AEROSPACE

AMERICA

Satellite envy

Balloons could outperform spacecraft by surfing the stratosphere. We go deep on one company's plan.

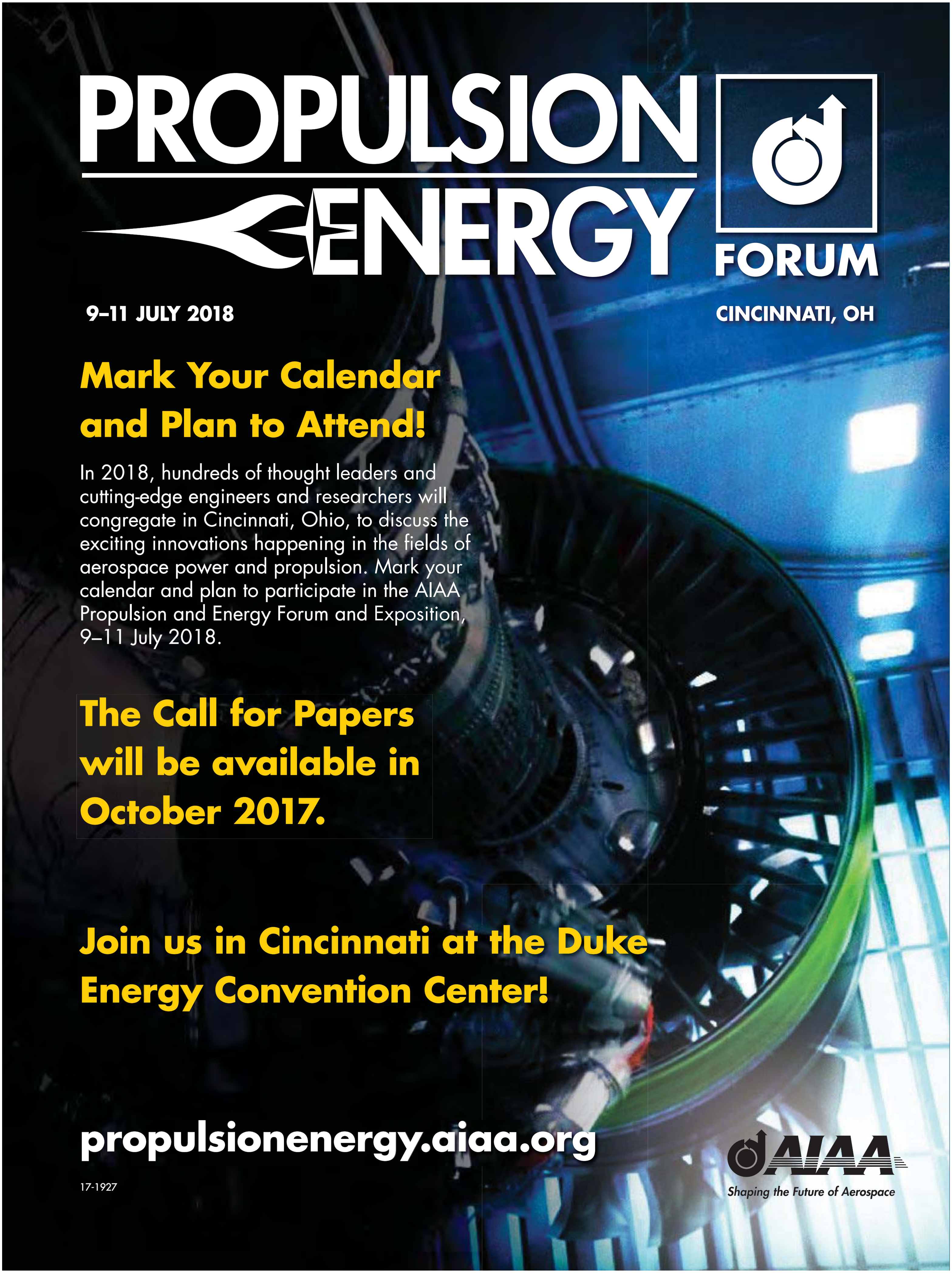
PAGE 24

OCTOBER 2017 | A publication of the American Institute of Aeronautics and Astronautics | aerospaceamerica.aiaa.org

AIAA
Shaping the Future of Aerospace

On the cover: A crew prepares a Stratollite for launch in Arizona.

Image credit: World View


PROPULSION
ENERGY
FORUM
9–11 JULY 2018
CINCINNATI, OH
Mark Your Calendar and Plan to Attend!
In 2018, hundreds of thought leaders and cutting-edge engineers and researchers will congregate in Cincinnati, Ohio, to discuss the exciting innovations happening in the fields of aerospace power and propulsion. Mark your calendar and plan to participate in the AIAA Propulsion and Energy Forum and Exposition, 9–11 July 2018.
The Call for Papers will be available in October 2017.
Join us in Cincinnati at the Duke Energy Convention Center!
propulsionenergy.aiaa.org
17-1927
AIAA
Shaping the Future of Aerospace

AEROSPACE AMERICA

OCTOBER 2017, VOL. 55, NO. 9

EDITOR-IN-CHIEF
Ben Iannotta
beni@aiaa.org

ASSOCIATE EDITOR
Karen Small
karens@aiaa.org

STAFF REPORTER
Tom Risen
tomr@aiaa.org

EDITOR, AIAA BULLETIN
Christine Williams
christinew@aiaa.org

EDITOR EMERITUS
Jerry Grey

CONTRIBUTING WRITERS
Keith Button, Adam Hadhazy, Tom Jones, Robert van der Linden, Debra Werner, Frank H. Winter

James "Jim" Maser **AIAA PRESIDENT**
John Langford **AIAA PRESIDENT-ELECT**
Sandra H. Magnus **PUBLISHER**
Rodger S. Williams **DEPUTY PUBLISHER**

ADVERTISING
Joan Daly, 703-938-5907
joan@dalyllc.com

ART DIRECTION AND DESIGN
THOR Design Studio | thor.design

MANUFACTURING AND DISTRIBUTION
Association Vision | associationvision.com

LETTERS AND CORRESPONDENCE
Ben Iannotta, beni@aiaa.org

Aerospace America (ISSN 0740-722X) is published monthly by the American Institute of Aeronautics and Astronautics, Inc., at 12700 Sunrise Valley Drive, Suite 200 Reston, VA 20191-5807 [703-264-7500]. Subscription rate is 50% of dues for AIAA members (and is not deductible therefrom). Nonmember subscription price: U.S., $200; foreign, $220. Single copies $20 each. Postmaster: Send address changes and subscription orders to Aerospace America, American Institute of Aeronautics and Astronautics, at 12700 Sunrise Valley Drive, Reston, VA, 20191-5807, Attn: A.I.A.A. Customer Service. Periodical postage paid at Reston, Virginia, and at additional mailing offices.

IN THIS ISSUE

Tom Jones

Tom flew on four space shuttle missions. On his last flight, STS-98, he led three spacewalks to install the American Destiny laboratory on the International Space Station. He has a doctorate in planetary sciences.

PAGE 12

Adam Hadhazy

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

PAGE 16

Keith Button

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

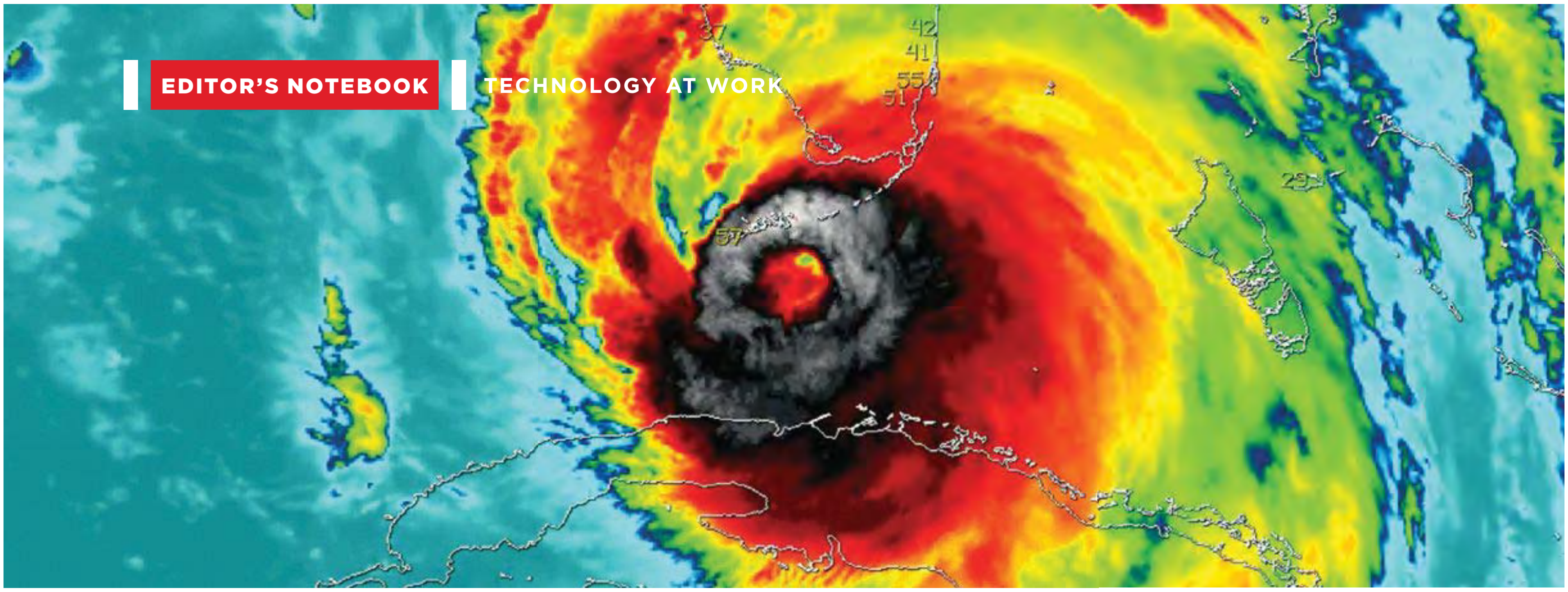
PAGE 24

Debra Werner

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

PAGE 34

DEPARTMENTS



Lessons from Harvey and Irma

▲ **Hurricane Irma** approaches the Florida Keys on Sept. 10 in this test image from the Advanced Baseline Imager on NOAA's GOES-16, the first of a next generation series of weather satellites.

The storm losses in Texas and Florida could have been even worse were it not for the many talented and energetic young people who decided years ago to pursue careers in aerospace and the associated sciences, such as weather forecasting.

The accurate forecasts and fast relief efforts were set up by the difficult lessons of 2005's Hurricane Katrina, and also by years of technical innovation and budget fights over how to spend federal dollars. There were the Hurricane Hunter planes and NOAA weather satellites that fed the forecast models; the overhead images of the storm aftermath that reassured some evacuees and broke the hearts of others. There were the algorithms, software and communications networks that tied the information together and shared it.

In light of all this, the aerospace industry should not need to gussy itself up to continue attracting the best and brightest. In our high schools and universities at this very moment, I would bet that young people have come away energized about the professionals they saw in action. They will cut through the policy controversy about climate change that has paralyzed my generation. They will reshape the aerospace industry in ways that none of us can predict.

Those well into their careers, like me, will need to be open-minded about the coming changes. Someone who needs to forecast a hurricane's path, or calculate what it will take to calm our amped-up atmosphere, doesn't care whether the data comes from an agency, a startup or a giant corporation. The information needs to be accurate and the supply of it can't vanish with the whims of the business cycle or budgets on Capitol Hill. Other than that, the sky is open.

As with any human calamity, there will be lessons from Harvey and Irma. One of them has to do with the power of math. Algorithms, it turns out, can be tools for good or ill. They are the foundation of the forecasting models that warned of Harvey's epic rainfall and nailed the track and intensity of Irma. But automated versions of algorithms also reportedly drove up the prices of airline tickets for evacuees who had no other way to get out of harm's way. When the next emergency comes, it won't do to say the prices were the fault of an algorithm.

A better world lies ahead, so long as the humans stay in charge of the technology. ★

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

Looking to the future and the past

NASA

Gemini 8 astronauts Neil Armstrong and David Scott prepare to board their spacecraft at Cape Kennedy in Florida in 1966.

While I'm very excited about [Elon] Musk and [Jeff] Bezos and their commercial plans to return to the moon and go to Mars, I feel the need to remind the newer generation of the past glory days of NASA and pioneering space in the early years.

Now at my advanced age of 81, it seems like only yesterday when I was 21 and part of the pioneering of space. Where did those years go?

So many of my colleagues are no longer here. Every week another of my friends shows up in the obituary column. I feel that soon I'll be the last one standing.

It's hard not to reflect on the past. Someone once said that you are left with memories and regrets.

I've got wonderful memories.

And a few regrets, of course.

And now more time to think about them.

But [I'm] still looking forward to the future and being around to experience the wonder of it all.

William Ketchum
San Diego
Bill.rocketman@gmail.com
AIAA associate


SPACE FORUM
17–19 SEPTEMBER 2018
ORLANDO, FL
SEE YOU NEXT YEAR
• Game Changers - Make connections with the individuals who drive change in space policy, research and development, funding, and manufacturing.
• Collaboration - You will exchange the most original perspectives, stimulating research developments, and innovative solutions. You'll find out what lies ahead and get introduced to emerging technologies that are affecting aerospace.
• Develop Skills - You'll increase your influence and develop skills when you present your research, take a continuing education course or workshop, or participate in the student and young professional programs at 2018 AIAA SPACE Forum.
• Network, Network, Network - More than 80% of participants who responded to our latest AIAA SPACE Forum satisfaction survey said that they'd met someone new, and almost 20% said that they established a personal contact with prospective employers.
Lean More!
space.aiaa.org
AIAA
Shaping the Future of Aerospace

Around the Institute

It has been a while since I have had an opportunity to just take a moment and highlight some of the exciting activities happening around the Institute, so that is the subject of this month's Corner Office. Truly it has been a very dynamic year!

First and foremost our new governance structure went into effect at the May Board meetings. The Board of Trustees (Board) and the Council of Directors are busy getting organized — identifying any policies, procedures, or other organizational aspects that are still needed while also working jointly on creating the Institute's strategic plan for the next four years. In addition, the Resource Working Group, which has been meeting for the past year, will be making recommendations at the September Board meeting on how the Institute can thoughtfully and appropriately resource member activities in the new structure. These recommendations will be folded into the development of the Institute strategic plan. An enormous amount of work has gone into, and continues to be dedicated to, helping define the future of the Institute as the transition plays out over the next three years. Our members are active in so many areas!

Since 2015 we have had two new member communities created around some exciting emerging technologies: hybrid electric propulsion for aircraft and transformational electric flight. The Aircraft Electric Propulsion and Power Working Group has been set up and is taking a multidisciplinary approach to bringing the large civil transport and the small aircraft and personal air vehicle communities together as well as bringing new people and disciplines to engage with AIAA. Furthermore, a large and energetic Transformational Flight Program Committee has positioned AIAA as the go-to organization for any and all things related to transformational electric flight.

We have also started some educational outreach related to cybersecurity. Our monthly newsletter Protocol highlights recent cyber-problems that you might not otherwise have heard about and explains general issues related to cybersecurity. This is a subject that can be intimidating and mysterious and it is imperative that all aerospace professionals become more familiar and comfortable with this topic. I encourage you to go to **www.aiaa.org/cybersecurity** and opt-in to continue receiving it. We also invite you to forward this newsletter to your colleagues who are not necessarily associated with AIAA. Finally, our DEMAND for UNMANNED UAS community continues to thrive at AVIATION and in collaboration with some of our sister societies. The areas I mentioned above are on top of all the great things our established technical communities continue to engage in, whether that be short courses, excellence in technical papers, and outreach. We are a busy Institute!

Our Diversity Working Group continues its mission to encourage participation and collaboration across all members of our community regardless of race, gender, or ethnicity. The members work quite closely with the K–12 STEM committee to encourage young people from all backgrounds to engage with aerospace. (For more details of the Diversity Working Group's plan and activities, go to: **www.aiaa.org/Diversity**.) Recently inaugural chair Susan Frost, of NASA Ames, stepped down after a two-year term, and I would like to thank her for her leadership in the group's formative years. I am excited to announce that Jandria Alexander of The Aerospace Corporation has taken over as chair.

We've made some changes on staff as well over the past year. As one of the goals of the new governance structure is to provide more opportunities for member engagement, we have changed the name of our "Member Services" Division to "Member Services and Engagement" Division. This might seem like a small change, but the difference is quite important. For AIAA to be successful in the dynamic world around us, staff cannot just "serve," which implies passively reacting when addressed, but rather actively "engage" with members. It is equally vital that our members, and frankly, nonmember aerospace professionals, actively engage with the Institute to do great things for the aerospace sector. Working together we can accomplish anything!

As you can see from just the brief highlights AIAA continues to make an impact. Please keep your eyes open for ways you might engage with the Institute in those areas that you are passionate about. For now, however, if you are interested in becoming involved with the Aircraft Electric Propulsion and Power Working Group or the Transformational Flight Program Committee, please contact Tom Irvine at tomi@aiaa.org and he will put you in touch with the volunteer leadership of these groups. If you have suggestions for new working groups or areas where AIAA should be active, either contact your Group Director or Tom Irvine. If you are interested in being a member, or volunteering for Diversity Working Group activities, please send an email to diversitywg@aiaa.org. ★

Sandra H. Magnus, AIAA Executive Director

U.S. Naval Institute

New life for an old idea

BY KEITH BUTTON | buttonkeith@gmail.com

▲ **The airship USS Macon** crashed off the coast of Point Sur, California, in 1935. Now several companies say they want to build modern flying aircraft carriers.

Eighty-two years after the crash of a Navy airship designed as an airborne takeoff and landing point for biplanes, the concept of basing planes on dirigibles may be on its way back, this time as a base for drones.

TP Aerospace of Massachusetts is designing a blimp it calls Skybase for an undisclosed client. The blimp could launch, recover and refuel five 90-kilogram drones equipped with cameras, says Paul Adams, head of operations and part owner of the company.

TP Aerospace is not alone in the trend of basing drones on dirigibles. The retail giant Walmart applied for a U.S. patent in August for "gas-filled carrier aircrafts" from which unmanned aircraft would deliver products to customers. Last year, Amazon patented a similar idea.

Why would anyone want to build an airborne aircraft carrier? As drones have become ubiquitous and cheaper to fly, entrepreneurs are starting to recognize their limitations. These small unmanned aircraft "don't have 3,000 miles of range and they're not going eight-tenths the speed of sound," says Ron Hochstetler, a lighter-than-air airship technology consultant, making a comparison to jets. "They need to be closer typically to where their mission is, and unless you're on the ground or the water nearby, you've only got the air as a way to get you closer."

Skybase would measure about 60 meters long, similar in size to today's Goodyear blimps but considerably smaller than the Navy's flying aircraft carrier that crashed in 1935 off the coast of Point Sur, California. The USS Macon measured 239 meters long and could carry up to six F9C Sparrowhawk biplanes. By contrast, Skybase would carry fixed-wing or quad-rotor drones, depending on the client's mission, equipped with cameras. A pilot on the ground would operate the blimp and drones, freeing Skybase to stay aloft for two days or more at a time, Adams says.

Amazon and Walmart are purposefully vague about their concepts, but airship industry observers believe their proposed floating warehouses would need to be massive to make sense economically and to accommodate the features described in their patent documents. Walmart's patent application describes an airship with a kitchen, bunks and bathrooms for workers who sleep and work in shifts. Amazon's patent calls for the airship to carry equipment like forklifts and trolleys. The Amazon patent does not say how big this floating warehouse would have to be, but says a "shuttle" airship measuring 30 meters long would loft workers to the warehouse and bring fresh inventory and new delivery drones.

Amazon's main airship would float above commercial airspace at 45,000 feet and on occasion descend to 2,000 feet to make advertising visible to people on the ground, according to the patent. Two airship experts questioned the viability of the concept, saying that to fly at 45,000 feet, an airship would need about six times more lifting gas than would be required to carry the same weight at 2,000 feet. Spokesmen for Amazon and Walmart declined to comment on the retailers' proposed airships. Amazon's Prime Air division has been flying drones for private delivery tests in the U.K. ★

China plays catch-up to U.S. drones

BY TOM RISEN | tomr@aiaa.org

China's Wing Loong 2 remotely piloted aircraft looks nearly identical to the MQ-9 Reaper, but U.S. analysts say the design lacks the engine power and flight range of the Reaper, highlighting the challenges facing China's aerospace engineers as they work to match U.S. drone capabilities.

The Wing Loong 2s, built by a unit of the state-owned Aviation Industry Corp. of China, have a wingspan, height, length, rear propeller, front imaging pods and landing gear that are nearly identical to the MQ-9 Reapers built in Poway, California, by General Atomics Aeronautical Systems. Chinese state media calls the Reaper a close competitor to the Wing Loong 2, which translates as Pterodactyl. Similarities between the two planes may be largely skin deep. Speed and endurance are key for remotely piloted aircraft, especially on reconnaissance missions, and China advertises that the Wing Loong 2 has a 370 kph top speed and can stay airborne for 20 hours. The General Atomics Aeronautical Systems website advertises superior engine performance for the Reaper, saying it has a top speed of 444 kph and can stay airborne for 27 hours.

"China's drones look similar to American ones on the outside, but China often struggles to match U.S. capabilities in key subsystem technologies such as engine performance, communications and stealth," says Paul Scharre, a senior fellow at the Center for a New American Security think tank in Washington, D.C., and a former policy official at the Office of the Secretary of Defense.

The Chinese are making unmanned aircraft a priority, but the U.S. has an edge in real-world flying and fighting with drones. The Reaper's software for its sensors, pilot controls, missile aiming and data sharing was improved over the years and can't be easily reverse-engineered, says Air Force Maj. Johnny Duray, who flew Reapers on combat and reconnaissance missions in Afghanistan, Syria and Iraq from 2014 until earlier this year. He is now a strategic policy fellow at the Air Force Association's Mitchell Institute in Arlington, Virginia.

China and nations that might buy the Wing Loong 2 will also need instructors with years of experience piloting unmanned aircraft to train officers.

"There are a lot of things you have to learn and unlearn when you come from a manned background," says Duray, who joined the Reaper program after flying conventionally piloted U-28A reconnaissance planes in Afghanistan and the Horn of Africa from 2009 to 2014. "You don't get sensory feedback when accelerating like you do in a manned aircraft."

Pilots must skillfully monitor screens in the Reaper ground control stations, and even pilots who did not transition from conventional aircraft need to learn to hit targets with missiles and maneuver the drones with the sometimes confusing controls, he says.

"If I was the Chinese and looking to improve the Reaper, I would say upgrade the human-machine interface," says Duray.

The Wing Loong 2 would also sacrifice the battery power needed for long flights when it carries the maximum 12 missiles and bombs, Duray says. The Reaper can carry four air-to-surface missiles and two bombs, but launching them drains vital battery power, he explains.

Competing on weapons exports is among the potential benefits of imitating American designs, because the U.S. places limits on its sales of unmanned aircraft whereas China does not. The Wing Loong 2's versatility for reconnaissance and combat missions is intended as a selling point for potential customers, says Elsa Kania, an adjunct fellow at the Center for a New American Security with expertise in Chinese military technology. So far, Egypt, Iraq and Saudi Arabia have purchased the Wing Loong 2. China is not among the 35 nations that have signed the Missile Technology Control Regime created in 1987 to restrict exports of missiles and related technologies. The U.S., as a signatory of that agreement, limits its exports of remote piloted aircraft that carry missiles, which gives China an opportunity to market its aircraft as an option, especially if they look similar to U.S. models. ★

▼ **Wing Loong 2,** on display in June at the Paris Air Show, resembles the Reaper and can carry 12 missiles and bombs.

Tom Risen

Space Command adapts

More online aerospaceamerica.aiaa.org

An Air Force maxim says that space is increasingly congested and contested. With that in mind, Maj. Gen. David Thompson led a team that created an Air Force office in the Pentagon to focus specifically on the budgetary and training needs arising from what the U.S. has called provocative acts in orbit by China and Russia, and also a spike in the number of privately owned satellites. This new office will advise the Air Force chief of staff on military-related space matters. Before this office was established in August, there had been only an Office of the Deputy Chief of Staff for Space Policy. Thompson's Air Force career dating back to 1985 ranges from rocket propulsion engineering to launch oversight. I spoke with him by phone about a wide range of issues, from North Korea, to telecommunications bandwidth to threats to U.S. satellites.

— *Tom Risen*

MAJ. GEN. DAVID THOMPSON

POSITIONS: Special assistant to commander of Air Force Space Command since July 2017; in this role, he plans strategy and budgetary needs for Air Force space operations; Air Force is keeping him on staff for a new assignment yet to be announced. Previously vice commander of Air Force Space Command.

NOTABLE: Received his second star in 2013. Told in April by Air Force to create the Office of Deputy Chief of Staff for Space Operations, which will be filled by three-star general. That directorate became active at end of August. Up to 120 people will eventually work in directorate to ensure defense-related space needs are met. Thompson says launch dates are most memorable of his career. From 2002 to 2004, he commanded 2nd Space Launch Squadron, which launched Titan 2, Titan 4 and Atlas 2 rockets from Vandenberg Air Force Base in California.

AGE: 54

RESIDES: Colorado Springs, Colorado

EDUCATION: Bachelor of Science degree in astronautical engineering from the U.S. Air Force Academy in 1985; Master of Science degree in aeronautics and astronautics from Purdue University in 1989; Master of Science degree in national security industrial policy from the Industrial College of the Armed Forces in 2005.

North Korea missile capability

The biggest challenge that comes with a warhead, depending on the range you are going, is as much re-entry as it is launch and the incredibly high physical environment, the extreme acceleration and the extreme heat that is generated. The ability to survive that environment and then land precisely, that's really the biggest challenge when it comes to a long-range rocket with a warhead on top. Those are things we haven't seen demonstrated yet from North Korea. Who knows whether or not they have truly created a warhead, number one, small enough [to fit on a rocket] and, number two, that could survive that process? It's a lot harder problem than most people think.

Risk of an anti-missile launch being misinterpreted as an attack

If [U.S. Ground-based Midcourse Defense interceptor missiles] ended up missing [North Korean rockets] and flying into somebody else's airspace, something has gone terribly wrong. We set up the architecture, the engagement zones and the fallout zones to not even make that come close to being a fact. We don't have [deconfliction measures] set up as a routine procedure for that reason because we don't make it a potential issue. We know how to do that in other areas. I'm sure we could do that for missile defense if and when that ever became a requirement. You have to think about physics and either the results of a successful hit or the results of a miss. Understanding what you're defending, understanding the trajectory of where the missile is going to come, you then place your defense assets in a position to be able to conduct a successful engagement such that violation of a potential adversary's airspace is just never going to be a factor, physically and kinetically.

Rules of engagement in space

There hasn't really been a well-established set of norms of behavior and standards of conduct and rules of engagement in space since [the U.N. Outer Space Treaty of 1967]. I definitely believe there is a need to take the next steps. I'll leave it to the diplomats and the highest level national leaders to decide. There are rules of engagement and norms of conduct by which you engage with each other when ships encounter each other in international waters, or aircraft encounter each other in international airspace. And those don't really exist in space today. The Outer Space Treaty really only says two things of significance from a military perspective: The first is you don't put weapons of mass destruction in space or on any celestial body, and you can't claim the moon or any celestial body to be your sovereign territory.

Defending satellites

Would somebody likely go after those things kinetically? It's possible but less likely, I would say, just because to try and attack one satellite kinetically that's a commercial vendor, there's a whole host of other options. First and foremost in a jamming sense, because that's relatively easy to do. That's also why we need to work more with the commercial industry on how we would together protect the information that we're using. [The Wideband Global SATCOM constellation] has a little bit of extra jam resistance built in. We also have a capability on board that identifies sources of jamming and allows us to shape the beam to avoid accepting energy from that region.

Military-owned satellite benefits

There are a couple of reasons why you want some of your wideband communications on a dedicated military satellite. Some are those sensitive communications you want to provide extra protection to. When you compare operating a substantial portion of your wideband communications in a wholly owned system, you can do that as cost effectively and, in many cases, more cheaply than you can by buying it from the commercial market. It's specialized areas, times when you have surge requirements for wideband communications, either a surge for over a couple of years or specific geographic locations that you may not serve routinely, that you may not need military capability there but you can get it from the commercial market.

Improving military telecommunications

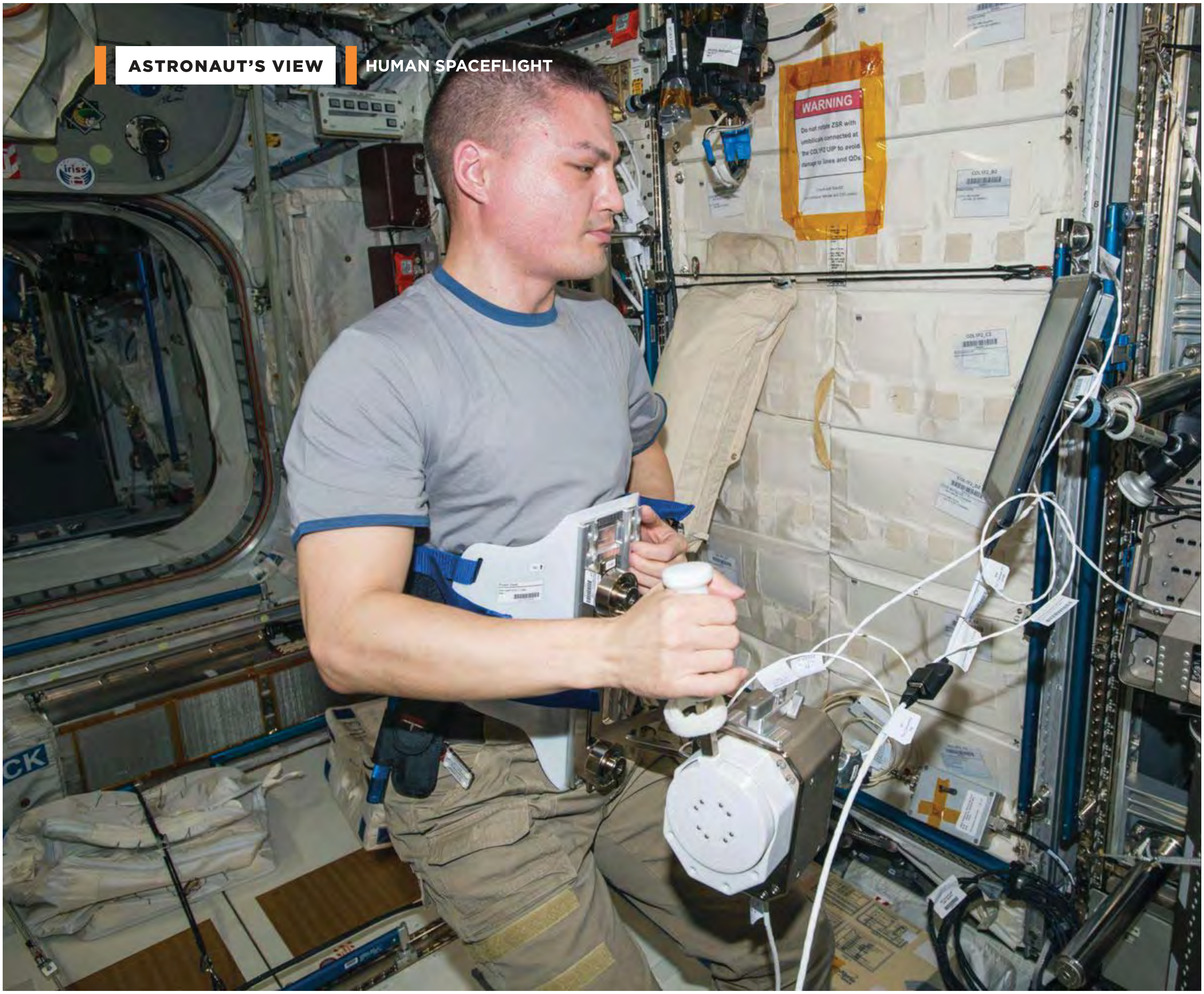
I think our biggest obstacle in making commercial satcom more effective for the Department of Defense is the Department of Defense. The biggest struggle is the way the Department of Defense goes about procuring its commercial wideband services. We don't really have a holistic approach to our global needs. We haven't aggressively negotiated for the types of things we need. We generally tend to lease transponders and bandwidth rather than looking at it in a service-based approach, or trying to buy services and capacity that we might apply globally rather than one-by-one individual sense. That's part of what the Wideband Analysis of Alternatives is supposed to tie together. The purpose of that analysis of alternatives is to look at the optimal mix of commercial and military systems for a future capability after Wideband Global SATCOM.

National Space Council

I think the National Space Council has a lot of great potential and is going to get involved in a lot of important things early. But I think the best thing it can do for us is make sure we have an understanding from that national level led by the vice president [about] how we can best coordinate, synchronize and integrate the activities of all executive agencies with common interests in space.

Space Corps proposal

I don't know that that's a National Space Council matter. There are two versions out there of the National Defense Authorization Act still on the table. The House version talks about a Space Corps. The Senate version does not. They will determine together what will appear in the final legislation and what they will tell the Department of Defense to do in that regard. ★



▲ **Aboard the International Space Station,** astronauts are participating in the Haptics-1 experiment to investigate technologies that astronauts in orbit would require to control robots on the surface of a planet or the moon. Here, NASA astronaut Kjell Lindgren wears a force-feedback torso harness.

Exploration telepresence

Astronauts in Mars orbit could orchestrate complex exploration of the surface by robots a full decade before a human landing is possible. Astronaut and planetary scientist Tom Jones argues that such virtual presence could get humans working on Mars by the early 2030s as a precursor to a landing.

By Tom Jones | Skywalking1@gmail.com | www.AstronautTomJones.com

European Space Agency

By the mid-2030s, NASA hopes to lead a partnership to land human explorers on Mars, pursuing the search for past or present life. NASA estimates that humans can orbit Mars by the early 2030s, and once established there, land at a date to be determined. But putting humans on Mars is difficult, risky and expensive. Crews would need to ride a multiton lander to the surface using entry, descent and landing technologies that are far from flight-ready. Yet another challenge would be launching astronauts off the surface. Without a major NASA budget increase, astronauts may not set foot on Mars until 2040 or beyond.

A promising technology — exploration telepresence — may help NASA jump-start the intensive human exploration of Mars. Astronauts orbiting Mars in the early 2030s could take real-time control of robotic eyes and hands on the surface, pursuing the search for life in earnest until surface expeditions become reality. They could first test the required technology on the moon or a nearby asteroid.

Putting human skills on Mars

Even as NASA pursues a Mars landing, our experiences with telepresence on Earth suggest how explorers in Mars orbit and, later, on Mars itself, could be teamed with surface robots to perform complex tasks.

I participated over the past year in a series of workshops hosted by the Keck Institute for Space Studies, examining how today's telepresence technologies could be advanced and adapted for planetary exploration.

It became clear to me that telepresence is already a terrestrial reality. U.S. Air Force pilots and sensor operators control armed unmanned aircraft half a world away. In the medical field, some operating rooms are equipped with what's called the da Vinci Surgical System. A surgeon peers into a high-definition video monitor while holding devices that translate his or her hand movements into movements by micro-instruments inserted into the patient's body a few feet away.

The da Vinci System is an example of virtual presence, also called low-latency telepresence, or LLT, defined as controlling a robot with a communications delay of less than human reaction time (roughly 0.25 second).

Surgeons have near-instantaneous control over their robotic tools, but controlling robots over long distances in space presents latency challenges. The round-trip radio delay, or latency, to the moon is 2.6 seconds, about 10 times human reaction time. Earth-to-Mars round-trip radio latency is anywhere from five to 40 minutes. From orbit around Mars, astronauts could send signals to and receive them from surface rovers in mere milliseconds, giving them LLT through robotic vision and tactile feed-

NASA

The Ames K10 rover performs a surface survey, while remotely controlled by an astronaut, during a 2013 demonstration at NASA Ames' Roverscape in California.

▲ **A surgeon looks at a** monitor while remotely operating micro-instruments inserted in a patient with the da Vinci Surgical System. Astronauts in Mars orbit could operate robots on the surface with similar low-latency technology.

back. With a communications link bandwidth of at least 1 megabit per second (about a third of what it takes to stream standard definition video on our Earthly internet), astronauts could exert real-time control over a rover's driving and manipulator systems. They could conduct intensive geological and biological field studies for years while NASA perfects its landing and ascent technologies.

Telepresence at Mars

Lockheed Martin last year proposed placing what it calls a Base Camp spacecraft in orbit around Mars as a habitat, logistics and transportation hub for eventual surface expeditions or astronaut excursions to the Martian moons Deimos and Phobos.

In my view, this Base Camp would provide a perfect vantage point for LLT.

While orbiting Mars, or perhaps while dug in on Phobos or Deimos, astronauts could control surface rovers in near-real time, conducting high-intensity field science through their robot proxies. Freed from the lengthy prep time, physical burdens and consumable limitations of a pressure suit, LLT-enabled astronauts could work far more rapidly and productively than rovers like Curiosity or its planned successor, Mars 2020.

NASA equips rovers to drive autonomously just a few tens of meters at a time, taking a day to process images and send up another set of driving or science commands. By contrast, astronauts in Mars orbit would teleoperate a rover and its appendages in near real time for enhanced dexterity and sensory feedback. Telepresent astronauts could tackle activities beyond the abilities of autonomous systems: drilling into suspected habitable zones, tapping subsurface springs, and traversing steep slopes or entering caves where autonomous rovers would fear to tread.

Astrobiologists in Mars orbit might direct sterilized rovers into regions most likely to harbor life. They could investigate likely habitats for Mars microorganisms, freed from worries that astronaut-borne organisms might muddle the research results.

Astronauts could build the surface infrastructure needed to support human explorers. LLT-directed robots could install power and communications links, activate propellant production plants, and outfit subsurface habitats for astronaut use.

Once astronauts reach the surface, they could begin other LLT operations, including directing scientific rovers around the planet. With "Mars walks" constrained by radiation exposure and suit limitations, telepresence would enable surface geologists and biologists to explore for hours on end in a shirt-sleeve environment. When their day's work is done, Earth-based scientists would pick up operations in autonomous or high-latency mode, as they do today.

Crew benefits

Contemplating a year or more in Mars orbit is a daunting prospect for a crew, but telepresence will enable them to apply their science experience and skills by putting their minds in virtual contact with rovers across Mars. That rich, global exploration experience will counteract the psychological stresses of the long journey as they start the flow of discoveries from human-directed exploration.

Telepresence would also enable crews, perhaps nestled in a buried habitat on Deimos, to avoid some of the harshest features of the Mars environment: radiation, extreme cold, dust storms and toxic soil chemistry.

Low-latency telepresence is a strategy that can be employed on the moon, the nearby asteroids, Mars and other hostile planetary surfaces across the solar system. It breaks the slow, rigid operating mold of rovers run from Earth, accelerating the delivery of high-value science from Mars even as crews prepare for eventual surface exploration.

Perhaps LLT's most valuable contribution is its clear demonstration of the value of human presence. Once astronauts are fully engaged in exploring Mars via telepresence, what naysayer could turn aside the drive to deliver scientists to the surface in person?

If NASA intends to put humans into Mars orbit in the early 2030s, it is important to wring the maximum science value from those costly trips.

Careful assessment

Will the science volume and quality from orbital telepresence help justify the expense and dangers of sustaining astronauts on successive, multiyear orbital expeditions? Such voyages expose the crew to the health hazards of years of living in free fall, the weightless condition that space travelers would experience during the transit to Mars. These hazards would persist in very low gravity on the Martian moons. The Mars surface offers a possibly safer 0.376-g environment. Should we not just wait a decade for the payoff from the first human landing?

I would argue that if NASA intends to put humans into Mars orbit in the early 2030s, it is important to wring the maximum science value from those costly trips. We should expect returns up front, rather than waiting for surface expeditions. My guess is that telescience will only whet our appetite for the enticing prospect of having scientists on Mars itself.

Planning for telepresence

To achieve LLT access to Mars in 15 years, NASA and its partners should accelerate ground and space trials of telepresence applied to real field science, determining what tasks can be done through supervised autonomy vs. real-time telepresence. Astronaut-operators on the International Space Station could practice LLT with robots in Antarctic deserts and rugged volcanic landscapes as analogs to Mars.

Future planetary robots should be designed with the vision, mobility, power, communications and manipulator systems to enable virtual presence on the moon, an asteroid surface and ultimately Mars.

Astronauts on the ISS have already controlled terrestrial rovers. Specifically, in 2013, through NASA's Human Exploration Telerobotics project, ISS astronaut Chris Cassidy controlled a planetary rover at Ames Research Center. Before this year is out, European Space Agency astronaut Paolo Nespoli from the space station will command a complex humanoid robot in a lab as part of continuing tests of the Multi-Purpose End-To-End Robotic Operation Network, or METERON. The next step will be to conduct field exploration trials from the ISS.

Such experience will help NASA design orbital workstations with comfortable 3-D vision, hand or voice-activated manipulator controls, and perhaps tactile feedback from robotic "hands." NASA is already considering having astronauts in the 2020s remotely drive and manipulate tools on a moon rover from its planned Deep Space Gateway in lunar orbit. Stepping up to true telepresence from lunar orbit would be a logical and worthwhile next step.

The value of humans at Mars

On a shakedown cruise of a Mars orbital vehicle, a crew could explore the dusty, low-gravity surface of a near-Earth asteroid by teleoperating surface hoppers that would cover far more ground at less risk than a suited astronaut could. With lunar and asteroid field experience, crews should then be ready for intensive LLT operations at Mars.

Robotics experts at the Keck Institute workshops were cautious about the promise of artificial intelligence. They thought it unlikely that AI robots will be able to substitute for humans around and on Mars, even two decades from now.

Our species' curiosity seems unlikely to be satisfied until humans themselves make the long voyage to Mars. The most fundamental questions about Mars biology will likely be answered only once the human mind can fully engage with that alien surface. Low latency telepresence offers the chance to touch that surface sooner rather than later, proving the real value of human explorers in our quest to understand the solar system. ★

COURSE CORRECTOR

If NASA or amateur astronomers spot a space rock headed for Earth and this object is large enough to wipe out a city, what should we do? Adam Hadhazy spoke to managers of a proposed mission that could give us the answer.

BY ADAM HADHAZY | adamhadhazy@gmail.com

Not to scale.

On Oct. 12, 2017, a hefty asteroid will give our planet a shot across the bow. The house-sized space rock, designated 2012 TC4, will miss Earth by 50,000 kilometers — a mere fifth of the moon's remove.

Knowing about a threat is one thing; mitigating it is another. Planners of a proposed 2020 mission called AIDA (pronounced "eye-EE-duh"), the Asteroid Impact and Deflection Assessment, are proceeding on that planetary defense front. The mission would consist of two spacecraft, one to strike a small asteroid and hopefully nudge it onto a slightly new course, and the other to watch and characterize the collision up close.

NASA is preparing the kinetic impactor portion of the mission, a proposed spacecraft dubbed DART, the Double Asteroid Redirection Test. DART received the agency's go-ahead in June to enter a preliminary design phase. This spacecraft would cruise toward the asteroid Didymos, arriving in its vicinity in October 2022 when the object and its moonlet, nicknamed Didymoon, make a near but harmless sweep past Earth. The rendezvous would be short-lived, though, for DART's goal is to intentionally plow right into Didymoon. The punch of the sacrificial spacecraft should alter the moonlet's orbit around its host asteroid by a tiny, yet measurable amount. Didymoon is no threat to Earth, but this kind of slight momentum transfer might well save us from catastrophe from other objects. Over a span of millions of kilometers, the cumulative trajectory change would turn a collision with a genuinely Earth-bound asteroid or comet into a safe, albeit nerve-wracking, close shave.

There is no shortage of enthusiasm in some quarters to get this mission done. DART would be "the first demonstration of a kinetic impactor and we want to know that it works if we ever have a realistic threat," says Cheryl Reed, the DART project manager at the Johns Hopkins University Applied Physics Laboratory in Maryland. For Lindley Johnson, NASA's planetary defense officer and a DART leader, the "mission is deeply exciting" because it would demonstrate autonomous navigation software for a guided-missile-like strike, show off a next-generation thruster powered by sunlight and electricity, not to mention how NASA might someday "'save the world,' so to speak," as Johnson puts it.

Didymoon's name might be amusing, but an asteroid of its size, 160 meters across, could do enormous damage, although short of endangering the entire world. For a sense of scale, the asteroid that blazed into the atmosphere as a meteor over Chelyabinsk, Russia, in 2013 measured only about 20 meters across, NASA estimates. The 1908 asteroid or comet that leveled a forest near the Podkamennaya Tunguska River in Siberia was probably just twice Chelyabinsk's size. The behemoth that wiped out the dinosaurs and 75 percent of Earth's species measured an estimated 10 km across.

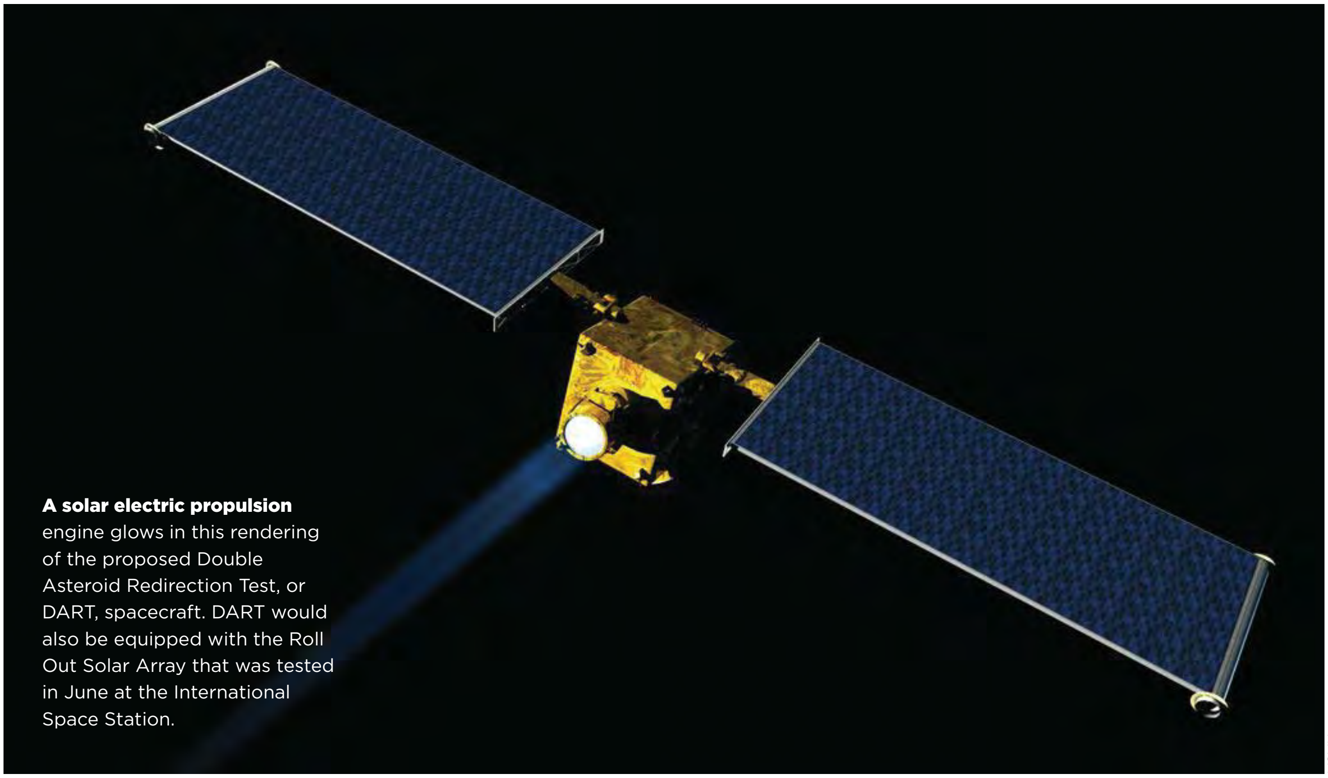
If DART makes it off the drawing board and works as planned, NASA will have demonstrated a technique for protecting us from what is the most likely risk from space: a collision with a Didymoon-size asteroid that could gouge out a crater at least a kilometer wide and hurl searing heat and debris for tens of kilometers. In short, a city killer.

The DART technique could in theory be applied on smaller objects, but the trick would be to spot those far enough away and get enough lead time, something that can't reliably be done now because of the dimness of these objects at considerable distances. Designers have ideas about how to scale up the concept for kilometer-class objects too, should that ever be necessary.

Hammers of the gods

Protecting the planet is a task that Congress has increasingly asked of NASA. The agency's Planetary Defense Coordination Office, established in 2016 and led by Johnson, has brought together efforts dating back to the 1990s to make early detections of potentially hazardous space rocks. These include asteroids whose orbital paths take them near Earth, as well as their icier cousins, comets, which swing out to vast distances from the sun and can come at our planet at great speed from unexpected angles. "It's an area people think a space agency needs to be involved in," says Johnson.

So far, sky surveys conducted by ground telescopes have pinned down the paths of around 94 percent of the monster objects a kilometer or more in size expected to cross Earth's path. None in that size range are anticipated to pose a threat for at least a century. The odds of humanity imminently facing such a calamitous collision are low in the grand scheme, though, with impacts on that magnitude occurring approximately once every million years. As for that behemoth space rock that doomed so many species 65 million years ago, we can breathe a further sigh of relief,



A solar electric propulsion engine glows in this rendering of the proposed Double Asteroid Redirection Test, or DART, spacecraft. DART would also be equipped with the Roll Out Solar Array that was tested in June at the International Space Station.

NASA

for they coldcock our planet only every 100 million years or so and likely would be spotted with many years of warning.

A far likelier scenario is an asteroid bearing down on us that is about the size of Didymoon, says Johnson. Space rocks in this 150-meter ballpark strike not in abstract geological intervals, but in spans applicative to human history, every few thousand years on average. And unlike the Chelyabinsk asteroid, these objects are substantial enough to survive passage through the atmosphere and reach the ground. Their impacts would devastate a sizable population area. Scientists estimate 25,000 city-killers lurk in our solar system, though to date, surveys have turned up about 8,000. "We've only found around a third of this population," says Johnson. "They are a large enough hazard that we should be seriously concerned about them and how to divert them."

Researchers have given serious thought to numerous asteroid mitigation techniques. They range from detonating nuclear weapons to deploying "gravity tractor" spacecraft, whose subtly insistent gravitational attraction could escort space rocks off collision courses. Of the bandied-about ideas, many like the kinetic impactor the best. "The kinetic impactor is at the top of our list largely because the technology for doing it is the most mature," says Johnson. As he points out, space agencies have already performed the feat, for instance with NASA's Deep Impact mission that plowed an impactor into a comet's nucleus in 2005, though with no expectation of changing its speed and course.

"Essentially, we are just positioning ourselves in [Didymoon's] way."

– **Cheryl Reed,** Johns Hopkins University Applied Physics Lab

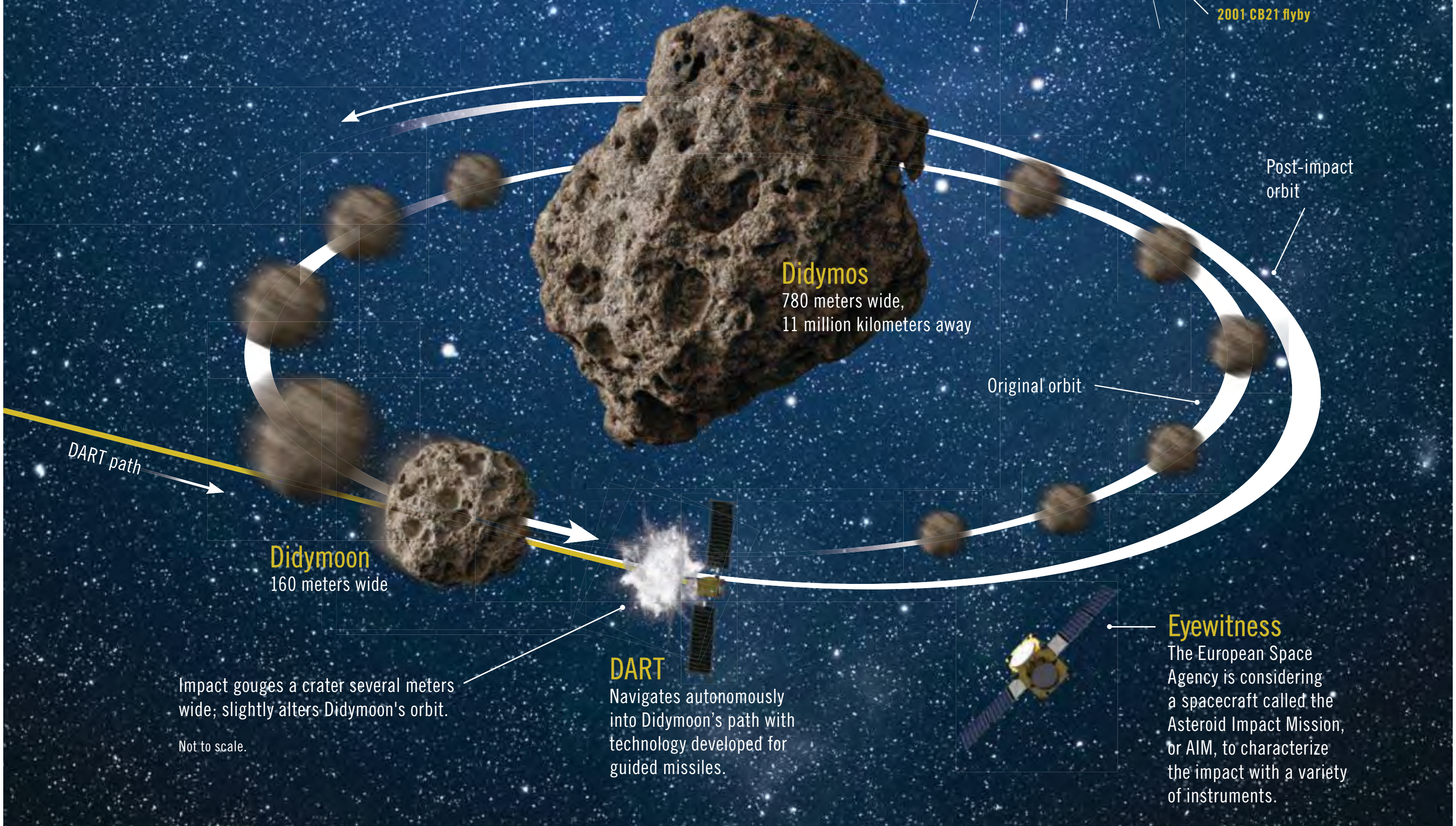
Gliding on ions

Despite its unconventional suicide mission, DART would look like a typical interplanetary craft. At around 1.3 meters in height and width — about the size of a squat refrigerator — it will be constructed of conventional aluminum honeycomb panels, weighing in circa 500 kilograms. DART's solar panels would be of a new roll-out variety, first tested by NASA at the International Space Station in June 2017. Rather than rigid panels, a Roll Out Solar Array consists of flexible thin-film photovoltaics that unfurl from a compact, cylinder shape, reducing mass and

Nudging an asteroid

Orchestrating a collision between a dangerous space rock and a spacecraft might only change the velocity of the rock by mere millimeters, but over vast distances that change in trajectory should make the rock miss Earth. NASA hopes to test this kinetic impactor concept next decade with the Double Asteroid Redirection Test or DART spacecraft.

A flexible launch window opening in December 2020 means DART could fly by asteroid 2001 CB21 to gather science and calibrate on the way to the Didymos-Didymoon asteroid system.



Sources: NASA and the Johns Hopkins University Applied Physics Laboratory volume for launch. [See related story, Page 34.] The spacecraft's maneuvering capabilities would come courtesy of standard, hydrazine-fueled thrusters.

Elsewhere on the propulsion front, DART will forge ahead as the first slated flight of the NASA Evolutionary Xenon Thruster–Commercial (NEXT-C) ion drive. A next-generation solar electric propulsion system, it pumps energy reaped by the solar arrays into a chamber full of xenon gas, creating a plasma like that found in a neon sign. Charged grids at the back of the engine shoot the ionized gas into space, generating thrust. The thrust is minuscule, on the order of a few hundred millinewtons, equivalent to the pressure felt on your palm when holding a handful of coins. But over significant time and interplanetary distances, ion drives can attain greater speeds than their conventional chemical brethren, reaching up to 324,000 kilometers per hour, more than five times faster than the speedy Voyager 1 probe.

"The difference between electrical and chemical is like the tortoise and the hare," says Michael Patterson, who was principal investigator for the NEXT technology development program at NASA's Glenn Research Center in Ohio. The electrical tortoise in his analogy starts out slow, but steadily accelerates, eventually overtaking the chemical-burning hare that started fast, ran out of fuel and then could only coast along. Just as importantly for deep space missions, NEXT-C is efficient, using just a tenth of the propellant of a chemical rocket for equivalent momentum, slashing fuel needs at launch.

Speed and fuel efficiency are not the purposes for integrating NEXT-C into DART as a tech demonstration, however, given the relatively short voyage to Didymos. Instead, the benefit is launch window flexibility. DART's designers plan for it to rideshare on a commercial rocket, meaning it could be carried to space as an additional payload on any number of regularly scheduled launches. The electric propulsion system can spiral DART out from Earth, biding time before then setting off for Didymos, versus having to depend on a specific launch date. The upshot, says Reed: "NASA does not have to buy us a rocket." That translates to significant cost savings and keeps DART inexpensive for a planetary mission at around $250 million, Reed says.

Throwing a DART

To bring its journey to a close, DART must accurately hit Didymoon near the space rock's center, maximizing the transfer of momentum. The mission drew inspiration for its name from this bull's-eye-like goal. "DART is a good analogy of throwing a dart at a dart board and trying to get very close to the point you're trying to hit," says Reed. A key nuance is that Didymos and Didymoon will be moving faster than DART. The asteroid pair will overtake the spacecraft to cause the collision, sort of like if the dart board flew through the air to meet a slower projectile. "Essentially, we are just positioning ourselves in [Didymoon's] way," says Reed. "Our thrusting is neither accelerating nor braking; think of it as steering, aligning ourselves to the body to be in the right spot at the right time."

DART and Didymoon will be hurtling toward each other at a rate of 6 kilometers per second — about 10 times faster than a bullet shot from an AK-47.

To pull this off, she and her colleagues have turned to the Johns Hopkins Applied Physics Laboratory's history of developing guided missiles for the U.S. Navy. For DART, this has culminated in the Small-body Maneuvering Autonomous Real-Time Navigation — acronym SmartNav — algorithm, which will zero in on Didymoon through image processing and guidance, navigation and control. At a distance of about 38,000 kilometers, or about an hour and a half before impact, SmartNav will begin processing target uncertainties and making precision adjustments via the thrusters to tweak the spacecraft's position.

Ahead of their crash, DART and Didymoon will be hurtling toward each other at a rate of 6 kilometers per second — about 10 times faster than a bullet shot from an AK-47. What the smash-up will look like depends on the moonlet's composition, thought to be primarily iron and nickel, as well as compaction. Most likely, DART will blow out a crater several meters wide and eject a plume of material into space. To large ground telescopes conducting scientific observations of the impact's aftermath, Reed says the ejecta will probably appear as a comet's tail-like cone of lighter, diffuse material. Even relatively modest telescopes with 1- to 2-meter-wide mirrors should be able to detect this plume, mean-

NASA

▲ **NASA's Deep Impact** probe collided with Tempel 1 on July 4, 2005. A camera on the mission's flyby craft recorded a bright, small flash. Researchers found Tempel 1 has a fluffy structure of fine dust. They also detected carbon-containing materials in the comet's ejection plume.

ing members of the general public could monitor the crash's aftermath in real time at participating science centers.

Besides compelling visuals, the plume should further alter Didymoon's orbit on top of the kinetic impactor's prod. "It's not just the force of the spacecraft hitting the object," says Johnson. "The material ejected away from the surface, away from impact crater — that acts like an additional rocket force that enhances the momentum transfer from the impact."

As a binary asteroid, the Didymos system — Greek for "twin" — should provide a uniquely ideal way to measure the effectiveness of this deflection approach. From our planetary vantage point, Didymoon passes behind its host, the 800-meter-wide Didymos, over the course of an 11.9-hour orbit. Slight perturbations to the timing of that orbit would be readily quantifiable to ground telescopes using optical light observations and radar. Overall, DART is expected to alter the speed of Didymoon's orbit by about half a millimeter per second, resulting in an orbital period change of perhaps 10 minutes. Officials want to understand the degree of this alteration to inform future planetary defense. For example, they might want to dial up the mass of a kinetic impactor, based on a threatening asteroid's properties, or alternatively throw many impactors at it to render enough of a deflection.

Keeping watch

NASA is expected to make an ultimate decision regarding DART in March 2018, after the preliminary design is submitted. Meanwhile, the second spacecraft element of the AIDA mission remains in jeopardy. As originally conceived, AIDA called for a sister vessel, named the Asteroid Impact Mission, or AIM, to arrive at Didymos ahead of DART. AIM would characterize the rocky Didymos duo up close and offer a front-row seat to DART's demise and its deflection assessment. The European Space Agency developed this partner craft for several years, but at a governing body meeting in December 2016, AIM's budget was not further approved. Researchers are now working on a slimmed-down version of AIM, which will not include a planned Didymoon lander or an optical communications tech demonstration.

If eventually greenlit, AIM could visit Didymos after DART and still gather valuable data, says Patrick Michel, the European lead on AIDA and the director of research at France's National Center for Scientific Research at the Observatoire de la Côte d'Azur. Or, the DART team could wait to go to Didymos until its next closest pass, in 2024, and the two spacecraft might sync up then.

Michel has his fingers crossed that AIM does fly and helps advance humanity's ability to shield itself against cosmic slings and arrows. "The risk of an asteroid impact is the least probable natural risk, compared to earthquakes, tsunamis and hurricanes," Michel says. "But it is the only one that we can predict and prevent by feasible means that just need to be tested."

For the kinetic impactor as well as other countermeasures to reliably succeed, early detection many months or even years ahead of a menacing asteroid's or comet's planetfall will be critical. Despite what movies like 1998's "Armageddon" depict, when a Texas-sized asteroid appears out of nowhere, en route to smashing Earth 18 days hence, emergency responses such as nuclear Hail Marys have little chance of averting disaster.

No matter how thorough the vigilance, though, some smaller, potentially deadly asteroids will still blindside the Earth — especially if, like Chelyabinsk's, they come from the direction of the sun, where telescopes cannot discern them. Over the longer term, modern humanity's luck could suddenly run out. Just ask the dinosaurs.

"Finding these asteroids before they find us is the best way," says University of Arizona planetary scientist Vishnu Reddy, who is leading the detection and tracking efforts of the space rock careening past in October 2017 and is not involved in AIDA. "The best defense we have is time." ★

INTRODUCING THE HUB

A **NEW** multi-use area built into the heart of AIAA expositions! The HUB will include many attendee favorite activities like the AIAA Bookstore and author signings, PLUS new and innovative features such as charging stations, a lounge area, refreshments, and much more. Need to identify a place to meet up with friends? Make the HUB that place!

PLENARY AND FORUM 360 SESSIONS

- Digital Enterprise Business Models—Their Impact on the Aerospace Industry
- The Dawn of Digital Engineering
- Digital Transformations Disrupting Aerospace Business Models
- Data, Data Everywhere—the Power & Potential
- Data, Data Everywhere—the Devil in the Details
- Digital Natives Leading the Digital Transformation in Design and Knowledge Environments
- Dude, Where's My Flying Car?
- On Demand Mobility—Enabling Technologies and Capabilities
- On Demand Mobility—Regulatory and Operational Challenges
- Welcome to the Holodeck
- Prizes & Challenges—How Crowdsourcing Can Help Solve Technology Gaps
- Human–Machine Teaming
- Serving Our Robot Overlords

TECHNICAL PROGRAM

More than 2,700 papers from 43 countries, giving you extensive access to a wide range of the latest research and development, not just in your own areas of expertise, but across technological boundaries.

COURSES AND WORKSHOPS

- Aircraft and Rotorcraft System Identification Engineering Methods for Manned and UAV Applications with Hands-on Training Using CIFER®
- **NEW!** Large Eddy Simulation of Turbulent Combustion: Theory, Modeling and Practice
- **NEW!** Introduction to Software Engineering
- **NEW!** Stochastic Mechanics of Materials and Structures
- **NEW!** Missile Guidance
- **NEW!** Aeroelastic Wind Tunnel Testing and Aeroelasticity Considerations for Non-Aeroelastic Tests
- Future CFD Technologies Workshop
- 5th International Workshop on High-Order CFD Methods

LEARN MORE

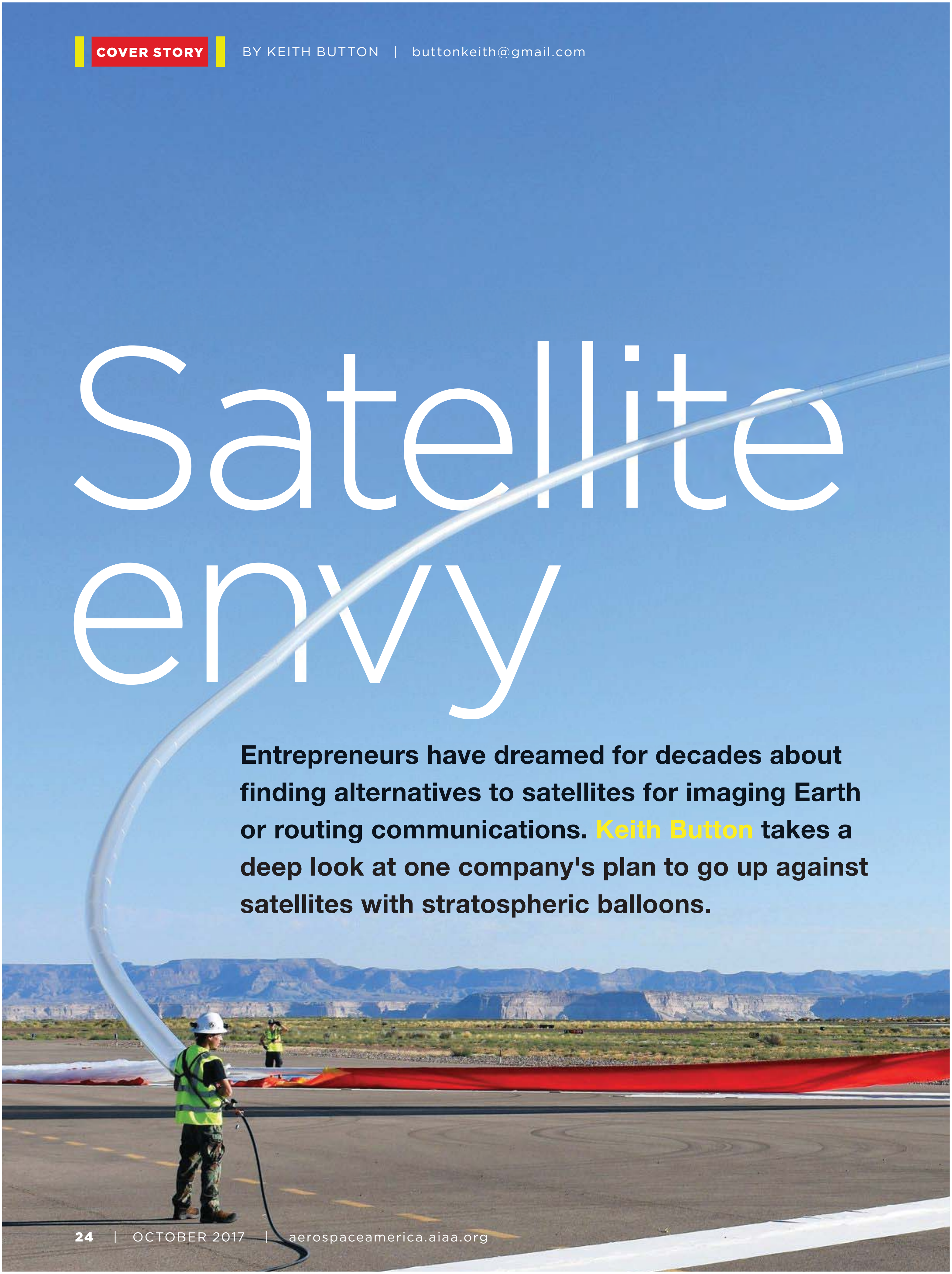
scitech.aiaa.org/forumschedule

DUNMORE AEROSPACE

BASTION TECHNOLOGIES

AIAA *Shaping the Future of Aerospace*

BY KEITH BUTTON | buttonkeith@gmail.com



Satellite envy

Entrepreneurs have dreamed for decades about finding alternatives to satellites for imaging Earth or routing communications. Keith Button takes a deep look at one company's plan to go up against satellites with stratospheric balloons.

World View

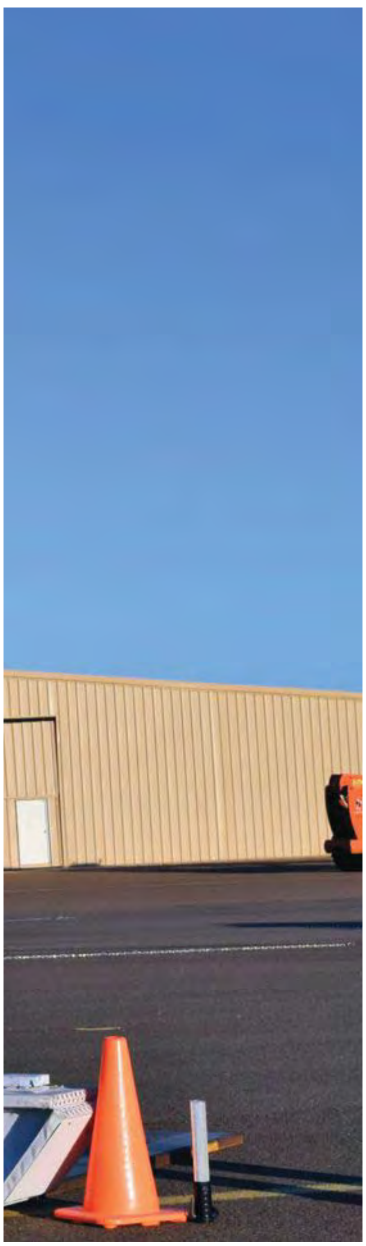
Satellites are famously expensive to build and launch, and once in orbit they can't be repaired or upgraded except in the most extraordinary of cases. Many have tried to find a more satisfying option, among them were former U.S. Secretary of State Alexander Haig and his son, Alex. In the 1990s, they led a failed effort to hoist networks of dirigibles into the stratosphere to beam internet and phone service to the farthest reaches of the world.

Among the latest to take up the challenge is World View Enterprises, a small company formed in 2012 in Tucson, Arizona. The company originally planned some day to charge tourists $75,000 each for rides to the stratosphere in balloons, but in 2015, sensing pent-up demand in the space industry, the company toggled to focus on a nearer-term goal of carrying cameras and other instruments in the stratosphere. World View has now grown to 70 employees and is flight-testing helium-filled, stratospheric balloons that it calls Stratollites, each steered with a novel ballasting concept.

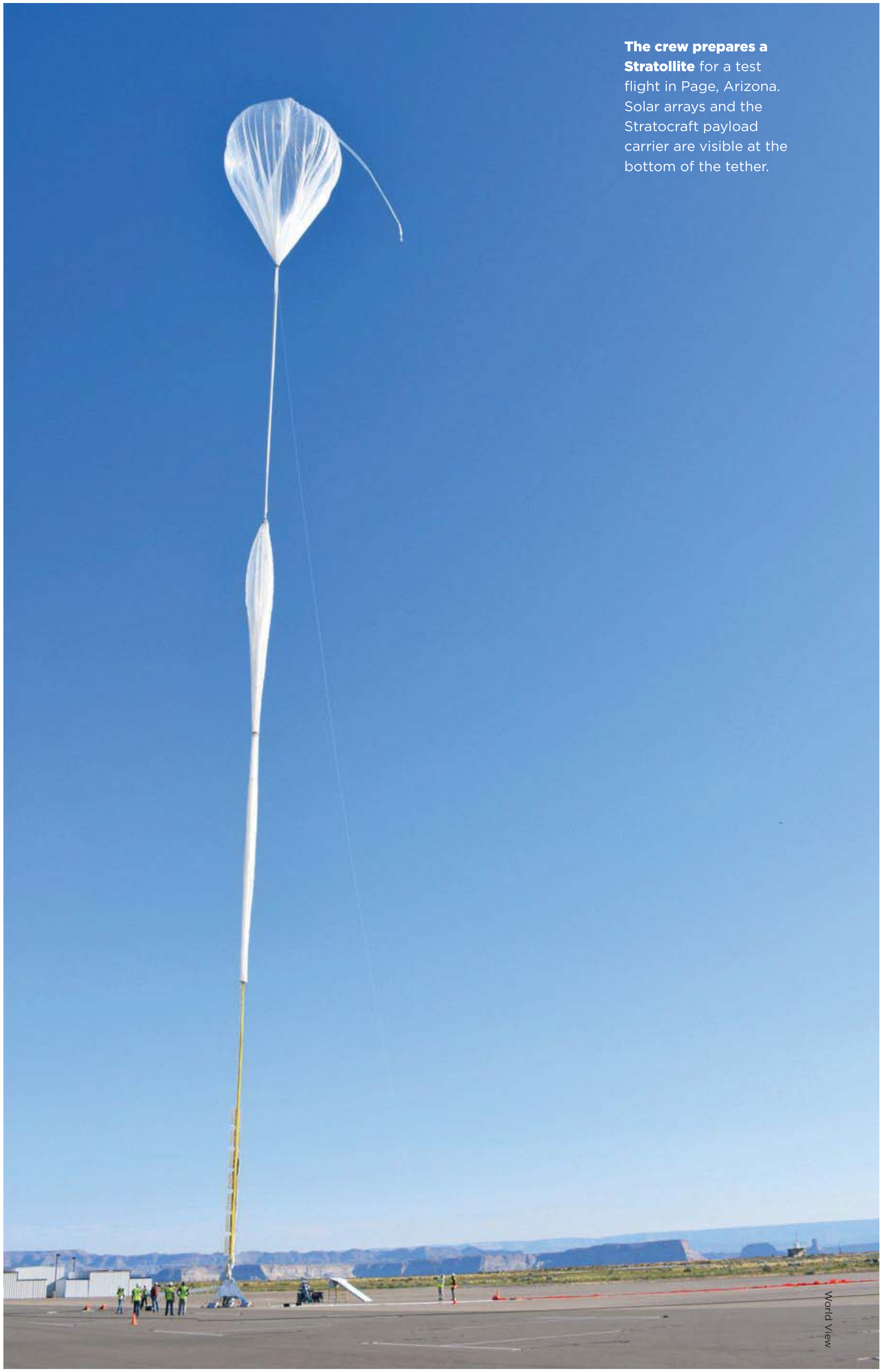
Getting to this point was not easy. Designers had to adjust their thinking about balloons and innovate in some unexpected ways.

Co-founder Taber MacCallum, who in 2014 helped then-Google executive Alan Eustace set a sky diving record, says that when he and his colleagues first started looking at the technology for World View, their thinking was, "it's a big sack of gas" so "how hard can this be?" As it turned out, pretty hard. For the camera or communications applications, they must keep each balloon properly positioned for months at a time; and each balloon's electricity-generating solar arrays must stay pointed at the sun. These days, MacCallum describes balloons as "complex and full of little subtleties."

▼ **Taber MacCallum,** World View's chief technology officer, left, works with his crew to prepare a Stratocraft for launch.



World View



The crew prepares a Stratollite for a test flight in Page, Arizona. Solar arrays and the Stratocraft payload carrier are visible at the bottom of the tether.

World View

If World View can push its technology beyond testing, Stratollites might be stationed high over cities or regions to deliver fine resolution imagery on demand. That can't be done from space today, because low Earth orbit satellites whiz over their imaging targets at intervals and geostationary satellites must fly at 35,000 kilometers above the equator. World View says Stratollites would cost an estimated 1 percent of a conventional satellite's price to operate, while adding greater maneuverability and the advantage of returning payloads to the ground for repairs or updates.

For World View, 2017 could turn out to be a turning point year. In collaboration with Ball Aerospace of Colorado, one of the world's leading manufacturers of satellite cameras and satellites, World View sent a Stratollite to an altitude of 75,000 feet with Ball's visible-light and near-infrared cameras on flights in February and August. U.S. Southern Command was the client for the August flight. In June, a Stratollite tested solar-panel-pointing software in the stratosphere and also drew publicity by carrying a sandwich from the KFC fast food chain. NASA has taken notice too. In July, the agency's Space Technology Mission Directorate collected 27 hours of data during a Stratollite flight. The directorate is interested in the possibility of controlling exploratory balloons on Mars with World View's altitude control technique.

Navigating with wind

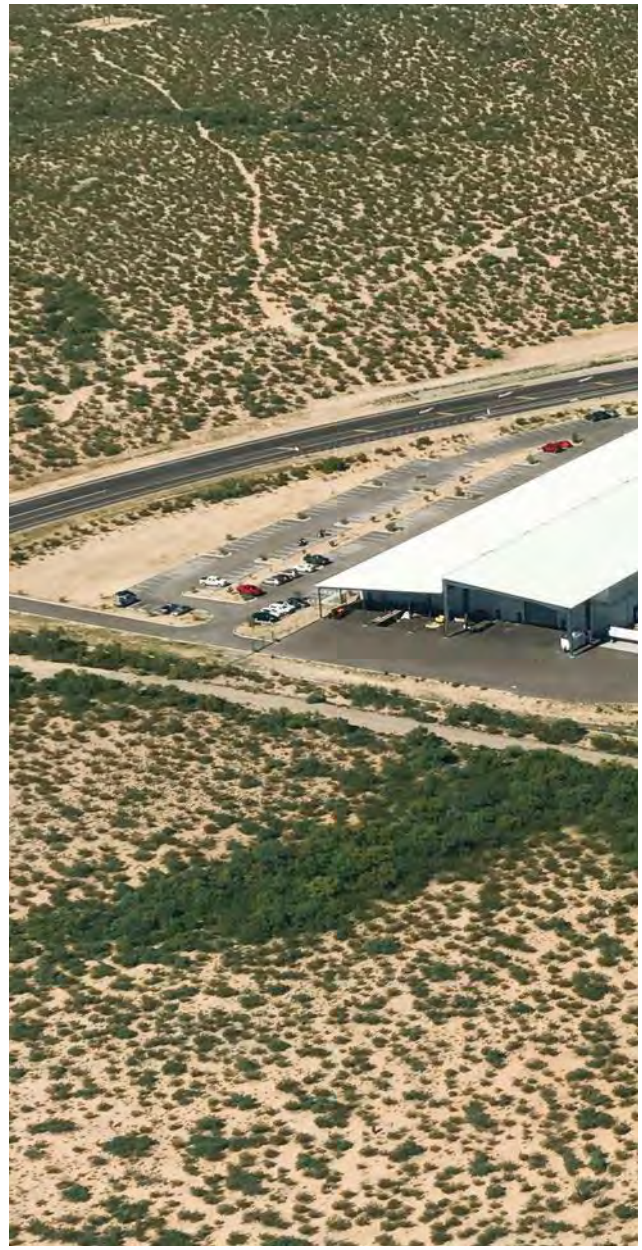
When World View engineers got to work, they knew they would need a method for keeping the balloons over specific coverage areas for long periods. Propellers weren't an option because of their weight and energy demands, plus they would need to reach up to 3 meters across to push the thin air at that altitude. MacCallum and his colleagues drew lessons from their participation in Eustace's record-breaking parachute jump in 2014, called the StratEx Space Dive. They gained first-hand experience with the stratification of wind currents in the stratosphere, meaning that currents at one altitude flow in one direction and in different directions at other altitudes.

MacCallum and his World View team decided they could keep a balloon crisscrossing over a coverage area by moving it up or down in the stratosphere. The question was how to do it. At first, MacCallum considered pumping helium between the balloon and a ballast tank. Compressing the helium into the tank would lower the balloon's buoyancy and it would sink to a lower altitude. Blowing helium back into the balloon and letting it expand would make the balloon rise. That technique wouldn't work for the Stratollite because the compressor would have to expend too much energy trying to pump the light helium molecules at high altitude. Also rejected was the idea of having the balloon enclose the helium for lift and also draw in or expel air from the atmosphere as ballast, as Google was doing to steer its Project Loon balloons, which aim to deliver high speed internet. The Google approach turned out to be problematic because the Stratollites must be larger than the Project Loon balloons. Each must inflate to 40 meters tall and 23 meters across, dwarfing conventional weather balloons, to carry about 500 kilograms of equipment. That includes batteries, solar panels, flight control electronics, tanks, heaters, a GPS transponder to alert other aircraft as it ascends and descends through commercial airspace, 50 to 100 kilograms of cameras or other cargo, and a parachute to return everything to Earth at the end of the flight. As the World View engineers tried to scale up the concept of inflating a balloon with helium and ballast

INSPIRING RECORD

On Oct. 24, 2014, then-Google executive Alan Eustace set a sky diving record by jumping from a helium-filled balloon that carried him to an altitude of 135,890 feet.

The StratEx Space Dive jump-started interest in high-altitude balloons as alternatives to satellites. During the run-up to the record attempt, Google started Project Loon, a planned fleet of balloons that would provide internet services. A friend of Eustace's, Taber MacCallum, helped create a company called World View, which aims to image Earth with balloons called Stratollites.



air, the balloon's altitude was too hard to control through the day-night temperature changes.

The team came up with a different steering strategy. Helium continues to provide the lift, but each Stratollite controls its altitude by compressing air from the atmosphere and packing it into ballast tanks, making those tanks heavier and pulling the balloon down. Or the ballast tanks can release air, making them lighter so the Stratollite rises. World View says it has flown about 50 test flights, dating back to 2015. Along the way, engineers found a wide gulf between how their balloon should work in theory and how it actually performed in the thin air and extreme temperature swings at altitude. They bridged that gulf with flight testing and creative ground tests.

Staring at the sun

Another complexity the engineers had to figure out was how to keep the solar-electric arrays pointed at the sun from their position on tethers below the balloon. It would be tricky because the air is so thin in the stratosphere that momentum is transferred easily from the arrays to the balloon and vice versa.

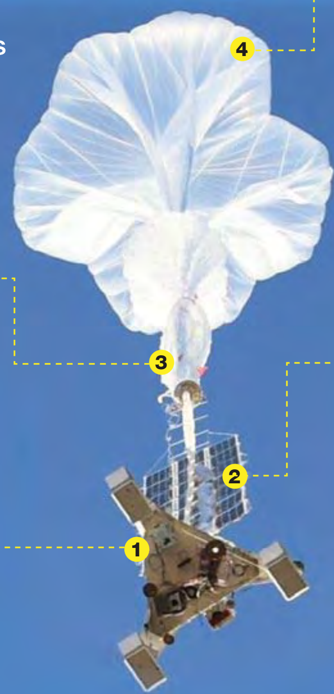
"You're spinning yourself underneath the balloon, but every time you rotate around underneath the balloon to go point at something, you make the balloon rotate above you," MacCallum says. "And when you try to stop rotating, the balloon starts to rotate. There's this constant dance going on with the momentum of the balloon."

On top of that are the unforeseen forces from air currents and moving parts — MacCallum calls them perturbations. "You can make it all work fairly well

▲ **World View** engineers test fill a balloon at Spaceport Tucson in Arizona.

Here's a Stratollite

Stratollites can ascend up to 46 kilometers, carrying 4,500 kilograms and fly for months at a time.



PRIMARY LIFT BALLOON
Provides the initial and sustained lift up to 75,000 feet. The balloon is composed of a custom blend of high-performance polyethylene film, can hold up to 30,000 cubic feet of lift gas, and, when fully expanded at altitude, grows to 25 times its original size from launch.

SECONDARY BALLOONS
The secondary balloons help the Stratollite change altitude so that it can steer to and linger above customer areas of interest.

SOLAR PANEL LADDER
This is the primary power generator for long-duration missions. It is controlled by a pointing mechanism that constantly turns the solar panels toward the sun for maximum exposure. Power is generated from the ladder throughout the day, stored on batteries, and distributed throughout the night (including to customer payloads).

THE STRATOCRAFT
The pyramid-shaped Stratocraft is made of aluminum and lightweight composite material and carries customer payloads on its underbelly. It also houses hardware, including avionics, and descent and altitude control equipment.

Source: World View

when everything is perfectly still, and there's no perturbations," he explains. "But as soon as you introduce a perturbation, now the system has to react to the perturbation and recover from the perturbation, and then relock on the sun, and then as things start to slow down, keep reacting to this changing set of momentums," he says. The engineers solved the problem by writing computer models that accounted for the balloon's rotation and the rate at which that rotation would slow. The computer code controls motors that will slightly turn the solar array, or let the balloon's rotation do the work. The engineers started with a model that described how they thought the balloon would rotate against and with the solar array. They then confirmed that model with actual measurements from four steel I-beams, 1 to 4 meters long, that they hung on a single vertical wire at World View's Tucson offices, to stand in for the Stratollite solar array, balloon and other appendages. The aerospace engineers poked at the I-beams with sticks, trying to turn the beams, which were balanced at their midpoints and separated from each other on the wire by bearings that allowed them to turn freely and tiny motors that tried to keep one of them facing in one direction. Once their computer code could keep the I-beam stand-in for the solar array pointed in the desired direction in spite of their poking, the engineers were ready to test it in flight.

The first successful in-flight test of the solar array pointing code was the KFC sandwich flight in June, which lasted about 17 hours — cut short from a planned four-day flight because of a leak in the balloon. "That was the first time we had ever accomplished getting the solar array properly pointing at the sun," MacCallum says. "That was a huge one for us."

Picking up bad vibrations

Ball Aerospace had its own engineering hurdles to solve for its Stratollite flights. Ball is interested in the potential new markets for its sensors that Stratollites could open up for the company.

Bill Good, Ball's airborne initiatives technical lead, says the company's engineers knew how to smooth out vibration for their sensors taking images while flying on drones or satellites, or combating the extreme temperatures of space for the satellite cameras. But designing adaptations for sensors to work in the stratosphere, where there is neither the vacuum of space nor the significant atmosphere present at ground level, is a unique hurdle.

"This is a region right in the middle, where you don't have zero atmosphere but you have some fraction of it," Good says. "That actually can be more difficult to model, and it's a challenge."

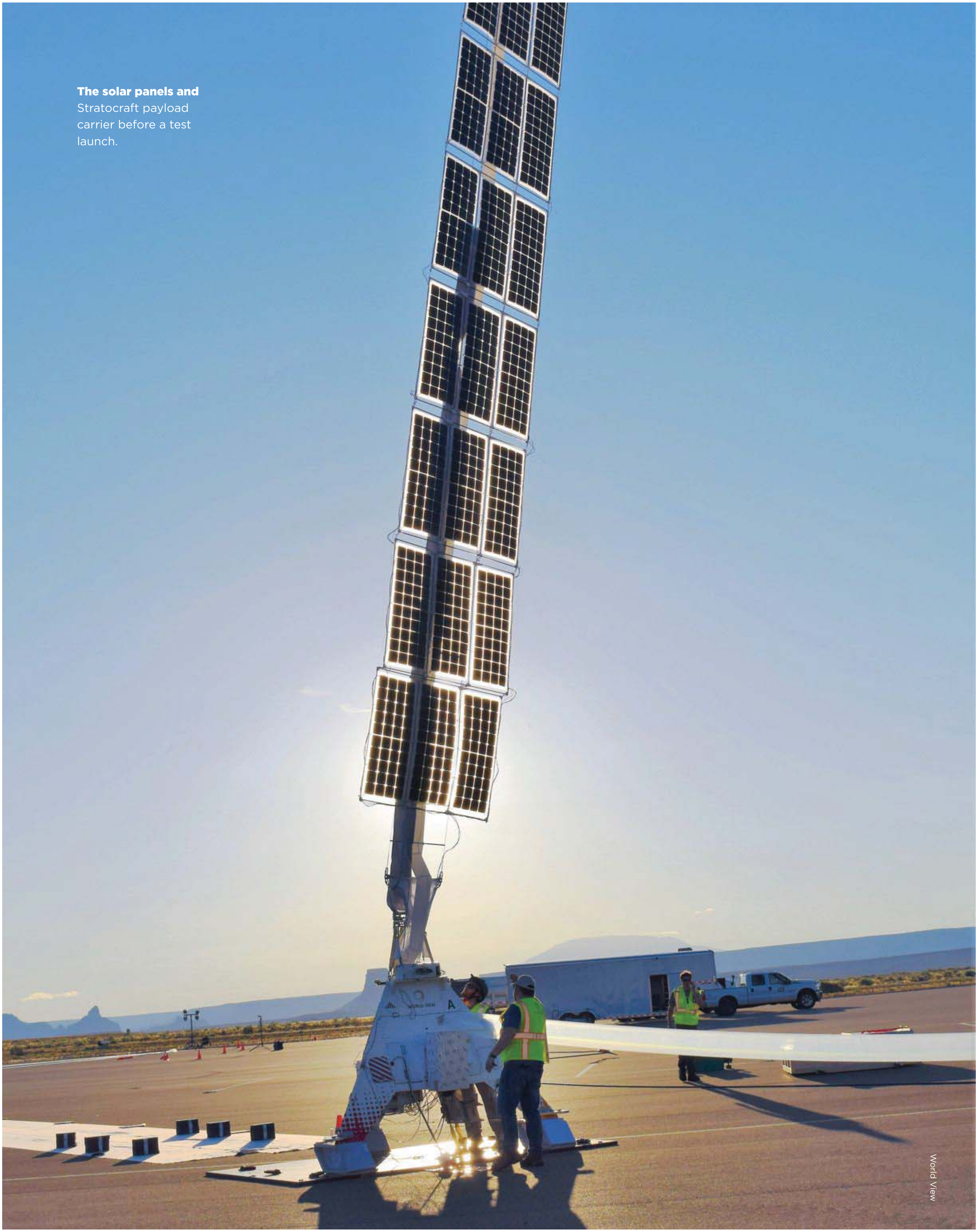
Ball put its analysts to work writing computer models that could simulate the stratosphere's thin air and temperatures, as low as minus 50 degrees Celsius. They designed heaters for their sensors based on the computer model and then they tried the sensors and heaters in a test chamber in Boulder, Colorado, that simulated the partial vacuum and cold of the stratosphere. They put the sensors and heaters to the test in February by recording images from a Stratollite at altitudes up to 76,900 feet with resolutions of less than 5 meters, and for one sensor in the sub 1-meter range. During the Stratollite flight in August, they transmitted images to the ground.

Another challenge was that a Stratollite creates vibrations in flight that are different from those en-

"There's this constant dance going on with the momentum of the balloon."

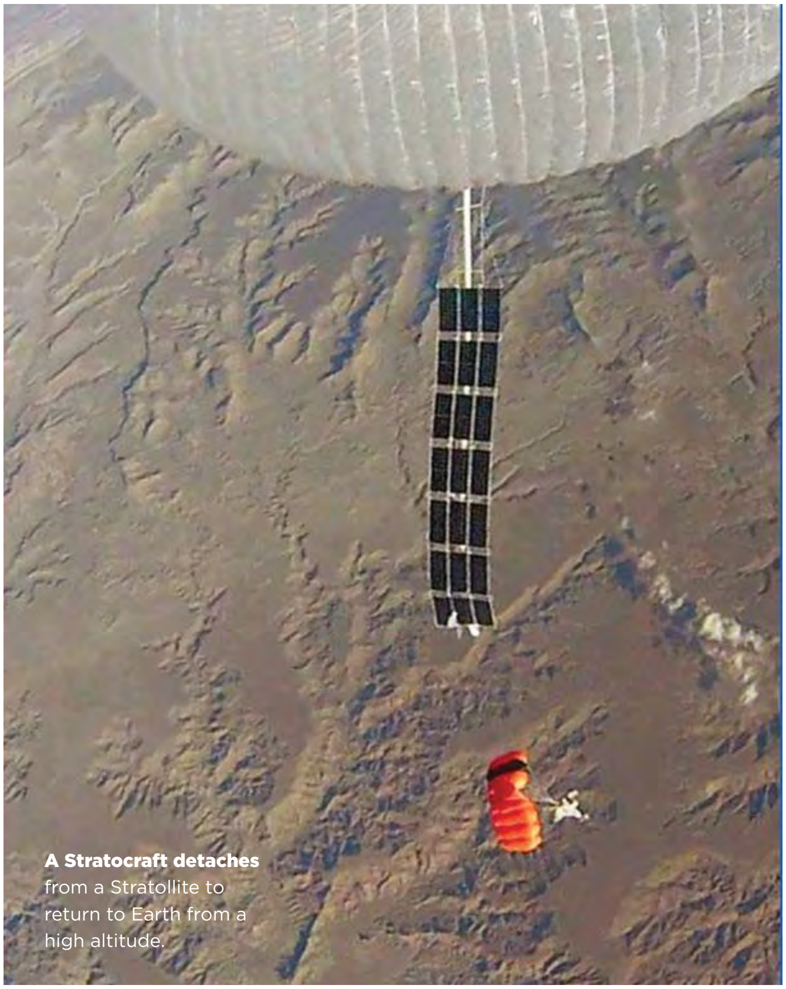
— **Taber MacCallum,** World View co-founder and chief technology officer, describing the difficulty of keeping the Stratollite's solar-electric arrays pointed at the sun from their position on tethers below the balloon.

▼ **Google's Project Loon** launches its balloons with an apparatus that includes a crane and side panels that protect the balloon from wind until it's ready to be released.



The solar panels and Stratocraft payload carrier before a test launch.

World View



A Stratocraft detaches from a Stratollite to return to Earth from a high altitude.

World View

countered by cameras on airplanes or satellites. So Ball's engineers measured and evaluated the vibrations of the February test flight. At the start of Ball's collaboration with World View, Ball's engineers knew nothing about the level of vibrations on a stratospheric balloon flight. "To avoid image blur, we needed to understand what the platform was providing," Good says. "Airborne, satellite and Stratollite have this issue that they have to deal with."

The vibrations during the balloon flight were distinct from those of a mechanical plane engine, but not necessarily less challenging, he says.

Good declined to reveal the specific adaptations that Ball engineers made to dampen the vibrations on Stratollites. But, he says, in the past they've molded rubber fittings as shock absorbers for the cameras and adopted jitter- or image-stabilization software, similar to what's available from off-the-shelf digital cameras.

As World View edges toward offering weeks- or months-long flights for imaging services, science experiments, communications links or other cargo, more innovations are likely to be needed. "It feels a lot like the 'Mythbusters' TV show around here. Someone's got an idea, and they're going to go test it," MacCallum says. ★

MARKET DISRUPTOR

For decades, satellites have relied on solar arrays that are folded up inside their launch vehicles and unfolded mechanically after launch. This technique works, but the required rigid panels, deployment mechanism and hinges take up mass and volume that designers would rather dedicate to services for paying customers. Debra Werner spoke to those who witnessed a June space station experiment that may have changed everything.

By Debra Werner | werner.debra@gmail.com

The Roll Out Solar Array is attached to the International Space Station's robotic arm by way of a platform (at bottom of photo, below the AFRL logo) that contains sensors to help measure ROSA's performance.

NASA

Mechanical engineer Matt LaPointe, technical director at the small California company Deployable Space Systems, typed a command into a computer at NASA Mission Control in Houston as dozens of engineers looked on, their eyes riveted on a live stream from the International Space Station. After a few seconds, a latch on the end of the station's Canadarm2 lifted, and a roll of photovoltaic cells mounted on a proprietary composite fabric began to unfurl like a noisemaker at a birthday party. Within two minutes, the 1.6-meter-wide strip was fully extended 6 meters, the sun sparkling off a surface covered with solar cells.

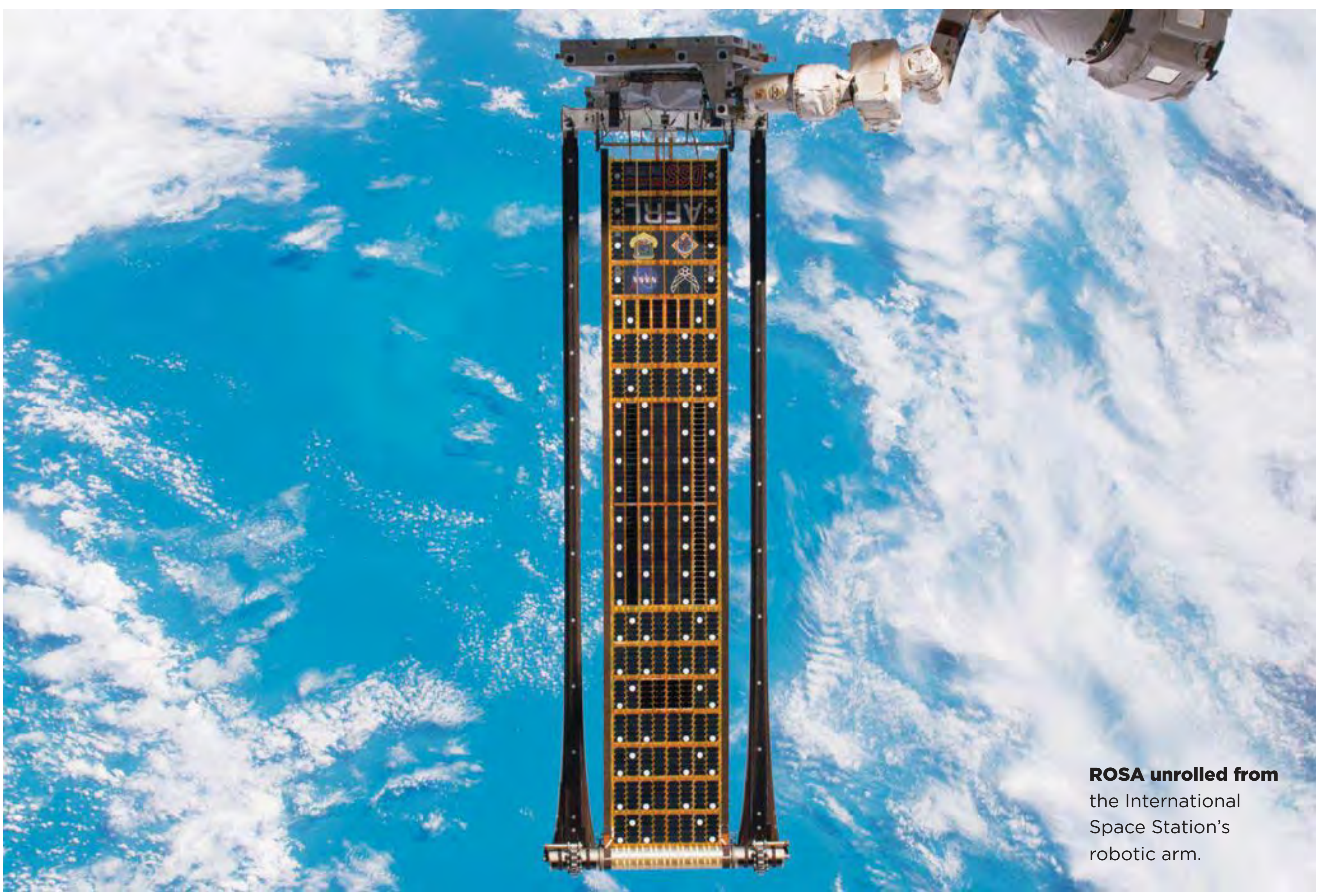
Meet ROSA, the Roll Out Solar Array. If the ROSA technology reaches space in operational form in two or three years as planned, it could completely disrupt the spacecraft market in a good way by delivering more power with dramatically less mass than today's rigid, fold-out arrays.

"I'd seen [ROSA] deploy dozens of times on the ground but to see it work in space, in full sunlight with the Earth in the background, that was just epic," says Harry Yates, a solar engineer at satellite-builder Space Systems Loral in California. SSL is a collaborator on ROSA with Deployable Space Systems and the Air Force Research Laboratory's New Mexico directorate, which provided expertise and the majority of funds for development of ROSA and carrying out the space station experiment.

The June tests conducted over six days showed that ROSA's flexible material and deployment mechanism survived their launch on a SpaceX Falcon 9 and worked as planned in microgravity. Once the latch released, the material unrolled automatically due to the pent up or "strain energy" of two compressed composite tubes, one on each side of the array. ROSA was mounted on a platform, which was

▼ **Air Force Research** Laboratory scientist Paul Hausgen demonstrates how "strain energy" unfurls the Roll Out Solar Array's slit-tube booms.

Anita Collins



ROSA unrolled from the International Space Station's robotic arm.

NASA

"Mass is such a valuable commodity on a satellite that if we can shave just 10 or 20 percent off a large component like a solar array, **we can put that mass toward more transponders on a communications satellite or toward a payload that is actually doing the mission."**

– **Jeremy Banik**, ROSA principal investigator at the Air Force Research Laboratory's Space Vehicles Directorate

also held in place by the Canadarm2, that housed the electronic controls for the experiment. This space version of a laboratory vibration table was equipped with sensors to gauge the deployed wing's strength, stiffness and durability. The readings were transmitted to engineers on the ground for each of the four times the wing was released and retracted. Engineers from the Air Force and Deployable Space Systems gauged the deployed wing's strength, stiffness and durability. They also measured the photovoltaic performance of ROSA's solar cells at various temperatures, sun angles and when the array was in the space station's shadow.

Other tests lie ahead, but the station experiment amounted to validating ROSA in the space environment, says Brian Spence, Deployable Space Systems founder and president.

For its part, SSL is offering customers the option of purchasing ROSA with its 1300 satellite bus, a design that has formed the foundation of 100 geosynchronous communications satellites since its introduction in 1989. The version of ROSA tested in June was not large enough for the 1300, so SSL plans to build a full-scale qualification model of a ROSA array and put it through testing. SSL needs to see how well the flexible material and cells respond to repeated thermal cycles. That testing will be completed over the first few months of 2018, Yates says.

For satellite designers, ROSA touches two of the letters in the SWAP (size, weight and power) tradeoff formula. Its canister and rolled-up array take up less volume and weigh less than today's foldup arrays with their battery-driven motors and cranking mechanisms. At the same time, they generate more power.

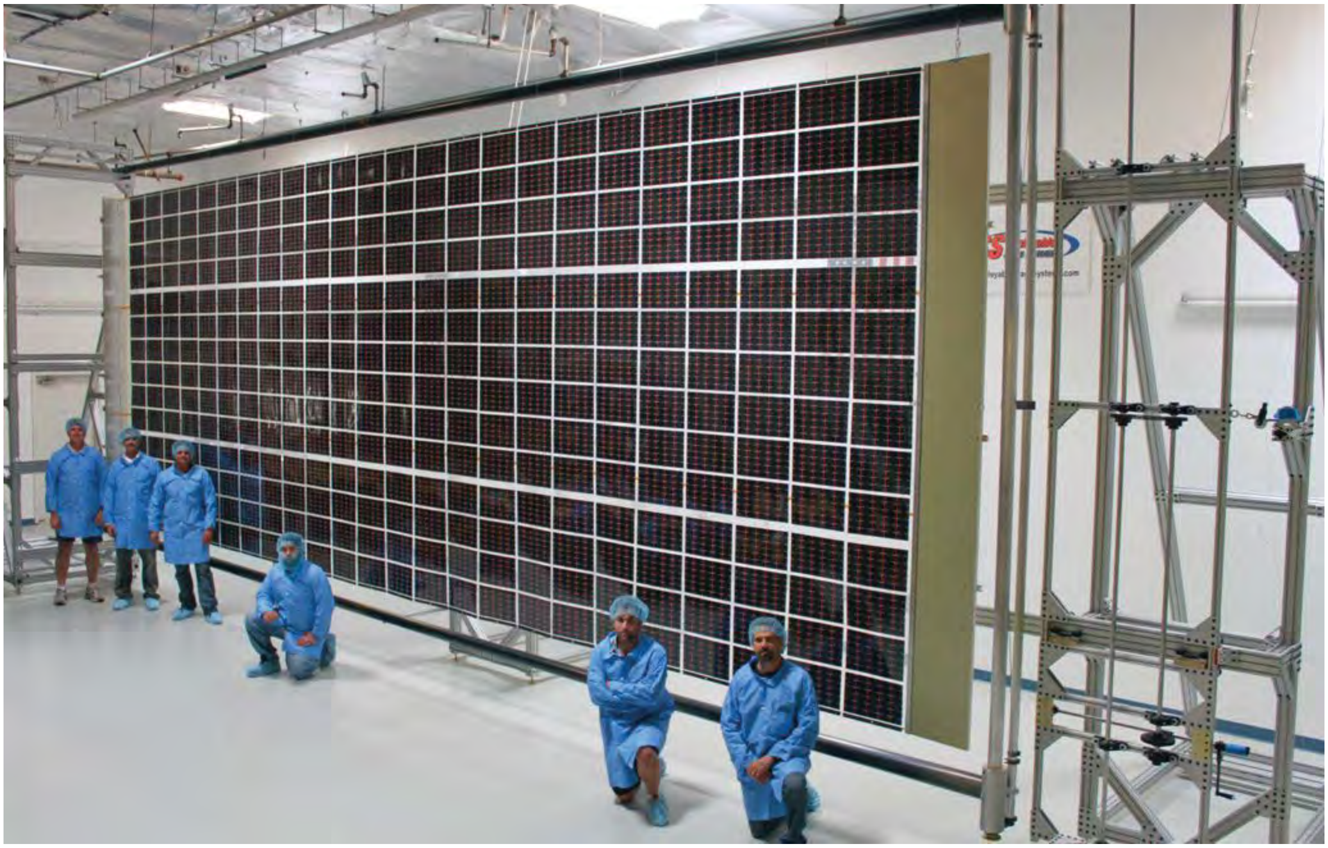

NASA

▲ **Deployable Space** Systems tested a smaller version of the Roll Out Solar Array at NASA's Glenn Research Center in Ohio to determine how solar cells would hold up to rolling and unrolling several times.

"Mass is such a valuable commodity on a satellite that if we can shave just 10 or 20 percent off a large component like a solar array, we can put that mass toward more transponders on a communications satellite or toward a payload that is actually doing the mission," says Jeremy Banik, ROSA principal investigator at the Air Force Research Laboratory's Space Vehicles Directorate in Albuquerque, New Mexico.

The Air Force estimates that ROSA's technology could help it reduce the mass of its next generation of communications and precision navigation and timing satellites for a savings of $1.4 billion.

NASA engineers think ROSA could be especially valuable as the source of power for solar electric propulsion, in which a propellant is electrified and accelerated to create thrust. Today, communications satellites often rely on solar electric propulsion for station-keeping. NASA is looking for far more pow-



Deployable Space Systems

▲ **ROSA underwent** testing at Deployable Space Systems.

> "It's a very elegant design. The tubes, rolled up flat for stowage, want to return to a round cross-section. **It's that spring force that drives it to unroll."**
>
> – **Harry Yates**, a solar engineer at satellite-builder Space Systems Loral

erful solar electric propulsion systems that could propel spacecraft from one orbit to another.

A candidate for the first demonstration of that technology could be the Deep Space Gateway, the crew habitat the agency wants to establish in lunar orbit in the early 2020s to begin preparing astronauts for future missions to asteroids or someday Mars. ROSA and a rival technology, Orbital ATK's MegaFlex solar array, have "the operational and performance characteristics" for that mission, says Dave Manzella, the chief engineer for NASA's Solar Electric Propulsion Technology Demonstration Project at NASA's Glenn Research Center in Ohio.

For all those applications, the arrays would have to be significantly larger than the 1.6-meter-by-6-meter version that unfurled in orbit on June 18. The Air Force Research Laboratory gathered data on the structural dynamics of the deployed wing to improve the computer models that will predict the performance of larger arrays.

The Air Force Research Laboratory started funding the project in 2008 and NASA signed on in 2009 to pay for development of larger versions of ROSA.

In addition to funding, the Air Force Research Laboratory contributed a key component of ROSA when it transferred technology to Deployable Space Systems for carbon fiber laminate tubes, the components whose strain energy unfurls ROSA. Traditional rigid solar panels fold for launch and unfold in orbit along mechanical hinges. For simplicity's sake, the Air Force Research Laboratory and Deployable Space Systems were eager to do away with the hinges.

"It's a very elegant design," Yates says. "The tubes rolled up flat for stowage want to return to a round cross-section. It's that spring force that drives it to unroll."

ROSA combines those tubes with photovoltaic cells and circuitry housed in common mass-produced modules that Deployable Space Systems combines to produce arrays of various sizes and shapes. "It scales up in size so much easier than a rigid panel array," Banik says.

All those benefits are designed to lower the cost of producing power in orbit. "You get more power than you would with comparable rigid arrays in the same stowed volume," Spence says. Plus, the flexible arrays generally weigh less than comparable rigid ones.

"Those metrics are important," Banik says. "We can save money and increase capability." ★

20 TWENTIES

Submit Your Nomination Today!

Recognizing Top University Talent

The future innovators and creators for the aerospace and defense industry.

The 20 Twenties program recognizes the accomplishments and drive of 20 science, technology, engineering and math students in their 20s and currently enrolled in a master's degree or bachelor's degree program. Open to students around the globe, 20 Twenties selects the best of the best, based on their academic record, their service to the community at large, and the value of their research projects. We'll introduce this next generation of leaders on the pages of *Aviation Week & Space Technology* in our digital and print publication.

How to Nominate: Deans or faculty members of engineering/technical schools may nominate students who embody Aviation Week Network's 20 Twenties and are on course to change the future of aerospace and defense.

Submit your Nomination Today:

AviationWeek.com/20TwentiesNomination

All submissions must be received by November 15, 2017.
Questions? Contact Carla Sands at carla.sands@aviationweek.com

In Association With:

AIAA
Shaping the Future of Aerospace

AVIATION WEEK
NETWORK

A blueprint for attracting and retaining talent

AIAA

▲ **Students compete in** the AIAA 2017 Design Build Fly competition in April. Aerospace companies have to offer the brightest young professionals opportunity, training and state-of-the-art facilities, says an industry executive.

Why are so many students and young professionals attracted by jobs in Silicon Valley? One reason is this region's reputation as the place to be for anyone who wants to push technology forward by going digital. Too often, U.S. aviation companies find themselves on the losing side in the competition for top talent. Michel J. Tellier of Dassault Systèmes says this does not have to be the case.

By Michel J. Tellier

Attracting and retaining talent in the aviation industry has always been challenging, but it has proved especially difficult over the past few years due to the rise of high-tech companies in other fields. This has left my company and others in a fierce competition for the best and brightest at the very time when the International Air Transportation Association predicts that air travel will double to 7.2 billion passengers in 20 years. More travelers mean a greater demand for aircraft and innovations. On top of this, manufacturers have an almost eight-year backlog of orders because of a record number accrued over the past 10 years in the commercial sector.

Adding to the challenge, the number of aerospace software and systems engineers eligible for retirement is increasing, as documented by Aviation Week's annual Workforce Study. While aviation companies are reorganizing to make their operations leaner, more agile and more connected, there is still a shortfall of talented engineers when the industry needs them most.

In an industry as technology-intensive as aviation, companies must attract top talent with the right set of skills. That means seeking new workers, whether aerospace engineers or workers on the plant floor, with various backgrounds who can leverage new technologies like additive manufacturing, robotics, modeling and simulation, and the latest virtual tools to help accelerate production to meet the demand.

Silicon Valley-based high-tech companies, including Facebook, Amazon and Google, are breaking into market space that was traditionally held by commercial and defense aerospace sector, or A&D. At the top of the mind of engineers in Silicon Valley are autonomous transportation, drones, complex systems-based products, a thrust of innovation in the space sector, and sustained activity in defense and cyber security. With cutting-edge technology and rapid digital transformation, Silicon Valley appeals to top engineers in a way we haven't seen before. As such, engineers whose skill sets would more specifically apply to the aviation field now have a much wider opportunity to explore other professions.

Today, the aviation industry is rapidly innovating across design, manufacturing and product development. The shortage of top talent in the industry threatens to bring that innovation to a standstill. To help mitigate the looming skill gaps, Dassault Systèmes has implemented new solutions and procedures to attract and retain top talent to the aviation industry, including investing in educational programs and arming millennials with access to cutting-edge software and concepts.

Platform technologies appeal to a younger workforce

Today's top performing companies usually focus on the future, which means focusing their investments in new areas of technology. Across industries, we see some of the leading technology companies, including Google, Apple and Amazon, adopting platform technologies in support of digital transformation. For enterprises and startups alike, a business platform is an all-in-one software solution that allows companies to manage the entire product lifecycle, from ideation to creation, from a single collaborative space in the digital realm. In fact, more than 70 percent of startups and 50 percent of traditional companies have adopted a platform technology. Implementing a platform technology ensures efficient communication and collaboration across offices, states and countries.

With more than 70 percent of companies worldwide already experimenting with digital transformation, those who don't move with the trend will be left behind. Cutting-edge technology appeals to young engineers and is one of the major reasons they choose Silicon Valley over aviation.

My company's 3DEXPERIENCE platform is an example. It streamlines work and helps to accelerate the onboarding and integration of new employees by providing them with one easy-to-use tool. It connects people, data, solutions and ideas by housing information in one intuitive, visual interface, which enables stronger collaboration and diminishes frustration for young engineers who are familiar with using cloud platform technology in their consumer lives.

Investing in the future

To create a culture of excellence and attract the best people, aviation companies need to invest in research and development. In addition to investing in our own R&D, Dassault Systèmes expanded its La Fondation initiative to the United States earlier this year. The company provides grants, digital content and skill sets in virtual technologies to education and research initiatives at forward thinking academic institutions, research institutes, museums, associations, cultural centers and other general interest organizations. It offers these institutions opportunities to transform the way people interact with and discover the world around them. In addition to influencing R&D today, La Fondation encourages a culture of innovation that students and researchers can take with them no matter what organization they join.

On-campus programs

Programs on college campuses invite students to bring to life what they've learned in the classroom. Students are encouraged to try new things and even make mistakes in a supportive and innovative environment. Additionally, through digital exploration of various software programs, the next generation of workers gets to understand the ins and outs of an organization prior to making a decision about employment.

Over the past year, we at Dassault Systèmes have created two innovative educational programs specific to the aviation industry to promote retention of talent. In April, we opened the 3DEXPERIENCE Center on Wichita State University's campus to encourage firsthand experiences for young engineers in new ways of working and how they can help lead the transformation of how programs are delivered. The 3DEXPERIENCE Center was developed in partnership with the university's National Institute of Aviation Research. Students get to oversee the process of creating a product from concept to production, all without ever having to create a physical model. This encourages them to push the evolution of airplane design, production and operation. This also allows students to have access to leading researchers to learn about the latest trends in aviation, including reverse engineering and additive manufacturing.

Additionally, in July, we partnered with eight educational institutions in Washington and with the Center of Excellence for Aerospace & Advanced Manufacturing to develop and refine the future workforce through cloud-based technology programs. These partnerships provide hands-on experience designing, engineering and manufacturing in the new Experience Economy where manufacturers design products to help customers build memories, rather than own products or receive services. Through the 3DEXPERIENCE platform, students can start a project on campus and continue building it anywhere in the world, enhancing domestic and international collaboration and communication. By exposing students to this new platform thinking, we are arming them with unique digital skills that industry leaders seek among new hires.

As demand for air travel and aircraft products increases, the aviation industry needs to ensure we're equipped with talent to support these needs. By establishing a foundation for education early on for students to have access to the crucial skills needed to succeed, aviation and technology companies can better prepare for the future. ★

Michel J. Tellier
directs aerospace and defense (A&D) business for Dassault Systèmes, the 3-D design and lifecycle software subsidiary of the Paris-based Dassault Group. Based in Seattle, he holds a Bachelor of Science degree in mechanical engineering from Dalhousie University in Nova Scotia.

MEMBERSHIP MATTERS






Your Membership Benefits

1. **Get Ahead of the Curve –** Stay abreast of in-depth reporting on the innovations shaping the aerospace industry with ***Aerospace America***, and a daily dose of vetted industry news in the ***AIAA Daily Launch*** – both delivered free with AIAA membership.

2. **Connect with Your Peers –** Whether you are ready to travel to one of AIAA's five forums, or you want to stay close to home, AIAA offers the best opportunities to **meet the people working in your industry and interest.**

3. **Explore More Opportunities –** AIAA has deep relationships with the most respected and innovative aerospace companies in the world. They look to our membership for the most qualified candidates. As an AIAA member, you get access to our **Career Center** to view job listings and post your resume to be seen by the best companies in the industry.

4. **Publish Your Work –** If you are searching for the best place to publish or present your research, look no further! AIAA has five targeted **forums**, eight specifically focused **journals**, and a number of co-sponsored conferences to choose from. Find your peers, publish your work and progress in your career!

5. **Save Money –** Get free access to all our **standards documents** and get discounts on forum registrations, journal subscriptions and book purchases. These savings can quickly pay for your membership!

www.aiaa.org

AIAA
Shaping the Future of Aerospace

16-1030

AIAA Bulletin

DIRECTORY

AIAA Headquarters / 12700 Sunrise Valley Drive, Suite 200 / Reston, VA 20191-5807 / www.aiaa.org

To join AIAA; to submit address changes, member inquiries, or renewals; to request journal fulfillment; or to register for an AIAA conference. Customer Service: 800/639-AIAA (U.S. only. International callers should use 703/264-7500.)

All AIAA staff can be reached by email. Use the formula first name last initial@aiaa.org. Example: megans@aiaa.org.

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

Other Important Numbers: Aerospace America / Karen Small, ext. 7569 • AIAA Bulletin / Christine Williams, ext. 7575 • AIAA Foundation / Karen Thomas, ext. 7520 • Book Sales / 800.682.AIAA or 703.661.1595, Dept. 415 • Communications / John Blacksten, ext. 7532 • Continuing Education / Jason Cole, ext. 7596 • Corporate Members / Tobey Jackson, ext. 7570 • Editorial, Books and Journals / Heather Brennan, ext. 7568 • Exhibits and Sponsorship / Chris Semon, ext. 7510 • Honors and Awards / Patricia Carr, ext. 7523 • Journal Subscriptions, Member / 800.639.AIAA • Journal Subscriptions, Institutional / Online Archive Subscriptions / Michele Dominiak, ext. 7531 • Media Relations / John Blacksten, ext. 7532 • Public Policy / Steve Sidorek, ext. 7541 • Section Activities / Emily Springer, ext. 7533 • Standards, Domestic / Hilary Woehrle, ext. 7546 • Standards, International / Nick Tongson, ext. 7515 • Student Programs / Rachel Dowdy, ext. 7577 • Technical Committees / Karen Berry, ext. 7537

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

Calendar

Notes About the Calendar

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

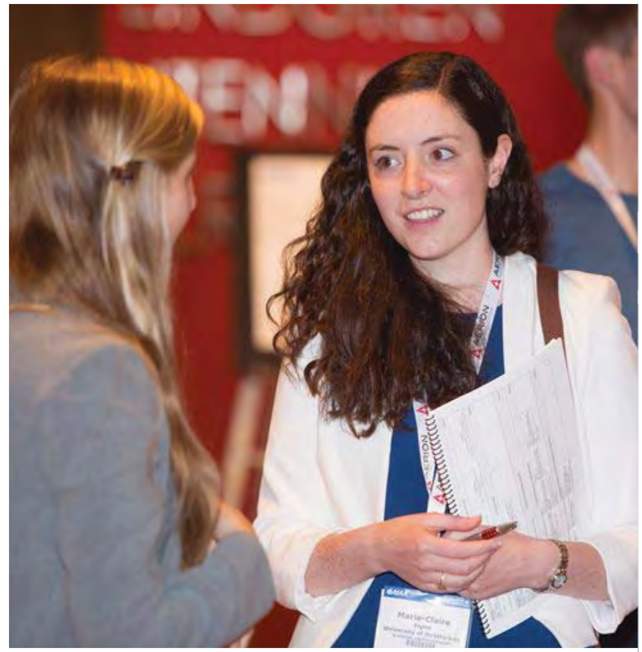
DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2017			
3–4 Oct†	Drone World Expo	San Jose, CA	
11–12 Oct†	International Symposium for Personal and Commercial Spaceflight	Las Cruces, NM	
16–19 Oct†	Joint 23rd Ka and Broadband Communications Conference and 35th International Communications Satellite Systems Conference (ICSSC)	Trieste, Italy (www.kaconf.org)	8 Jun 17
23–26 Oct†	International Telemetering Conference	Las Vegas, NV (www.telemetry.org)	
13–15 Nov†	1st International Academy of Astronautics (IAA) Conference on Space Situational Awareness	Orlando, FL (www.icssa2017.com)	
4–8 Dec†	Flight Software Workshop	Laurel, MD (www.flightsoftware.org)	28 Aug 17
2018			
6–7 Jan	5th International Workshop on High-Order CFD Methods	Kissimmee, FL	
6–7 Jan	Future CFD Technologies Workshop: Bridging Mathematics and Computer Science for Advanced Aerospace Simulation Tools	Kissimmee, FL	
6–7 Jan	Aircraft and Rotorcraft System Identification Engineering Methods for Manned and UAV Applications with Hands-On Training Using CIFER ® Course	Kissimmee, FL	
6–7 Jan	Large Eddy Simulation of Turbulent Combustion: Theory, Modeling and Practice Course	Kissimmee, FL	
6–7 Jan	Introduction to Software Engineering Course	Kissimmee, FL	
6–7 Jan	Stochastic Mechanics of Materials and Structures Course	Kissimmee, FL	
6–7 Jan	Missile Guidance Course	Kissimmee, FL	
7 Jan	Aeroelastic Wind Tunnel Testing and Aeroelasticity Considerations for Non-Aeroelastic Tests Course	Kissimmee, FL	
8 Jan	2018 Associate Fellows Recognition Ceremony and Dinner	Kissimmee, FL	
8–12 Jan	AIAA SciTech Forum (AIAA Science and Technology Forum and Exposition) Featuring: – AIAA/AHS Adaptive Structures Conference – AIAA Aerospace Sciences Meeting – AIAA Atmospheric Flight Mechanics Conference – AIAA Information Systems — Infotech@Aerospace Conference – AIAA Guidance, Navigation, and Control Conference – AIAA Modeling and Simulation Technologies Conference – AIAA Non-Deterministic Approaches Conference – AAS/AIAA Space Flight Mechanics Meeting – AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference – AIAA Spacecraft Structures Conference – Wind Energy Symposium	Kissimmee, FL	12 Jun 17
22–25 Jan †	64th Annual Reliability & Maintainability Symposium (RAMS)	Reno, NV (Contact: http://www.rams.org)	
21 Mar	AIAA Congressional Visits Day (CVD)	Washington, DC (www.aiaa.org/CVD)	
1 May	2018 Fellows Dinner	Crystal City, VA	

†Meetings cosponsored by AIAA. Cosponsorship forms can be found at https://www.aiaa.org/Co-SponsorshipOpportunities/.

AIAA Continuing Education offerings

AIAA Symposiums and Workshops

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2 May	Aerospace Spotlight Awards Gala	Washington, DC	
3–10 Mar †	IEEE Aerospace Conference	Big Sky, MT (Contact: www.aeroconf.org)	
8–10 May	AIAA DEFENSE Forum (AIAA Defense and Security Forum) Featuring: – AIAA Missile Sciences Conference – AIAA National Forum on Weapon System Effectivenss – AIAA Strategic and Tactical Missile Systems Conference	Laurel, MD	
28–30 May †	25th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (Contact: www.elektropribor.spb.ru)	
28 May–1 Jun	SpaceOps 2018: 15th International Conference on Space Operations	Marseille, France (Contact: www.spaceops2018.org)	6 Jul 17
25–29 Jun	AIAA AVIATION Forum (AIAA Aviation and Aeronautics Forum and Exposition) Featuring: – AIAA/CEAS Aeroacoustics Conference – AIAA Aerodynamic Measurement Technology and Ground Testing Conference – AIAA Applied Aerodynamics Conference – AIAA Atmospheric Flight Mechanics Conference – AIAA Atmospheric and Space Environments Conference – AIAA Aviation Technology, Integration, and Operations Conference – AIAA Flight Testing Conference – AIAA Flow Control Conference – AIAA Fluid Dynamics Conference – AIAA/ASME Joint Thermophysics and Heat Transfer Conference – AIAA Modeling and Simulation Technologies Conference – AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference – Plasmadynamics and Lasers Conference	Atlanta, GA	9 Nov 17
25–29 Jun†	15th Spacecraft Charging Technology Conference (SCTC)	Kobe, Japan (Contact: http://www.org.kobe-u.ac.jp/15sctc/index.html)	
3–6 Jul†	ICNPAA-2018 - Mathematical Problems in Engineering, Aerospace and Sciences	Yerevan, Armenia (Contact: http://www.icnpaa.com)	
9–11 Jul	AIAA Propulsion and Energy Forum (AIAA Propulsion and Energy Forum and Exposition) Featuring: – AIAA/SAE/ASEE Joint Propulsion Conference – International Energy Conversion Engineering Conference	Cincinnati, OH	
19–23 Aug†	2018 AAS/AIAA Astrodynamics Specialist Conference	Snowbird, UT (http://www.space-flight.org)	
17–19 Sep	AIAA SPACE Forum (AIAA Space and Astronautics Forum and Exposition) Featuring: – AIAA Complex Aerospace Systems Exchange	Orlando, FL	
1–5 Oct†	69th International Astronautical Congress	Bremen, Germany	



PROPULSION ENERGY FORUM

More than 1,100 attendees representing a wide spectrum of the propulsion and energy community – from across the United States and 28 other countries – convened in Atlanta, 10–12 July, for a very engaging and informative 2017 AIAA Propulsion and Energy Forum. The forum included more than 240 students and featured nearly 500 technical presentations.

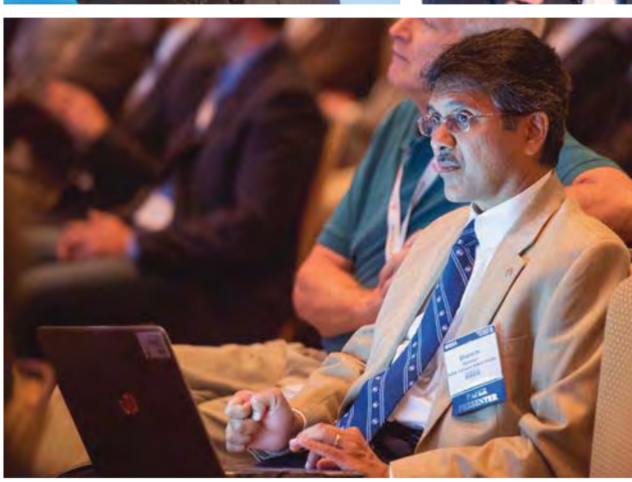

System Engineering Needs Panel

UAS Propulsion Panel


Aircraft Propulsion Panel


A.P. "Sakis" Meliopoulos


William Gerstenmaier



Recognizing Top Achievements – An AIAA Tradition

For over 80 years, AIAA has been committed to ensuring that aerospace professionals are recognized and celebrated for their achievements and innovations that make the world safer, more connected, accessible, and prosperous. AIAA celebrates the following individuals who were recognized between July and September 2017.

Presented at the AIAA Propulsion and Energy Forum, 10–12 July 2017, Atlanta, Georgia

AIAA Aerospace Power Systems Award

Thomas W. Kerslake
Power System Engineer
NASA Glenn Research Center

For exceptional service to the aerospace space power community; invaluable technical contributions to the design, analysis, test, and on-orbit operation of photovoltaic solar arrays; and dedicated technical leadership of electrical power subsystem development resulting in multiple successful spacecraft mission deployments.
Nominated by: Michael Piszczor, NASA Glenn Research Center

AIAA Air Breathing Propulsion Award

Campbell D. Carter
Air Force Research Laboratory
Wright-Patterson AFB

For a distinguished record of technical contributions to laser and optical diagnostics for combustion, turbulent-, supersonic- and plasma-assisted combustion and sustained service to the community.
Nominated by: Faure Joel Malo-Molina, Air Force Research Laboratory

AIAA Energy Systems Award

Suresh K. Aggarwal
Professor, Department of Mechanical and Industrial Engineering
University of Illinois at Chicago

For outstanding contributions to energy and combustion systems through pioneering work on advanced spray and flame model development for improved engine performance and pollution reduction.
Nominated by: Tom I-P. Shih, Purdue University

AIAA 2017 Engineer of the Year Award

Michael Keidar
Professor, School of Engineering and Applied Science
George Washington University

For significant contributions to fundamentals and applications of electric propulsion, particularly micro-propulsion for small satellites.
Nominated by Norman Wereley, University of Maryland

AIAA Propellants and Combustion Award

Ken N. C. Bray
Professor Emeritus, Department of Engineering
University of Cambridge

For his pioneering contributions to fundamental understanding of mixing, combustion and gas dynamics for high speed propulsion and his teaching, research and enriched international collaborations.
Nominated by: Ashwani Gupta, University of Maryland

AIAA Wyld Propulsion Award

John R. Brophy
Engineering Fellow
Jet Propulsion Laboratory

For leadership and technical contributions resulting in the implementation of electric propulsion on deep-space NASA missions and enabling the Asteroid Retrieval Mission.
Nominated by Dan Goebel, Jet Propulsion Laboratory

AIAA Sustained Service Award

Marc D. Polanka
Professor, Air Force Institute of Technology
Wright-Patterson AFB

For service to the Dayton-Cincinnati Section as past chair of the section, past chair of the DCASS Conference, and continued service as honors and awards chair and AFIT student section faculty advisor.

Robotic Refueling Mission (RRM) Team

Juno Mission Team

Part of the canceled AIAA SPACE Forum; Awards Will Be Presented at a 2018 Event

von Kármán Lecture in Astronautics

The Alpha Magnetic Spectrometer on the International Space Station: Unlocking the Secrets of the Cosmos

Samuel C. C. Ting
Thomas Dudley Cabot Professor of Physics
Massachusetts Institute of Technology
Nominated by: William Gerstenmaier, NASA Headquarters

Space Automation & Robotics Award

Robotic Refueling Mission (RRM) Team
NASA Goddard Space Flight Center

In recognition of the Robotic Refueling Mission Team for their work in advancing the state of robotic servicing technology enabling the routine serving of satellites.
Nominated by: David Spangler, OceaneeringSpace Systems

Space Operations and Support Award

ISS Loop A Response Team
Anthony Vereha, Todd Quasny, ISS Flight Controllers
NASA Johnson Space Center

For leadership and innovation in working the External Thermal Control System Loop A Flow Control Valve failure on the International Space Station.
Nominated by: Michele Brekke, Michele Brekke and Associates

Space Systems Award

Juno Mission Team
Jet Propulsion Laboratory

For exceptional achievement in the development and implementation of the Juno mission, resulting in groundbreaking data that is revolutionizing our understanding of Jupiter.
Nominated by: Charles Elachi, Jet Propulsion Laboratory

von Braun Award for Excellence in Space Program Management

Maj. Gen. Roger W. Teague
Director, Space Programs
Assistant Secretary (Acquisition),
U.S. Air Force

For exceptional achievement in space missions, through innovative strategic thinking, revolutionary program management, and inspirational leadership on program execution.
Nominated by: Tom Taverney, Leidos-Space System Development

Presented at the 36th Digital Avionics Systems Conference (DASC), 17–21 September 2017, St. Petersburg, Florida

AIAA Dr. John C. Ruth Digital Avionics Award

John R. Moore
Principal Systems Engineer
Rockwell Collins, Inc.

For pioneering work to develop enabling technologies for Unmanned Aircraft Systems, and the standards to adopt them into the National Air Space.
Nominated by: Alan Tribble, Rockwell Collins

Learn more about the AIAA Honors and Awards program at aiaa.org/HonorsAndAwards

AIAA Announces Section Award Winners

Awards Honor Outstanding Section Programming in a Variety of Categories

AIAA has announced its 2016–2017 Section Award winners. The Section Awards honor particularly notable achievements made by member sections in a range of activities that help fulfill the Institute's mission. The Institute believes that vital, active sections are essential to its success.

Section awards are given annually in five categories based on the size of each section's membership. Each winning section receives a certificate and a cash award. The award period covered is June 1, 2016–May 31, 2017.

The **Outstanding Section Award** is presented to sections based upon their overall activities and contributions through the year. The winners are:

Very Small: **First Place: Delaware,** Breanne Sutton, section chair; **Second Place: Adelaide,** Mark Ramsey, section chair; **Third Place: Wisconsin**, Rob Michalak, section chair

Small: **First Place: Sydney,** Benjamin Morrell, section chair; **Second Place: Savannah,** Ted Meyer, section chair; **Third Place (tie): Northern New Jersey**, Raymond Trohanowsky, section chair; **Third Place (tie): Twin Cities,** Kristen Gerzina, section chair

Medium: **First Place, Long Island,** David Paris, section chair; **Second Place: Tucson**, Brian Biswell, section chair; **Third Place (tie): Tennessee,** Joseph Sheeley, section chair; **Third Place (tie): Wichita,** Linda Kliment, section chair

Large: **First Place: Northern Ohio,** James Gilland, section chair; **Second Place (tie): Orange County,** P. Chase Schulze, section chair; **Second Place (tie): San Diego**, Stevie Jacobson, section chair; **Third Place: St. Louis**, Robert Dowgwillo, section chair

Very Large: **First Place: Greater Huntsville,** Brandon Stiltner, section chair; **Second Place: Rocky Mountain,** Brian Gulliver, section chair; **Third Place: Hampton Roads,** Alaa Elmiligui, section chair

1 **Attendees at** the Rocky Mountain Section's annual Technical Symposium

2 **An evening** of Public Policy with the Twin Cities Section

---

The **Career and Professional Development Award** is presented for section activities that focus on career development, such as time management workshops, career transition workshops, job benefits workshops, and technical versus management career path workshops. The winners are:

Very Small: **First Place: Delaware,** Timothy McCardell, career and professional development officer

Small: **First Place: Sydney,** Andrew Gong, career and professional development officer; **Second Place: Savannah,** Scott Terry and Ricky Odey, career and professional development officers

Very Large: **First Place: Hampton Roads,** Elizabeth Ward, career and professional development officer

---

The **Communications Award** is presented to sections that have developed and implemented an outstanding communications outreach program. Winning criteria include level of complexity, timeliness, and variety of methods of communications, as well as frequency, format, and content of the communication outreach. The winners are:

Very Small: **First Place; Delaware,** Joseph Scroggins, communications chair, and Timothy Dominick, public policy officer; **Second Place: Adelaide,** RaviTeja Duggeneni, webmaster

Small: **First Place: Sydney,** Timo Moisiadis, webmaster; **Second Place: Utah,** John Metcalf, section chair; **Third Place: Northwest Florida,** Chi Mai, secretary

Medium: **First Place: Tucson,** Michelle Rouch, aerospace and societies officer, and Alan Jennings, webmaster; **Second Place: Long Island**, David Paris, section chair and newsletter editor; **Third Place: Tennessee,** Andrew Redmon, newsletter editor and webmaster

Large: **First Place: Albuquerque,** Sally Smith, newsletter editor; **Second Place: St. Louis,** Alex Davies, newsletter editor and webmaster; **Third Place: San Diego,** Chris McEachin, secretary

Very Large: **First Place: Rocky Mountain,** Brian Gulliver, section chair, John Grace, webmaster, and Adrian Nagle, newsletter editor; **Second Place: Greater Huntsville,** Erin Walker, communications officer; **Third Place (tie): Dayton/Cincinnati**, Donald Rizzetta, secretary; **Third Place (tie)**: **Hampton Roads**, John Lin, newsletter editor

---

The **Membership Award** is presented to sections that have worked to increase their membership by planning and implementing effective recruitment and retention campaigns. The winners are:

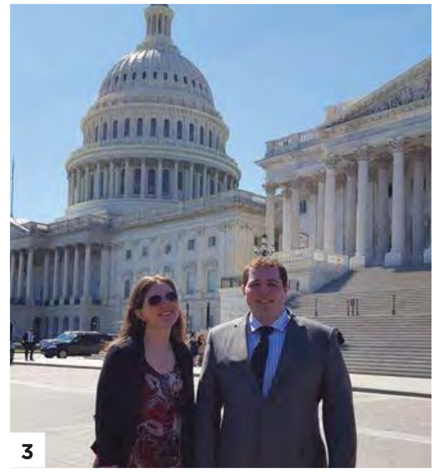
Very Small: **First Place: Delaware,** Christina Larson, membership officer

Small: **First Place: Sydney,** Benjamin Morrell, section chair; **Second Place: Twin Cities,** Kristen Gerzina, section chair; **Third Place: Savannah**, Edward Meyer, section chair

Medium: **First Place: Tucson,** Rajka Corder, membership officer

Large: **First Place: Orange County,** Bob Welge, membership officer; **Second Place: St. Louis,** Nicholas Moffitt, membership officer; **Third Place: San Diego,** Brian Quan, membership officer

Very Large: **First Place: Hampton Roads,** Troy Lake and Marlyn Andino, membership co-chairs; **Second Place: Greater Huntsville,** Brandon Stiltner, section chair; **Third Place: Rocky Mountain,** Marshall Lee, membership officer


3

4

3 **Members of** Team Delaware at Congressional Visits Day 2017

4 **Tucson Kids'** Club participants and their creations with members of the Tucson Section

---

The **Public Policy Award** is presented for stimulating public awareness of the needs of aerospace research and development, particularly on the part of government representatives, and for education section members about the value of public policy activities. The winners are:

Very Small: **First Place: Delaware,** Tim Dominick, public policy officer

Small: **First Place: Twin Cities,** Cristin Finnigan, public policy officer; **Second Place: Savannah,** Suzanne Swaine, section vice-chair

Medium: **First Place: Tucson,** Matthew Angiulo, public policy officer; **Second Place: Long Island,** David Paris, section chair and public policy officer

Large: **First Place: Albuquerque,** Mark Fraser, public policy officer; **Second Place: Cape Canaveral,** Jarvis Hudson, public policy officer; **Third Place: Orange County,** Kamal Shweyk, public policy officer

Very Large: **First Place: Greater Huntsville,** Robert LaBranche, public policy officer; **Second Place: Rocky Mountain,** Tracy Copp, public policy officer; **Third Place: Hampton Roads,** Steven Dunn and Michelle Lynde, public policy officers

---

The **STEM K–12 Award** is presented to sections that have developed and implemented an outstanding STEM K–12 outreach program that provides quality education resources for K–12

5 **Sydney Section** members work with students on the future of planetary exploration

6 **The Orange** County booth supporting STEM activities at the Team America Rocket Challenge

7 **Young Professionals** enjoying the evening at the Tucson Section's YP Social

teachers in the STEM subject areas. The winners are:

Very Small: First Place: Delaware, Elishabet Lato, STEM K–12 outreach officer

Small: First Place: Sydney, Andrew Neely, STEM K–12 outreach officer; **Second Place: Northwest Florida,** Angela Diggs, STEM K–12 outreach officer; **Third Place: Savannah,** Alex Rummel, STEM K–12 outreach officer

Medium: First place: Tucson, Elishka Jepson, STEM K–12 outreach officer and Michelle Rouch, aerospace and societies officer; **Second Place: Southwest Texas,** Joan Labay-Marquez, STEM K–12 outreach officer; **Third Place: Tennessee**, James Burns, STEM K–12 outreach officer

Large: First Place: Orange County, Janet Koepke, STEM K–12 outreach officer; **Second Place: St. Louis**, Robert Dowgwillo, section chair; **Third Place: San Diego,** Ken Kubarych, education officer

Very Large: First Place: Greater Huntsville, Brandon Stiltner, section chair**;** **Second Place: Houston,** Jennifer Wells, section chair; **Third Place: Rocky Mountain,** Susan Janssen, education officer

---

The **Young Professional Activity Award** is presented for excellence in planning and executing events that encourage the participation of the Institute's young professional members, and provide opportunities for leadership at the section, regional, or national level. The winners are:

Very Small: First Place: Delaware, Daniel Nice, young professional officer

Small: First Place: Savannah, Cameron Carson, young professional officer; **Second: Twin Cities**, Nicholas Janak, young professional officer

Medium: First Place: Tucson, Natalie Davila-Rendon, young professional officer

Large: First Place: San Diego, Lindsay Sweeney, young professional officer; **Second Place: Orange County,** Daniel Tompkins, young professional officer

Very Large: First Place: Greater Huntsville, Tamara Statham, young professional officer; **Second Place: Hampton Roads**, Rebecca Stavely, Michelle Lynde, Vanessa Aubuchon, and John Wells, young professional officers; **Third Place: Los Angeles-Las Vegas**, Michael Creech, young professional section officer

---

The **Outstanding Activity Award** allows the Institute to acknowledge sections that held an outstanding activity deserving of additional recognition. The winners are:

Very Small: Delaware, Breanne Sutton, section chair**. Mission: Space.** January 24, 2017 was the largest Mission Space to date for Appoquinimink School District and the first year of participation for the AIAA Delaware Section. What started as Bunker Hill Elementary students' desires to view the skies through a telescope at night has grown to a district-wide event for 4th and 5th grade students, drawing a crowd of approximately 500 participants! The event featured two keynote speakers, including AIAA's own Breanne Sutton. Sutton's talk, titled "It really IS rocket science," gave the audience their first rocket lesson, describing how rockets work, how to make propellant, and designing an effective test program — complete with cool videos, flying balloons, and rockets soaring into the audience. West Virginia University's Robotics team also took the stage. Outside the auditorium, in addition to the telescopes that started the event, the participants could visit ILC Dover's space suit display, make pop bottle rockets, see moon rocks on loan from NASA, go inside an inflatable planetarium, and more. The AIAA Delaware Section along with Orbital ATK hosted a planetary lander station that was so popular that extra tables were set up and a mid-event supply run was needed. The students, parents, and volunteers all had a wonderful time and the section looks forward to participating in this great event again.

Small: **Northern New Jersey,** Raymond Trohanowsky, section chair. **Drone Racing/2017 Civil Air Patrol New Jersey Wing/ Northeast Region Combined Conference**. The AIAA Northern New Jersey Section coordinated this event along with support from the AIAA Southern New Jersey and Greater Philadelphia Sections. Forty-four participants took part in the official races, while many other participants just practiced. There were three 50-minute sessions, and the top two race times were awarded a free drone.

Medium: **Tucson,** Brian Biswell, section chair**. Phoenix ComicCon 17.** Phoenix Comicon is an annual convention celebrating comic books, movies, cosplay, and fandom, and it attracts over 100,000 attendees each year. The section's participation included a display booth, STEM outreach activities, and coordinating a speaker panel. Section members constructed a tabletop wind tunnel to demonstrate the forces of flight and get students interested in aerospace science and activities. Section members also talked to attendees about AIAA STEM programs, handed out educator associate membership forms to interested teachers, and advertised the section's rocket launching sessions. The Tucson Section also hosted two STEM outreach sessions titled *Actually it is Rocket Science!* During the event, students were shown how to construct a rocket from a drinking straw, modeling clay, and cardstock. A model of the inner solar system was setup, with the rocket launcher at the "sun" – participants were challenged to design a rocket that could reach Mars. Each student was given multiple opportunities to fly their rocket, refining the design after each flight test. AIAA STEM information was distributed to interested parents and educators in the audience.

Large: **St. Louis,** Robert Dowgwillo, section chair. **"What's in it for Me?" Recruiting Event.** The dinner meeting focused on getting information into the hands of those interested in joining AIAA. Seven new professional members and one new student member joined the organization during the event. Attendees were given the opportunity to network before and after asking questions of a panel of experienced AIAA members. Each panel member talked about their personal experiences with AIAA. Then the moderator led the panel in answering questions from the audience. The panel covered a wide range of topics: How AIAA can affect your career before your first job and as you begin to develop in the field, how to get involved locally and on national committees, and how encouraging the organization is to women engineers. Two audience members, who happen to be Boeing managers, contributed to the discussion by describing how AIAA added to their career and impacts their hiring process. A dedicated networking session immediately followed the panel discussion. Section Council members were present to answer questions and offer words of encouragement. The evening concluded with two prizes: 1) for the most interesting aerospace-themed hat or shirt, which sparked much conversation during networking, and 2) a door-prize drawing for members who brought non-members to the event.

Very Large (tie): **Greater Huntsville,** Brandon Stiltner, section chair. **Greater Huntsville Section Young Professional Symposium.** Young professionals (YPs) planned a two-day conference with 130 attendees and 30 YPs in the aerospace field presenting their technical work across aerospace specialties. The seven sessions were intentionally diverse across aerospace by including Structures, Modeling and Simulation, and Propulsion Systems. Topics included helicopter maintenance, cubesats, and the Space Launch System. Each session was moderated by one to two senior professionals in the field. Industry and government leaders provided mentorship in the roles of keynote speakers and panelists. These were government executives on both the NASA and DoD side. Section leaders helped the YPs make the needed contacts to request sponsorship and attendance from local government and industry. There was an evening event both nights after the event, which gave YPs the chance to talk to leaders in a more casual setting about career advice and their technical presentation.

Very Large (tie): **Houston**, Jennifer Wells, section chair. **Diversity Panel Dinner Event**. This diversity panel highlighted many of the disciplines and ways to collaborate better in a more innovative and inclusive environment that we have as a diverse aerospace workforce. The fields represented by the panelists included Architecture, Psychology, Law, Education, and Journalism/Public Relations. This event garnered significant positive feedback from section members, EC members, community members, guests invited by attendees, and the panel members themselves. Many people who were unable to attend due to conflicts requested more events of a similar nature in the future.


TONY WILSON
"Brick"

AIAA Foundation Presents Graduate and Undergraduate Awards

The AIAA Foundation annually awards financial aid to graduate and undergraduate students in science or engineering programs related to aerospace. Its graduate scholarship program presents awards to graduate students doing excellent research in the air and space sciences. The Foundation also offers scholarships to college sophomores, juniors, and seniors each year, and recipients can apply to renew their scholarships annually until they graduate.

Graduate Awards for the 2017–2018 Academic Year

Each year the AIAA Foundation presents the Orville and Wilbur Wright Graduate Awards. These $5,000 awards, given in memory of the Wright brothers' contributions to the evolution of flight, honor full-time graduate students. The winners are:

- **Alexandra Long**, Georgia Institute of Technology, Atlanta, Georgia
- **Sarah Cusson**, University of Michigan, Ann Arbor, Michigan

In addition, **Julia CrowleyFaranga**, Purdue University, West Lafayette, Indiana, received the Neil Armstrong Graduate Award. This $5,000 award honors the character and achievements of the late astronaut, military pilot and educator, Neil A. Armstrong.

The AIAA Foundation also presented the John Leland Atwood Graduate Award to **Thibaud Teil**, University of Colorado, Boulder, Colorado. Established in 1999, the $1,250 award, sponsored by endowments from Rockwell and what is now The Boeing Company and named in memory of John Leland "Lee" Atwood, former chief executive officer of Rockwell, North America, recognizes a student actively engaged in research in the areas covered by the technical committees (TC) of AIAA.

Three AIAA TCs also presented graduate awards:

- **Arthur Brown**, Massachusetts Institute of Technology, Cambridge, Massachusetts, received the General Aviation Systems TC's $1,000 William T. Piper Sr. General Aviation Systems Graduate Award.
- **Utku Eren**, University of Washington, Seattle, Washington, received the Guidance, Navigation, and Control (GNC) TC's $2,500 GNC Graduate Award.
- **Cody Allard**, University of Colorado, Boulder, Colorado, received the Modeling and Simulation TC's $3,500 Luis de Florez Graduate Award.

Undergraduate Scholarships for the 2017–2018 Academic Year

The AIAA Foundation have awarded ten AIAA Foundation undergraduate scholarships for the 2017–2018 academic year.

The $5,000 David and Catherine Thompson Space Technology Scholarship, named for and endowed by former AIAA President David Thompson, chairman, chief executive officer, and president of Orbital ATK, Dulles, Virginia, and his wife Catherine, was presented to **Deborah Jackson**, Embry-Riddle Aeronautical University, Prescott, Arizona.

The $5,000 Vicki and George Muellner Scholarship for Aerospace Engineering, named for and endowed by former AIAA President Lt. Gen. George Muellner, U.S. Air Force (retired) and president of advanced systems for Boeing Integrated Defense Systems (retired), and his wife Vicki, was presented to **Bindi Nagda**, Florida Institute of Technology, Melbourne, Florida.

The $5,000 Wernher von Braun Scholarship, named in honor of German rocketeer and founder of the U.S. space program, Wernher von Braun, was presented to **Trupti Mahendrakar**, Embry-Riddle Aeronautical University, Prescott, Arizona.

The $1,500 Leatrice Gregory Pendray Scholarship, awarded to the Foundation's top female scholarship applicant, was presented to **EliseAnn Koskelo**, Pomona College, Claremont, California.

Six AIAA Foundation scholarships were presented by AIAA Technical Committees (TC) to students performing research in the TC's area:

- The Liquid Propulsion TC presented a $2,500 scholarship to **Samantha Cendro**, University of Southern California, Los Angeles, California.
- The Space Transportation TC presented a $1,500 scholarship to **Sean Devey**, University of Alabama, Tuscaloosa, Alabama.

The Digital Avionics TC presented four scholarships of $2,000 each:

- The Dr. James Rankin Digital Avionics Scholarship was presented to **Lorenzo Novoa**, University of Texas at Arlington, Arlington, Texas.
- The Dr. Amy R. Pritchett Digital Avionics Scholarship was presented to **Stephen Scheuerle**, North Carolina State University, Raleigh, North Carolina.
- The Ellis F. Hitt Digital Avionics Scholarship was presented to **Scott Jarriel**, Colorado School of Mines, Golden, Colorado.
- The Cary Spitzer Digital Avionics Scholarship was presented to **Diane Nguyen**, University of Virginia, Charlottesville, Virginia.

For more information on the AIAA Foundation Graduate Awards and Undergraduate Scholarship Program, please contact Felicia Livingston at felicial@aiaa.org or 703.264.7502. Join us as we continue to inspire teachers and students. For more information and to donate, please visit www.aiaafoundation.org.

AIAA Scholarships and Graduate Awards site is now accepting applications for the 2018–2019 academic year. The application deadline is 31 January 2018. For more information, visit us online: www.aiaa.org/scholarships.

ASAT 2017 — Building a Unique Aerospace Tradition in Southern California

by Dr. Amir S. Gohardani, *Chair, AIAA Orange County Section*

The AIAA Orange County (OC) Section recently hosted the 14th annual AIAA Southern California Aerospace Systems and Technology (ASAT) Conference and Banquet on 13 May. Building on more than a decade-long tradition, this conference brought together Southern California engineers, educators, researchers, students, leaders, and enthusiasts for the fourteenth year in a row. The one-day program consisted of 31 presentations in a number of parallel tracks both in the morning and afternoon sessions. Each session was initiated by a prominent keynote speaker. The 2017 ASAT keynote speakers were: P**rof. George Bibel**, University of North Dakota with his talk Beyond the Black Box: The Forensics of Airplane Crashes, and **Dennis R. Jenkins**, Project Director, Samuel Oschin Air and Space Center, California Science Center Foundation with his talk Preparing the Final Mission of Space Shuttle Endeavor. The banquet speaker was **Michael S. Staab**, Spacecraft System Engineer/Flight Director, Mars Exploration Rover Mission, NASA Jet Propulsion Laboratory, with his talk on Perspectives from Saturn: Cassini's Two-Decade Exploration of the Ringed Planet.

Similar to past years, ASAT 2017 accepted unclassified presentations on all aspects of aerospace systems, technology, vehicle design, program management, policy, economics and education and was structured in three major categories:

1

2

3

4

5

6


7


8


9

• Aircraft Systems and Technology
• Space Systems and Technology
• Aerospace Public Policy and Education

The banquet, which immediately followed the conference, included an overview of section activities for the year and presentation of awards. Lotfi El-Bayoumy, AIAA OC Section's Honors & Awards officer, recognized the following individuals:

• **2017 Engineers of the Year:** Cody Gruebele (The Boeing Company) and Steve Butscher (The Boeing Company)

• **2017 Young Professionals of the Year:** Luis Duckworth (The Boeing Company) and Shaun Detloff (The Boeing Company)

• **2017 Student of the Year:** Colin Sledge (University of California, Irvine)

• **2017 Leadership Award:** Donald G. Brown (The Boeing Company)

For the third year, the Gohardani Presentation Award in Aeronautics and Aerospace was also presented to two of the most thought-provoking and exceptional all-around presentations delivered during the ASAT conference, based on: content, reasoning, organization, timing, management, style, clarity, interactivity, engagement with the audience, and an overall feedback. The annual award is presented in two categories: a Junior Category and a Senior Category, based on experience and expertise in aeronautics and aerospace. Sponsored by the Springs of Dreams Corporation, a nonprofit organization, each of these awards includes a monetary prize and a certificate. The 2017 Gohardani Presentation Award in Aeronautics and Aerospace (Junior Category) was presented to Nima Mohseni (University of California, Irvine) and Areg Hunanyan (University of California, Irvine), while the award in the Senior Category was presented to Dr. Thomas P. Barrera (LIB-X Consulting).

The 2017 ASAT conference marked another successful coordination and planning event by John Rose, and Dino Roman, co-chairs of this successful event.

1 **Michael S. Staab**, the AIAA OC Section's ASAT 2017 banquet dinner speaker

2 Lotfi El-Bayoumy (left) with **Cody Gruebele**

3 Lotfi El-Bayoumy (left) with **Steve Butscher**

4 Lotfi El-Bayoumy (left) with **Luis Duckworth**

5 Lotfi El-Bayoumy (left) with **Shaun Detloff**

6 Lotfi El-Bayoumy (left) with **Colin Sledge**

7 Lotfi El-Bayoumy (left) with **Donald G. Brown**

8 The 2017 Gohardani Presentation Award (Junior Category): **Dr. Omid Gohardani (left), Nima Mohseni, and Dr. Amir S. Gohardani (right)**

9 The 2017 Gohardani Presentation Award (Senior Category): **Dr. Omid Gohardani (left), Dr. Thomas P. Barrera, and Dr. Amir S. Gohardani (right)**

News

AIAA Delaware Section Hosts Cecil County STEM Academy

The K–12 STEM Outreach Committee would like to recognize outstanding STEM events in each section. Each month we will highlight an outstanding K–12 STEM activity; if your section would like to be featured, please contact Elishka Jepson (elishka.jepson@raytheon.com).

On 21 June 2016, the AIAA Delaware Section hosted seventeen students from various Cecil County high schools for a site visit at Orbital ATK in Elkton, MD. The students were visiting as part of Cecil County's STEM Academy, a two-day program where incoming high school sophomores visit local companies to see the variety of careers available with a STEM degree. AIAA Delaware Section members Chrissy Grasso, Eric Rohrbaugh, and Anthony LoRusso taught the students about Orbital ATK, the paths to becoming an engineer, the engineering process, and about rocket design and production.

Placed in teams, the students were challenged to build a straw rocket using the engineering process. Their task was to hit a target area with their straw rocket successfully and repeatedly. They consulted with local subject-matter experts in propulsion, structures, and materials. Many creative designs were built and tested, with one team nailing the target in the middle of the box, earning themselves bonus points and securing the win.

The students enjoyed the challenge and thanked the AIAA Delaware Section for welcoming them to Orbital ATK to show them the assortment of careers that are available with a STEM degree, especially within one facility. As the students continue their journey through the STEM Academy, they'll start working on an independent research or design project during their junior year. For those who have an interest in aerospace, some of the same engineers who helped them design their rocket today will return as individual mentors.

CALL FOR NOMINATIONS

AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award

Nominations are currently being accepted for the 2018 AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award. The recipient will receive a certificate and a $7,500 honorarium.

This award is jointly sponsored by the American Institute of Aeronautics and Astronautics (AIAA), the American Association of Airport Executives (AAAE), and the Airport Consultants Council (ACC).

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

Please go to **www.aiaa.org/speasaward** for further information or to download the nomination form. Presentation of the award will be made at the AAAE/ACC Planning, Design, and Construction Symposium, scheduled for February 2018.

DEADLINE for submission of nominations is 1 November 2017.
CONTACT: AIAA Honors and Awards Program • awards@aiaa.org

www.aiaa.org/speasaward

17-2051

Obituaries

AIAA Fellow Muntz Died in August

Eric Phillip Muntz died on 1 August. He was 83 years old.

Professor Muntz received his B.S. in Aeronautical Engineering (1956) and his M.S. (1957) and Ph.D. (1961) from the University of Toronto, Canada.

He joined the Department of Aerospace Engineering at the University of Southern California in 1969 and was promoted to Professor in 1971. Professor Muntz served as Department Chair for the Aerospace Engineering Department from 1992 to 1998 and oversaw the merging of the Aerospace Department with the Mechanical Engineering Department as the combined Department Chair from 2000 to 2003. He held the appointment as the A.B. Freeman Professor of Engineering from 2004 until he retired in May 2014.

Professor Muntz's research made seminal contributions to experimental aerodynamics with his development of electron beam fluorescence techniques. He also made important contributions to x-ray diagnostics applied to radiology. He was the holder or co-holder of over 25 patents.

Professor Muntz was elected to the National Academy of Engineering in 1993 and, in addition to being an AIAA Fellow, was elected a Fellow of the American Physical Society (1994). He was recognized with the 1987 AIAA Aerospace Contribution to Society Award: "For twenty-five years of achieving the effective incorporation of the technology dimension into government policy decisions to maintain our technological strength and lead to a better and safer world."

AIAA Associate Fellow Christensen Died in September

David L. Christensen died on 1 September. He was 85 years old.

Mr. Christensen was an aerospace consultant with over 60 years of experience in the design, development, and operations of aircraft, missiles, space vehicles, space payloads, and renewable energy systems. He began work at the White Sands Proving Grounds in 1953, and he joined the von Braun rocket team at the Army Ballistic Missile Agency in 1956, working on liquid rocket propulsion systems for the Redstone, Jupiter and Saturn rockets and was project engineer for the Saturn H-1 rocket engine.

In 1960 Mr. Christensen started his own consulting firm that provided technical and management support for major aerospace firms. He also provided contractual support services for the Saturn-Apollo Program.

Mr. Christensen was a senior research associate and director of Alternate Energy Research at the University of Alabama in Huntsville from 1967 to 1980, where he directed historical, environmental, renewable energy and space-related research programs. Beginning in 1980, he held technical management and business development positions at Wyle Laboratories, United Technologies and Lockheed Martin and was directly involved in many major aerospace projects.

From 1996 until his retirement in 2014, Mr. Christensen was senior staff engineer and manager of Business Development for Lockheed Martin Astronautics Division in Huntsville. He was the project lead for liquid rocket engines and propulsion system integration on the Liquid Fly Back Booster considered by NASA for replacement of the Solid Rocket Boosters on the Space Shuttle, and program manager (the team included members of the Lockheed "Skunk Works") for a D-21 Drone modification study, funded by NASA to develop a reusable Mach 6 flight test-bed using combined cycle rocket/ramjet engines needed for our future transportation systems. He was also the Lockheed Martin Team Lead on a NASA-funded task to design a "clean sheet" reusable space vehicle.

After his retirement, Mr. Christensen supported the UAH space program archives development and propulsion research activities. As a consultant, he performed peer reviews of internal space exploration proposals for NASA Headquarters and also performed research studies for Bigelow Aerospace to assess design concepts for inflatable structures used as habitats in orbit and on the surface of the moon and Mars. In October 2010, he accepted the Wernher von Braun Award for Community Service presented by the National Space Club of Huntsville. He was a longtime member of the Experimental Aircraft Association and a member of AIAA for over 50 years.

Technical Committee Nominations Are Due 1 November!

Membership nominations are open for AIAA Technical Committees (TC) for 2018/2019. Nominations are submitted online on the AIAA website at www.aiaa.org, under My AIAA, Nominations and Voting, Technical Committee Online Nomination. If you have any questions, please contact Karen Berry, 703.264.7537.

University of Nevada, Reno

Aerospace Engineering Program Director Opening

The University of Nevada, Reno (UNR) invites applications for the founding Aerospace Program Director within the Mechanical Engineering Department. Mechanical Engineering is one of five departments in the College of Engineering. It has recently grown to 18 tenured and tenure-track faculty positions, 4.5 full-time lecturers, and 1 research faculty member. The Department offers B.S., M.S., and Ph.D. degrees in Mechanical Engineering, is ABET accredited, and has approximately 750 undergraduate and 40 graduate students. It places emphasis on pursuing nationally-competitive grants, publishing in reputable journals, increasing its Doctoral program, enhancing its collaboration with industry, and providing national professional service. For more information about the department please visit http://www.unr.edu/me/.

The Department seeks candidates with strong leadership capability and commitment to developing new Aerospace Engineering undergraduate and graduate programs within the Department.

Required Qualifications: The successful candidate must hold an earned doctorate in Aerospace or Mechanical Engineering, or a closely related field. The candidate must have a proven record of professional and academic leadership, a distinguished national and international reputation in research, significant experience in innovative undergraduate and graduate education and student engagement, and qualifications consistent with a tenured appointment at the rank of full professor. The successful candidate will be expected to maintain an active sponsored research program and work with the faculty to initiate and develop the Aerospace Engineering programs.

Applications must be submitted online at: https://www.unrsearch.com/postings/25795. Review of applications will begin on December 1, 2017, and will continue until the position is filled. The position is available effective July 1, 2018. Salary, benefits, and startup package will be highly competitive. To support the Department's growth, a $14 million renovation of the Mechanical Engineering building was completed in August 2017. The renovation increased the buildings usable space by 3,100 sq.ft., and enhanced its instructional, office, administration, manufacturing and experimental/computational research facilities. It will also allow the Department to develop its planned Aerospace Engineering research and educational programs. Thanks to substantial growth in both student enrollment and tenure-track faculty positions, the College of Engineering has received funding to construct a new engineering building, scheduled to be completed in 2020. The new engineering building provides both additional space needed by the College and the modern facilities capable of supporting high-tech research and laboratory space. This building will allow the College to pursue its strategic vision, serve Nevada and the nation, and educate future generations of engineering professionals. Reno is on the eastern slope of the Sierra Nevada Mountains, and is recognized as a world class outdoor recreational area. It is 45 minutes from Lake Tahoe and 4 hours from San Francisco. Several famous winter resorts and hundreds of hiking and mountain biking trails surround the area. Yosemite National Park, the Black Rock Desert, Sacramento and Napa/Sonoma are all within driving distance. The Reno metropolitan area has a population of 425,000, and is served by an international airport. The University of Nevada, Reno recognizes that diversity promotes excellence in education and research. We are an inclusive and engaged community and recognize the added value that students, faculty, and staff from different backgrounds bring to the educational experience.

EEO/AA Women, under-represented groups, individuals with disabilities, and veterans are encouraged to apply.

Contact: Dr. Eric Wang
Mechanical Engineering/MS-312,
University of Nevada, Reno, Reno, NV 89557
Tel: (775) 784-6094
E-mail: elwang@unr.edu

DEPARTMENT OF AEROSPACE ENGINEERING - Open Rank Faculty Search

College of Engineering

University of Illinois at Urbana-Champaign

The Department of Aerospace Engineering at the University of Illinois at Urbana-Champaign seeks highly qualified candidates for multiple faculty positions in all areas of aerospace engineering, with emphasis on the areas of aerospace robotics/unmanned aerial systems, experimental hypersonics, and applied aerodynamics/aerospace vehicle design. Preference will be given to qualified candidates working in emerging areas of aerospace engineering whose scholarly activities have high impact. Please visit **http://jobs.illinois.edu** to view the complete position announcement and application instructions. Full consideration will be given to applications received by **November 15, 2017**. Applications received after that date may be considered until the positions are filled.

The University of Illinois conducts criminal background checks on all job candidates upon acceptance of a contingent offer.

The University of Illinois is an Equal Opportunity, Affirmative Action employer. Minorities, women, veterans and individuals with disabilities are encouraged to apply. For more information, visit http://go.illinois.edu/EEO. To learn more about the University's commitment to diversity, please visit http://www.inclusiveillinois.illinois.edu.

AEROSPACE ENGINEERING
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

THE UNIVERSITY OF ARIZONA
COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

DEPARTMENT HEAD

UA DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

We seek an engaging and articulate leader to guide this successful department as it secures additional faculty appointments and expands and enhances its undergraduate and graduate programs, research impact and visibility, and industrial partnerships.

The successful candidate will have a proven record of transparent, collaborative and effective strategic planning, communication and resource management. A distinguished record of achievement in scholarship, research and/or professional practice commensurate with an appointment at the rank of professor with tenure is required. Full posting (#F20856) and application instructions are at **https://uacareers.com/postings/16156.**

The department is dedicated to innovative interdisciplinary research and teaching in both aerospace and mechanical engineering. The department's research specialties include active flow control, aerospace guidance navigation and control, astrodynamics, biomechanics, computational and experimental fluid and solid mechanics, mechatronics, multibody dynamics, nanotechnology and renewable energy.

Research at the University of Arizona is strongly multidisciplinary and the department works extensively with, among others, the UA Department of Planetary Sciences, Arizona Health Sciences Center, BIO5 Institute for Collaborative Bioresearch, College of Optical Sciences and the Program in Applied Mathematics, all of which enjoy international recognition as centers for world-class academic programs and research.

The University of Arizona is located in Tucson, which has a vibrant, multicultural community – in 2016 UNESCO named it a World City of Gastronomy – and is home to a thriving industrial sector that includes Raytheon, Rincon Research, Paragon Space Development and Vector Space Systems.

1917

Oct. 1 The U.S. Army establishes a board to review the applications of American members of the Lafayette Flying Corps to transfer from their current French squadrons into the U.S. Army Air Service. These combat veterans provide much needed experience and expertise to the new squadrons of Americans about to enter combat. Ninety transfers are approved. David Baker, **Flight and Flying: A Chronology**, p. 102.

Oct. 20 The Junkers-Fokker Werke A.G. is formed, combining the assets of Hugo Junkers and Anthony Fokker into one company. While the company does not last long, it is widely believed that the thick cantilevered wing that was soon to grace the exceptional Fokker D.VII fighter was a direct result of the merger. Junkers pioneered both the cantilevered design and the thick wing, which produced superior lift and handling at altitude. David Baker, **Flight and Flying: A Chronology**, p. 103.

1942

Oct. 1 A Bell XP-59A Airacomet achieves the first U.S. jet-propelled aircraft flight, at Muroc Dry Lake, California. Piloted by Robert Stanley, the craft is powered by two I-16 engines developed at General Electric from the British design by Frank Whittle. E.M. Emme, ed., **Aeronautics and Astronautics 1915-60**, p. 44.

Oct. 3 The 5.5-ton A-4 rocket, later known as the V-2, makes its first flight from the Peenemunde rocket center in Germany. It travels 118 miles and reaches an altitude of about 158,400 feet and speed of 5,633 kilometers per hour. It is the first time a rocket reaches the fringes of space and is said to mark the start of the rocket age. W.R. Dornberger, **V-2**, pp. 1-18.

Oct. 9 The first U.S. bombing mission from the U.K. is made against steel and engineering works at Lille in occupied France. One hundred bombers, including B-24s and B-17s, participate. K.C. Carter and R. Mueller, **The Army Air Forces in World War II**, p. 47.

Oct. 22 The Navy authorizes Westinghouse Electric to construct two 19A axial-flow turbojet engines. This begins the development of the first practical jet engine of wholly American design. **United States Naval Aviation 1910-1980**, p. 119.

Oct. 24 Smithsonian Secretary Charles Abbot settles the Wright-Langley debate over who originated sustained manned flight. The controversy has raged since 1914, when Glenn Curtiss flew Samuel Langley's heavily redesigned 1903 Aerodrome. Langley's original Aerodrome failed to fly in 1903, just before the Wright brothers made their flight at Kitty Hawk, North Carolina. Langley, the Smithsonian secretary at that time, had his plane exhibited at the Smithsonian with a label claiming his original was capable of controlled manned flight. Because of this, Orville Wright did not permit the Wright Flyer to be exhibited there. Abbot now admits that the 1914 model had too many modifications to justify Langley's claims. M.D. Keller, **Fifty Years of Flight Research**, p. 53; **Flight**, Nov. 19, 1942, p. 562.

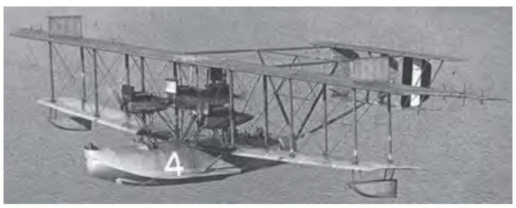
1967

Oct. 3 U.S. Air Force Maj. William Knight achieves the fastest flight in an X-15 to date when he takes X-15 No. 2 to Mach 6.7 (7,796 kilometers/hour) and 90,000 feet. This is a winged-aircraft world flight record that still stands. This flight also tests a Martin Co. ablative coating and checks the stability and control of a dummy ramjet. Knight had set the previous record for the X-15 on Nov. 18, 1966, when he reached Mach 6.33. Dennis Jenkins, **X-15 — Extending the Frontiers of Flight**, pp. 652, 655.

Oct. 3 The Soviet Union sends the Molniya I-6 communications satellite into orbit. The satellite relays TV signals from the Soviet Far East to Moscow and Paris. It is the sixth in Russia's Orbita network. The Russian news agency Tass reports that the satellite will also relay TV, radio, telephone and telegraph messages and form part of a new TV network scheduled to be in operation by the 50th anniversary of the Bolshevik Revolution on Nov. 7. **New York Times**, Oct. 4, 1967, p. 3.

Oct. 4 This date marks the 10th anniversary of the Space Age that began with the orbiting of the 83.4-kilogram Sputnik 1 satellite on Oct. 4, 1957. During the first decade of the Space Age, 803 satellites were launched. Of these, 529 were by the U.S., 269 by the USSR, four by France, and one by Italy. The U.S. total includes 14 manned orbital space flights while the USSR total amounts to nine manned orbital flights. During this time, there were also five soft landings on the moon that provided high-quality photos and on-site analyses of the lunar surface. Some 24 planetary flights produced close-up photos of Mars and atmospheric data on Venus. Anatoli Blaganravov, chairman of the Soviet Commission for Exploration and Use of Outer Space, comments on the first decade of space flight when he writes in an Associated Press article: "The Space Era is not a chance-phenomenon in the development of natural sciences. It is a legitimate and indispensable stage in the history of development of human society." U.S. Congress, **Report of the House Committee on Science and Astronautics,** 1967, passim; **Washington Star**, Oct. 1, 1967, p. C3.

Oct. 4 A static launch of a U.S. Air Force-General Dynamics F-111 crew escape module is tested on the Air Force's Missile Development Center rocket sled track at Holloman Air Force Base, New Mexico. The test is made on a motionless rocket sled and is blasted to an altitude of about 295 feet by a small solid-fuel rocket motor. **Aviation Week**, Oct. 16, 1967, p. 73.

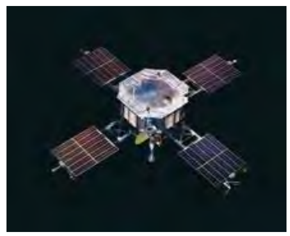


Oct. 10 Retired U.S. Rear Adm. Albert Read, who in 1919 commanded the Navy Curtiss NC-4 flying boat that, with a crew of five, became the first aircraft to cross the Atlantic, dies in Miami at age 80. Read's historic flight was a couple of weeks before the nonstop trans-Atlantic flight of John Alcock and Arthur Brown and eight years before Charles Lindbergh's nonstop solo trans-Atlantic flight. The NC-4 flight took 42 hours, three minutes over 23 days by way of the Azores. **Aviation Week**, Oct. 16, 1967, p. 34.

Oct. 17 A facsimile of the Daily Express newspaper front page is transmitted by an Early Bird satellite to Puerto Rico for republication in the newspaper El Mundo, published in the capital of Puerto Rico, San Juan. **Flight International**, Oct. 27, 1967, p. 701.

Oct. 18 The USSR's Venera 4 spacecraft, launched on June 12, enters Venus' atmosphere and ejects an instrumented capsule for landing on the planet. During its descent, it transmits data on Venus' intense atmospheric pressures and high temperature ranges as well as on the composition of its atmosphere, which is found to be largely carbon dioxide. After aerodynamic braking and automatic parachute deployment, the capsule lands on Venus but stops functioning. Western observers doubt the transmissions continue after the landing, especially since Venera 3–6 probes were not built to withstand the extreme pressures at the Venusian surface. Nonetheless, this mission is considered the first probe to perform in-place analysis of the environment of a planet other than Earth. **New York Times**, Oct. 19, 1967, p. A3.

Oct. 18 NASA launches its Orbiting Solar Observatory 4 by a Thor Delta from Cape Kennedy, Florida. Carrying nine scientific experiments, the OSO spacecraft is designed to study radiation from solar flares in support of manned space flight and to aid in weather forecasts. **Aviation Week**, Oct. 30, 1967, p. 26.

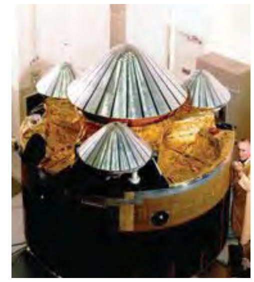


Oct. 19 NASA's Mariner 5 space probe makes a flyby of Venus to obtain scientific data on the nature and origin of the planet. Launched on June 14, the Mariner 5 makes its closest approach at 4,094 kilometers. Among other data, the spacecraft measures the planet's mass, electron density and other radiations. Following its return to cruise mode, Mariner 5 reports on interplanetary space weather. **New York Times**, Oct. 22, 1967, p. 12.

Oct. 30 Two unmanned Soviet spacecraft, Cosmos 186 and Cosmos 188, make the first fully automatic space docking. Each craft undertakes a mutual search, approach, mooring and docking. After 3.5 hours of a joint flight, the satellites separate on a command sent from Earth and continue to orbit separately. TV cameras onboard both satellites film the docking. The spacecraft make soft landings in a region of the USSR. Cosmos 186 lands on Oct. 31, and Cosmos 188 on Nov. 2. However, one of the vehicles is destroyed by its emergency destruction system. **New York Times**, Oct. 30, 1967, p. 54; **Flight International**, Nov. 9, 1967, p. 779.

And during October 1967
The first of three Lunar Landing Training Vehicles, developed and built by Textron's Bell Aerosystems Co. to help train Project Apollo astronauts to maneuver and land the Lunar Excursion Module on the surface of the moon, is delivered to NASA. **Flight International**, Dec. 21, 1967, p. 1046.

1992

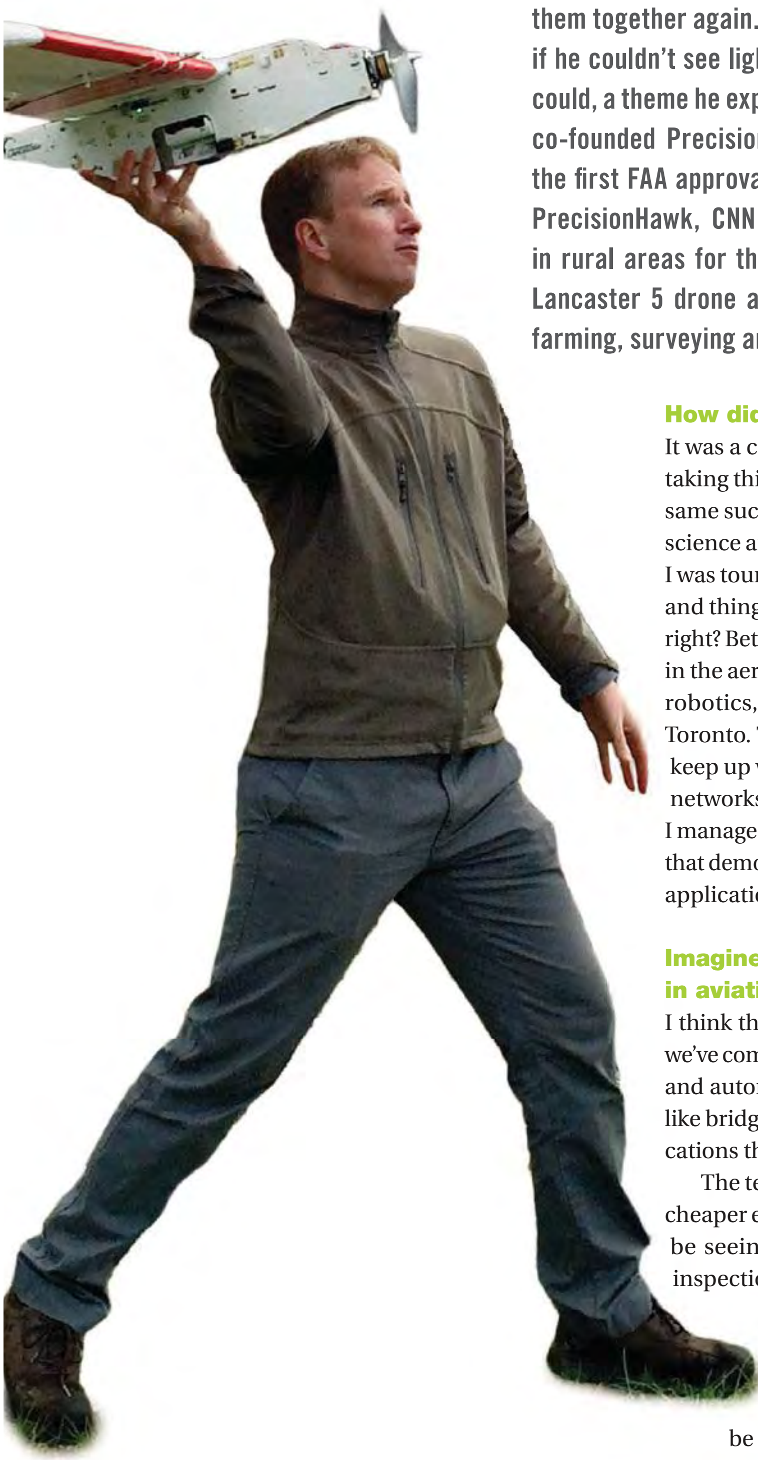


Oct. 3 After orbiting Venus for 14 years, the Pioneer Venus spacecraft consumes the last of its propellant. During its career, the craft's radar maps 90 percent of Venus' surface. The spacecraft worked perfectly although it was designed to last only 15 months. NASA, **Astronautics and Aeronautics, 1991-1995**, p. 258.

Oct. 12 SETI, or the Search for Extraterrestrial Intelligence, is started by NASA as a $100 million, 10-year project in which giant radio telescopes are to search for signs of intelligent life from target areas of 1,000 nearby stars. However, Congress canceled the program less than a year later. Among the contributors to the undertaking is author and futurist Arthur C. Clarke, above, through the British Interplanetary Society. The program commemorates the 500th anniversary of the landing of Columbus in the Western Hemisphere. NASA, **Astronautics and Aeronautics, 1991-1995**, p. 263.

ERNEST EARON, 41

Co-founder of and chief technology officer at PrecisionHawk



Growing up near Toronto, Ernest Earon was always taking things apart and putting them together again. Drawn to engineering, he became enthralled by the notion that if he couldn't see light enter a black hole or watch stars form, intelligent machines could, a theme he explored in his University of Toronto doctoral thesis. In 2010, Earon co-founded PrecisionHawk of Raleigh, North Carolina, a firm notable for winning the first FAA approval (August 2016) to fly drones beyond an operator's sight. Now, PrecisionHawk, CNN and BNSF Railway are testing commercial drone operations in rural areas for the FAA. PrecisionHawk sells the fixed-wing 15-meter-wingspan Lancaster 5 drone as well as quadcopters and six-rotor models for construction, farming, surveying and remote sensing.

How did you become an aerospace engineer?

It was a combination of things. I have always been extremely curious, always taking things apart and putting them together again (though not nearly at the same success rate) even from a young age. I was very comfortable with math, science and physics and so I knew that engineering was a good option for me. I was touring university with some friends when I got introduced to aerospace and things just clicked from there. I mean, every kid loves planes and rockets, right? Between that and the fact there are so many ways that we are still learning in the aerospace field, it was a pretty good fit. I went to do a Ph.D. in planetary robotics, machine learning and artificial intelligence at the University of Toronto. Then, I started moving into the terrestrial space. I've been trying to keep up with technology ever since. I managed research and development of networks of intelligent unmanned aircraft for Quanser Consulting. After that, I managed a project at the University of Toronto Institute for Aerospace Studies that demonstrated the use of multiple unmanned robotic aircraft for agricultural applications. I founded PrecisionHawk in 2010.

Imagine the world in 2050. What do you think will be happening in aviation?

I think that while the basics of the [drone] technology will be similar to what we've come to expect now, their use and ubiquity will be world-changing. Drones and autonomous flying machines will be used everywhere from applications like bridge inspection and delivery that we are aware of now, through to applications that we haven't even begun to contemplate yet.

The technology will move people as well as goods around. With better and cheaper electronics, computers, batteries, materials and manufacturing, we'll be seeing personal aircraft everywhere alongside flying delivery, repair, inspection, herding and monitoring drones.

All of this will turn the airspace, and the regulatory environment around it, on its head. Conveniently, people are starting to think about that now. So while I think there will be huge changes and disruption for the better across multiple industries as well as aerospace, it will be as chaotic as it often is with these kinds of innovations. ★

By Debra Werner | werner.debra@gmail.com