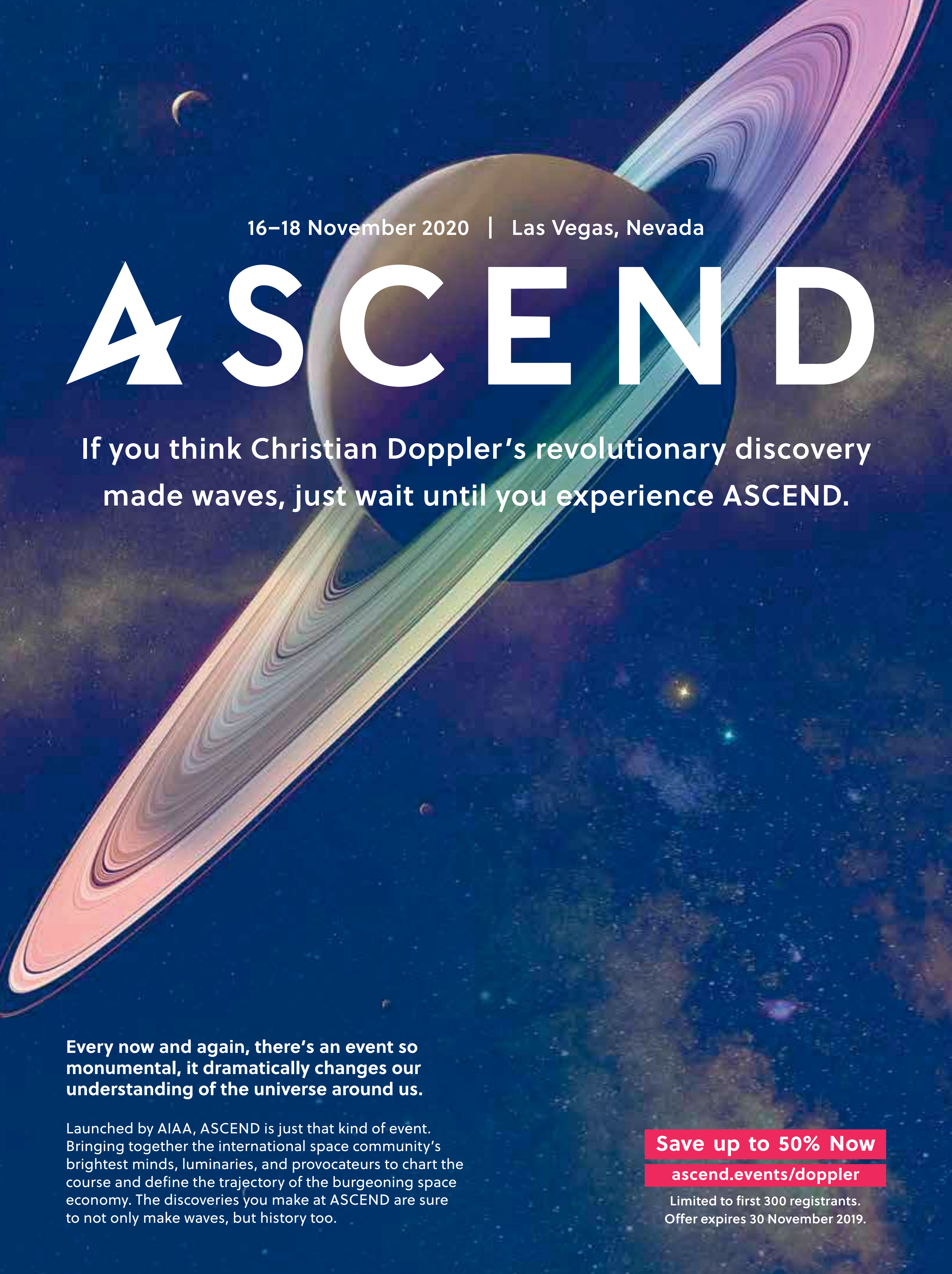
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