March 2016

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A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

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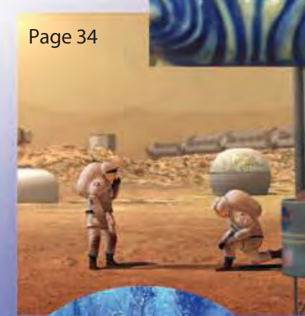

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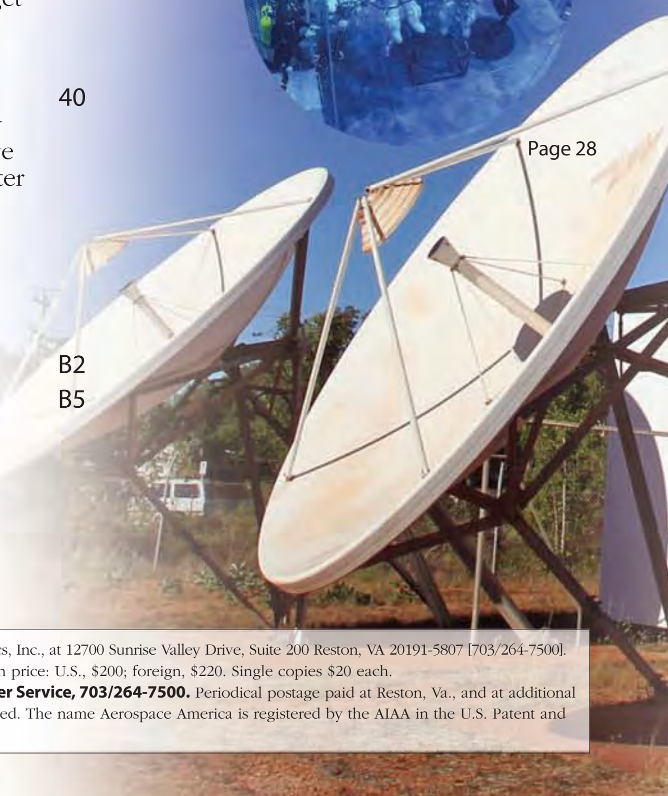

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ON THE COVER
The Intelsat 29e satellite being prepared for its January 27 launch.
Image credit: Boeing

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 address above, attention AIAA Customer Service, 703/264-7500.** Periodical postage paid at Reston, Va., and at additional mailing offices.

40,000 copies of this issue printed. This is Volume 54, No. 3.

AEROSPACE AMERICA

is a publication of the American Institute of Aeronautics and Astronautics

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March 2016, Vol. 54, No. 3

AIAA
Shaping the Future of Aerospace

Editor's Notebook

Why flight tracking is not enough

The air transportation community is edging closer to being able to track airliners no matter where they might be around the globe. As important as that tracking capability will be, it won't completely solve the problem we saw in the disappearance of Malaysia Airlines Flight 370 two years ago this month.

What authorities need is the ability to know in near real time what is happening aboard a stricken aircraft. The air transportation industry could then respond proactively and avoid the spectacle of crash investigators scouring the ocean floor for cockpit voice and flight data recorders and being unable to say much about the cause of the accident until the recorders are found and analyzed. That silence could leave a deadly mechanical flaw unresolved for months or years, in addition to exacerbating the anxiety of family members.

The article on page 28, "Faceoff over airliner tracking," discusses some of the hurdles to real-time streaming of data and audio as the next steps beyond tracking. Those hurdles must be crossed if the air industry is to join the networked age we are so accustomed to in other areas of our lives.

It's worth noting that the air transport industry isn't the only vast, sprawling community that has faced a transition like this. The U.S. military at the start of the wars in Afghanistan and Iraq regularly discerned the locations of suspicious vehicles. That trove of geospatial knowledge was often more frustrating than useful. What planners and troops really needed to know was the intent of the occupants of those vehicles.

The military figured out how to rapidly join signals and communications intelligence together with the coordinates of a target to form geospatial intelligence, meaning information that could improve targeting or prevent deadly mistakes.

The air transportation community is at the geospatial-knowledge phase. It usually knows where its airliners are, and it's about to take that capability worldwide. Next it needs the equivalent of geospatial intelligence. Streaming data from aircraft is the answer, but just as with any innovation, that won't be easy. Numerous issues beyond technology will need to be resolved. Costs must be covered, for one. Privacy questions must be addressed and cultural preferences probably need to be shifted.

The question of how to avoid overwhelming the bandwidth of safety-of-life communications is a big obstacle, but probably not an insurmountable one. Perhaps the airliner crew could be empowered to turn on real-time streaming in an emergency, or maybe a sudden change in an aircraft's course or altitude could trigger automatic streaming. On the ground, after all, we don't stream data continuously to the firehouse in case we ever have an emergency. We dial 911. We might even put the phone down and stay quiet, so the operator can hear what's going on and alert first responders. Perhaps the equivalent could be instituted for air transportation. Once satellite Internet becomes the norm aboard airliners, maybe these commercial services could be leveraged in an emergency, too.

There is no doubt in my mind that 21st century connectivity will be accomplished by the air transportation industry. The only question is whether this change will come in time to avoid the next MH370.

Ben Iannotta
Editor-in-Chief


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U.S. Army wants ideas for hypersonic control

The Advanced Hypersonic Weapon demonstrator lifts off from Kauai, Hawaii in 2011 on its first flight. The Pentagon is researching ways to control a hypersonic glider traveling at speeds over Mach 18.

U.S. Army

Hypersonic vehicles are hot, and not just in the literal sense that they generate tremendous heat as they streak through the sky at high Mach numbers. Hypersonic craft are a hot research topic in the U.S. Army and at the Pentagon because of the immense possibilities offered by a vehicle that can streak toward a target at speeds over Mach 18.

So far, the Army has flight tested technologies that could someday lead to an Advanced Hypersonic Weapon, a proposed hypersonic glider that is part of the Pentagon's Prompt Global Strike program, which calls for a conventional weapon that can hit any target on Earth within 60 minutes. Those tests have highlighted the question of how to control a vehicle blazing through the atmosphere at such high speeds. The service wants help with that question and has issued an Army Small Business Innovation Research solicitation seeking innovative ideas for controlling hypersonic vehicles. Responses were due in February.

The testing record explains the need for innovation. A 2011 test of DARPA's Falcon Hypersonic Technology Vehicle 2, or HTV-2, initially went well. After being boosted atop a Minotaur 4 rocket, it reached a speed of Mach 20 (24,501 kilometers per hour) for three minutes, and even managed to maintain controlled flight despite the initial shockwaves. But within minutes, the HTV-2 deliberately plunged itself into the Pacific Ocean after the onboard safety system detected an uncontrollable roll. Investigators blamed the mishap on the vehicle's skin peeling off in the intense heat.

During a 2014 test, the Advanced Hypersonic Weapon also had to be self-destructed because of an unspecified anomaly soon after launch.

The solicitation focuses on what it describes as a small, unmanned glider traveling at 20,921 kilometers per hour and at an altitude of 30 to 50 kilometers. It identifies potential "technology gaps" including "regions of non-continuum flow, laminar and turbulent flow transition, order of magnitude pressure variation between windward and leeward control force application, multi-phase flow, ablation issues, significant center of pressure shifts."

The solicitation calls for new aerodynamic control techniques for air-powered and unpowered hypersonic vehicles.

"Potential maneuver and control options might include propulsive, aerodynamic, blended methods and other innovative ideas," it says.

Hypersonic vehicles do present multiple control challenges, says Spiro Lekoudis, director of weapons systems for the Office of the Undersecretary of Defense for Acquisitions, Technology and Logistics.

"This flight regime necessitates very tight coupling of vehicle design and control system design, that allows the control system to effectively negotiate potential crossings of stable and unstable boundaries. The very existence of such boundaries can be catastrophic and thus designs robust to various perturbations is essential," Lekoudis says by email.

Lekoudis also cites difficulties such as rapid changes in aerodynamic load at hypersonic speeds, and changes in a vehicle's aerodynamic shape due to degradation of its materials.

Also, "the inability to replicate all flight conditions in ground facilities adds unknowns to a complex challenge," he adds.

Control is still an obstacle, but "no longer an insurmountable obstacle," according to Lekoudis. He does see other key issues to be solved, including thermal management and atmospheric degradation of materials.

michael.peck
michael.peck1@gmail.com
@Mipeck1

U.S. Air Force seeks ideas for de-icing Reapers

The U.S. Air Force is seeking solutions to icing issues that could prevent the MQ-9 unmanned aircraft from operating at the higher altitudes for which they were designed.

The MQ-9 Reapers are supposed to become the U.S. Air Force's primary means of hunting and killing terrorists, but a research solicitation describes a shortcoming with the unmanned planes in unusually blunt terms. Engineers designed the planes to fly at altitudes up to 50,000 feet, or almost twice the altitude limit of the MQ-1 Predators they are to replace, but the Air Force hasn't figured out how to de-ice the Reapers well enough to regularly permit flights at that altitude.

A step toward a solution could come this month when companies meet a deadline for submitting research proposals in response to a solicitation issued in December.

"Due to the urgent need for the combat capability of the MQ-9, the system was fielded without a complete understanding of the mechanism of ice formation at the altitudes flown by the MQ-9," the Air Force's solicitation reads. "Due to the lack of this data, the Air Force imposed conservative flight restrictions in order to reduce the risk to the weapons system."

Reaper pilots in ground control stations are instructed not to steer their craft into icing conditions that are moderate or worse and to turn the planes around if they encounter too much ice. In potential icing conditions, the Air Force recommends turning the aircraft's camera aft to prevent ice from forming on the lens and to spot any ice buildup. That's a problem, because the craft's video camera is supposed to provide an unblinking eye for monitoring suspected terrorist hideouts and tracking suspects when they go on the move.

"Based on these restrictions, the MQ-9s experience significant impacts to operations every year," says the Air Force, which has tried both passive and active de-icing systems. The current passive de-icing equipment doesn't de-ice well enough, and active de-icing consumes too much power.

So how does the Air Force want to proceed? The first step will be to determine exactly how ice is forming on high-altitude Reapers, according to the research solicitation. Next comes development of a de-icing solution. But even that approach is laden with difficulty, because "the MQ-9 is operated with zero excess power and weight for stores," the Air Force says. This means that adding de-icing equipment would sacrifice something else, such as payload or fuel, or consuming scarce power.

"It is not desirable to have to power down sensors and mission systems in exchange for anti-ice/de-ice systems," the solicitation says. "Thus, a passive solution and/or a very low power active one is sought."

Keven Gambold, a former Royal Air Force Predator pilot and Tornado fighter-bomber crewman, described icing as simply "lethal." It has also been an issue during flights by the MQ-1 Predator, which can only fly as high as 25,000 feet. Crews respond by asking permission to swing the cameras away from the ground to look ahead of the aircraft for bad weather.

Gambold, who heads the Denver-based training company Unmanned Experts, says that the solution for the Reaper can be found in the commercial aircraft sector, which has developed ice protection systems such as heaters, or pneumatic boots for the wings.

Gambold also recalls one problem being that the Predator's autopilot "was so clever" that it would automatically compensate for ice.

"You're flying at the right height, the right speed, everything seems to be going well, and then you look down, and you're burning 35 pounds of fuel an hour instead of 25."

michael.peck
michael.peck1@gmail.com
@Mipeck1

Researching a lightning path for aircraft

When energy races through the air, such as in a lightning flash, the energy leaves a cylinder of low-density air in its path. The effect is transient, lasting a fraction of a second, and leaves only 1 to 2 percent of the air density that existed before the strike.

PM&AM Research of Tucson, Arizona hopes to exploit the effect to help planes fly more efficiently and perhaps radically differently some day. The 15-person company is testing a set of electronics that would project laser-guided, artificial lightning in front of planes to create a tube-shaped bubble of extremely thin air for up to a few tenths of a second, which would provide a pathway with very little air resistance, or drag. The concept, called energy deposition, was conceived by physicist Kevin Kremeyer, who started PM&AM in 1998. The company conducts research in Kona, Hawaii, Tucson and College Station, Texas. Lots of tests lie ahead to show that the idea has merit, but Kremeyer envisions hotdog-shaped aircraft being propelled through low-density tubes punched through the atmosphere. On the ground, military trucks could be protected from roadside bombs by tubes created to diffuse explosive forces away from them.

Kremeyer says the aerospace applications he is studying would use energy deposition for both subsonic and supersonic flight. For NASA, for example, his company is developing applications for reducing surface drag and sonic booms for aircraft.

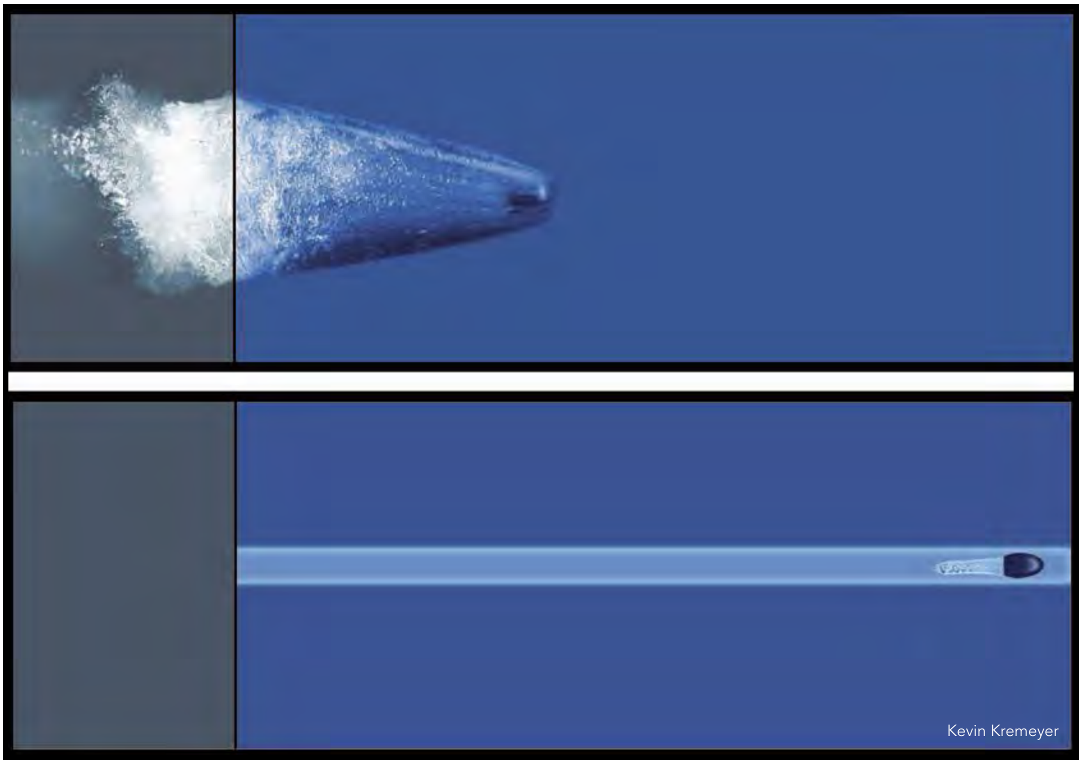
Kremeyer says he has figured out how to create those momentary tubes of low-density air. He compares the system to an electric welding arc that is guided by filament lasers. For an aircraft in flight, a circuit for the lightning would be created in a V-shape by two electrodes on the nose of the airplane, with lasers guiding the outbound and inbound paths of the electric arc. By continuously firing, the lightning could open a tube of low density air in front of the aircraft through which it could travel with very little resistance. If the tube were wide enough, an aircraft could travel at speeds of seven to 10 times of what is normally the speed of sound without encountering supersonic shock waves and the extreme friction they create.

Energy deposition could initially have less dramatic applications, such as breaking up sonic shockwaves or interrupting airflow upstream from appendages or inlets on supersonic airplanes, Kremeyer says. But ultimately, the technology could even change the fundamentals of flight, like the need for airplanes to have wings.

"If you can wind up blowing the air out of the way, you can actually obviate controlled surfaces. You don't need flaps. Your whole body becomes a control surface, a lifting surface, everything," Kremeyer says. "Just fly a fuselage, basically a 'hotdog'," he adds.

For the ground-based vehicle protection, the idea would be to create tubes of low-density air around a vehicle at the time of an explosion, much like predrilled holes in wood would act for hammering nails, Kremeyer says. The high-pressure gases created by the explosion would rush into the tubes rather than transferring their force to the bottom of the vehicle.

Keith Button
buttonkeith@gmail.com



A bullet traveling through water is quickly slowed as its energy is absorbed, as shown by the deformation of the water in the top illustration. For aircraft, using a burst of energy to create a momentary tube of extremely thin air through the atmosphere could leave a flight corridor with little air resistance, like the parting of the water for the bullet in the bottom image.

Anti-radiation vest eyed for Orion crew

StemRad of Tel Aviv is working with Lockheed Martin Space Systems to determine whether StemRad's radiation shielding vest, which is designed for first-responders on Earth, can be adapted for astronauts on Orion deep-space missions.

The two-year initial collaboration is partly funded by Space Florida, the state's aerospace economic development agency, and Israel's Matimop agency, which fosters international research and development programs involving Israeli technology.

Space radiation, particularly an extreme solar particle event, or SPE, is a known hazard for astronauts. High doses can lead to acute radiation syndrome, commonly known as radiation sickness. Depending on the severity of the event, the solutions for astronauts on the International Space Station range from sheltering in a protected part of the station to heading for the emergency return capsule. For crews en route to Mars in NASA's next-generation space capsule, Orion, the return option won't be available.

Orion is "designed to be a safe haven, so the probability of an astronaut getting ARS while inside the spacecraft is not likely," says Razvan Gaza, Lockheed Martin's lead for Orion radiation protection. But since extreme solar particle events can potentially last for days, astronauts may need to "leave the confines of the Orion storm shelter briefly to perform other tasks — in a docked habitat, for example" Gaza adds.

If a solar event were detected, the Orion crew members might don the proposed space vest, called AstroRad, over their clothing. The contoured radiation vest aims to minimize the probability of radiation-induced cancer by selectively protecting the lungs and bone marrow, which are especially prone to radiation damage, explains StemRad CEO Oren Milstein.

Oren Milstein, StemRad CEO, next to a manikin wearing a preliminary concept of the AstroRad vest for use in deep space. It is based on the StemRad 360 Gamma radiation vest worn by Milstein and by first responders on Earth.

AstroRad focuses its protection on stem cell concentrations within those organs, Milstein says, because radiation-induced mutation produces "thousands of mutated daughter cells, exponentially increasing the likelihood of cancer." He calls the strategy "smart shielding."

Because AstroRad is intended for temporary use inside a spacecraft, it is not designed to be integrated with current spacesuits. But if it proves effective in its primary role, it could be studied for extravehicular activities, Milstein says.

Francis Cucinotta, a radiation expert and professor in the University of Nevada's Department of Health Physics who is not involved with AstroRad, suggests that there could be lunar applications, too.

"Although the main protection on the moon is active dosimetry to alert astronauts to take shelter inside a vehicle," he says, AstroRad could "buy more time to get to a shelter before the cumulative dose from an SPE becomes unsafe."

NASA has options beyond AstroRad to explore, too. Charles Limoli, a researcher in the Department of Radiation Oncology at the University of California, Irvine, while not familiar with the AstroRad system, notes that "biological countermeasures are under development [to protect] various tissues depending on radiation dose."

In other words, astronauts could take medication rather than don vests. However, Limoli cautions, protecting the brain and central nervous system is problematic "due to the protective blood-brain barrier that limits the diffusion of many potential mitigating agents into the brain."

Dave Murrow, business development manager at Lockheed Martin, says that AstroRad is "promising in that it blends the latest in stem cell research with the latest in materials capability."

If its development is successful and "reaches an acceptable technical readiness level," Murrow says, "the decision to fly AstroRad on Orion missions would be determined by a trade" between the benefit to astronauts and "the penalty of the shield's mass," alongside the usual safety reviews and space qualification procedures.

Mark Williamson
mark@williamsonspace.co.uk

Will Skylon fly?

A British company continues to press toward the goal of a single-stage-to-orbit space plane, despite questions from some in the hypersonics community about the design's feasibility. Keith Button explores the project's challenges with its technical director and outside experts.

It's been a dream for decades: Build a space plane with airbreathing engines so you can avoid the weight and drag of carrying oxygen with you for combustion. While you're at it, reuse your vehicle, like an airplane, so you can save the time and money of building a new one for every trip.

That's the goal of the U.K.-funded Skylon project led by Reaction Engines Limited, or REL, of Abingdon in the U.K., where engineers aim to build a reusable 325-ton space plane that would deliver a 15-ton payload to a 300-kilometer orbit.

Skylon would be propelled by two liquid hydrogen-fueled Synergistic Air-Breathing Rocket Engines, or SABRE for short, that would operate in two modes. The flight would start in the airbreathing mode, in which the engines would gather oxygen for combustion from the atmosphere. This mode would accelerate Skylon to 4,220 mph, at which point the engines would shift to a rocket mode in which they would draw hydrogen and oxygen from tanks to reach orbit at 19,000 mph.

The technical challenges facing Skylon are enormous. The engines must be protected from severe heating but the components providing that protection can't be so heavy that Skylon can't reach orbit. Some in the global hypersonics research community doubt that the concept is feasible, even as they admire the company for trying and see promise in some aspects of the concept.

The SABRE engine "has a lot of advantages over any other concept that I know of. But the going to space [with a] single stage — that's still science fiction, in my view," says Michael Smart, head of supersonic combustion ramjet research at the University of Queensland's Centre for Hypersonics in Brisbane, Australia. He considers himself a Skylon skeptic, and he is not alone.

The question is whether Reaction Engines, which plans to begin engine component testing this year in preparation for ground testing in 2019, can prove the doubters wrong.

That would amount to achieving something the U.S. spent hundreds of millions of dollars trying but failed to do in the 1980s under the Pentagon-NASA X-30 National Aero-Space Plane program and in the 1990s under NASA's X-33 Venture Star program.

Reaction Engines is well aware of this history, and its executives do not downplay the challenges.

"Single stage to orbit is the most technically difficult way of getting into space, but it has the most promise, in terms of getting the cost down. If you can make the vehicle reusable, then you have an airplane on your hands, instead of a multi-stage rocket that needs refurbishing and rebuilding every time you fly it," says Richard Varvill, the company's technical director and chief designer.

Controlling weight

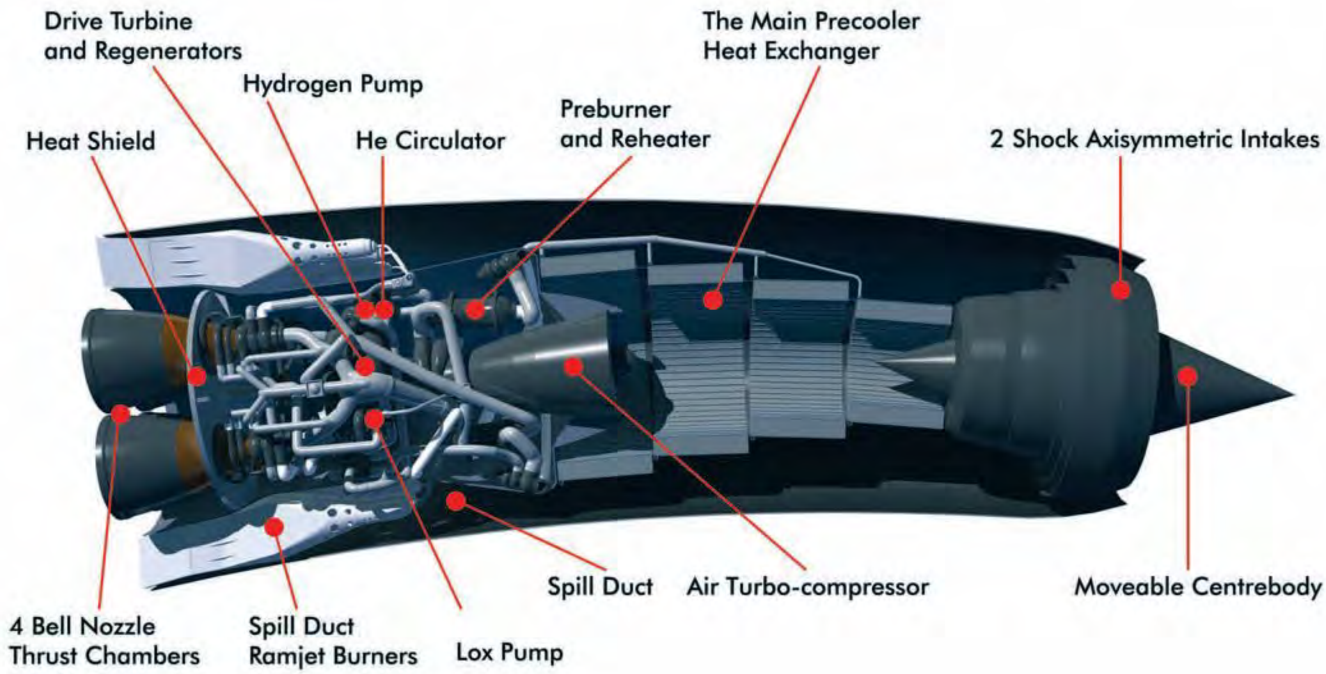
Hypersonics experts like to say that a particular component or technology must earn its way into a design, and often the weight of the technology is the deciding factor. That's how it is for Skylon, too.

"Can you engineer [each] component to the weight required? That's really where the challenge lies. And we're still doing a lot of work inside the company to try and convince ourselves of that," Varvill says.

For SABRE, the problem springs largely from the fact that it will require a helium-cooled chamber, called a precooler, to chill the incoming air, which will be in a superheated state after being slowed to subsonic speeds for combustion. If the precooler can be made light enough, the payoff could be enormous. With the air now flowing sub-

Reaction Engines

Engineers and designers behind U.K.'s Skylon are attempting to quell skeptics by building a reusable, single-stage space plane with an air-breathing engine that would reduce the amount of propellant carried onboard.



Skylon's two Synergistic Airbreathing Rocket Engines, or SABRE, will be crucial to determining the space plane's success. The hydrogen-powered SABRE is designed to cool and convert incoming air, reducing the vehicle's need to carry oxidizer.

Reaction Engines

sonically and at temperatures that won't melt the engine, everything beyond the precooler can be more or less conventional. Blades would compress air for combustion, similar to the process in a turbojet, and the combustion chamber and nozzles would be like those of a traditional rocket. While others in the hypersonics community are toiling to perfect exotic, bladeless air-breathing supersonic combustion ramjet engines, Reaction Engines will have sidestepped that challenge.

"It's a well-known fact that we're not fans of scramjets," Varvill says.

The precooler will be a complex device, however. Thousands of 1-millimeter-wide, helium-circulating tubes will line its walls. The helium will be cooled by Skylon's liquid hydrogen fuel.

An advantage, Varvill says, is that the SABRE engine can provide thrust over a wide velocity range, up to Mach 5.5 in fact, before switching to rocket mode.

"It's very hard to get a scramjet to operate over a range of speeds," Varvill says. That's because it must be finely tuned to maintain combustion with the extreme forces created by massive amounts of air flowing through at supersonic speeds, and with buffeting from supersonic shock waves in that flow.

A scramjet "would really like to fly at just one speed, and then you optimize the engine geometry for the one operating condition. Obviously for a launch vehicle, it has to be accelerating the whole time. That requires a lot of variable geometry inside the engine, which makes it heavy," he says.

Scramjet engines tend to be massive compared to the aircraft they propel — the engines can make up most of the airframe, running from the nose to the tail and taking up much of the diameter of the fuselage — because of the massive amounts of air they must ingest.

Need for speed

To reach low Earth orbit, Skylon must reach Mach 25. NASA earned a Guinness World Record in 2004 for flying an unmanned, scramjet-powered aircraft — the X-43A — at Mach 9.6. The question facing Skylon engineers, and one that other hypersonics researchers are keenly interested in, is how to get all the way to orbit with a meaningfully sized payload.

Among the prominent scientists in the hypersonics research community is Glenn Liston, chief of the high speed experimentation branch of the Air Force Research Laboratory at Arnold Air Force Base in Tennessee. Liston oversees research and testing of hypersonic engines to be used in missiles and, potentially, spaceplanes.

"One of the top challenges that we face is that if we're going to take something into that high-speed range, then those pieces that make high speed possible, we're going to drag them through the low-speed range; we're going to take them all the way up to space," Liston says. "They have to buy their way on. That's a challenge; they need to have enough performance to do that."

Part of deciding what earns its

way on board can be determined by the weight of the propellant compared to the overall vehicle weight. Two proposed single-stage-to-orbit vehicles from the past provide good examples of the issue, says David Van Wie, chief technologist at the Applied Physics Laboratory at Johns Hopkins University, which tests and develops scramjet engines.

The Lockheed Martin X-33 never flew, but its launch mass would have been 92 percent propellant, with only 8 percent remaining for the structure of the vehicle, control systems, engines and payload. NASA canceled the program in 2001 because of the weight and structural problems. In a 1999 test, the X-33's hydrogen tank failed when the outer skin and core of the tank wall peeled away from the inner skin.

NASP, also known as the Rockwell X-30, never flew, either, but it would have had about 70 percent of its takeoff weight devoted to propellants. Engineers ran into additional weight problems from the design elements required for carrying people aboard, plus the weight of the air-breathing engines, and the inlets and exhaust nozzles required to allow them to cover low and high speeds. NASP was canceled in 1993.

Nevertheless, many researchers continue to like the idea of operating an air-breathing engine at high Mach numbers, because such an engine could have three times the specific impulse — a measure of fuel efficiency — of a rocket engine at speeds above Mach 5, Van Wie says. That's because they don't have to carry their own oxygen. At lower speeds, without the extreme conditions created by hypersonic flight, an air-breathing engine might have 10 times the specific impulse of the rocket engine. The higher the specific impulse of an engine, the less propellant it requires and the more weight on a space plane that can be devoted to the structure and payload. But air-breathing engines also tend to be heavier than rocket engines.

About 80 percent of Skylon's takeoff weight would be propellant, Varvill says.

Lockheed Martin's X-33 was one of the failed attempts to build a single-stage-to-orbit space plane. NASA canceled it in 2001 in part because of its heavy weight, 92 percent of which was propellant.

Different approach

For now, Reaction Engines is focusing on the experimental engine. Later, the company will address the long list of design challenges from the extreme heat and buffeting conditions at Mach 25 and on re-entry into the atmosphere.

"No one has ever seen an engine like this, where the air compressor is actually driven by a helium loop. That's the new bit that people want to see demonstrated effectively," Varvill says.

By using subsonic air, and using a precooler to bring the air temperature down, the rest of the engine doesn't see the wide range of conditions that a ramjet/scramjet experiences from supersonic and hypersonic — above Mach 5 — airflows, Varvill says. The upper limit for the speed of the SABRE engine is dictated by the precooler, and limits on the range of temperatures that the metal in the heat exchanger can withstand, Varvill says.

From Mach 5.5 to Mach 25, the speed required for orbit, the SABRE engine would be in rocket mode, burning oxygen and hydrogen carried on board. As with the turbojet portion of the SABRE engine, the rocket engine mode will use technology that is typical of other modern rocket engines.

The full-sized experimental engine to be tested by 2019 will be a stripped-down version of the SABRE, built to prove the operation of the helium loop and the basic function of the engine — that it can compress air to the correct levels for liquid hydrogen combustion. The engine probably won't have an intake channel or a nozzle system, Varvill says.

At the same time, the company plans to test a smaller-scale version of the SABRE engine's precooler under high temperature conditions. In 2012, the company showed that the engine's precooling system worked at room temperatures down to cryogenic temperatures, but it didn't have funding available to test it with heated air, like the temperatures the engine would encounter at supersonic speeds, Varvill says. The air inlet on the SABRE engine would capture air moving by the vehicle at speeds up to Mach 5 and slow it down to subsonic speeds before combustion, making it very hot. Skylon now has plans to test the precooler by 2019 at potential test chamber sites that can create the Mach 5 temperature conditions and show that the precooler can cool the hot air to the desired outlet temperature.

The company's latest design, the SABRE 4 engine, is a more thermodynamically sophisticated engine that will require less liquid hydrogen than the original SABRE engine.

After the ground demonstration engine has been built and tested, sometime around 2020, another engine would be installed in a single-engine flight test vehicle. The engine and airframe would be tested under high-speed and temperature conditions.

The Skylon engineers will have to develop an outer skin for the airframe that can withstand high temperatures and remain elastic during the rigors of high-speed flight, for example, as well as develop safe fueling procedures and tanks for the liquid hydrogen, Varvill says.

The first flight test vehicle, with its single engine, would look more like a missile than a space plane, Varvill says. It would be built to test the initial stage of a flight to space — taking off from the ground and accelerating to about Mach 5 with air-breathing engines — and then the engine would shut off and the aircraft would glide back to the ground. Next would be a flight vehicle with a rocket engine to explore the ascent after Mach 5, when the air-breathing engine's inlet is closed and the air-breathing function is turned off as the engine switches to rocket mode.

Another challenge is that Skylon's engineers will have to find ways to lengthen the lifetimes of certain components, Varvill says. Skylon is looking for 200 flights out of the vehicle, for example, but a high-performance rocket combustion chamber like the one in the space shuttle main engines will begin to develop cracks after about 20 firings. With certain seals, bearings, turbopumps and compressors in the precooler of the SABRE engine, unlike with turbojet engines, oil can't be used because it will freeze. That means the bearings have to function with little lubrication, which shortens their life, he says.

Tough audience

Some question the feasibility of Reaction Engines' approach. The SABRE engine could be a significant breakthrough for air-breathing engines, but maybe for a point-to-point aircraft instead of a space plane, says Smart, the scramjet scientist at the University of Queensland.

Van Wie, the scramjet scientist at Johns Hopkins, says that even with the benefits that airbreathing engines can bring to a design, the technical problems yet to be solved means that it may be awhile before someone manages to build the first single-stage-to-orbit vehicle.

"People have talked about this going back several decades. It's kind of viewed as the Holy Grail that would provide flexible operations. But nobody yet has come up with a real detailed approach on how to achieve that," Van Wie says. "I know the Skylon crowd, they have their belief in a unique solution to do that, but it's still pretty far off into the future."

The solution will probably come from thinking smaller, says Liston, the Air Force Research Laboratory scientist.

"I think [single-stage-to-orbit] is possible and practical, but it probably won't look like the drawings we had from the mid-'60s, where you've got a 1 million to 2 million pound vehicle that takes off, flies to space and comes back after delivering a 10,000-pound payload," Liston says.

Instead, it may make more sense to optimize a space plane for carrying small payloads — with a plane the size of a B-1 bomber or even as small as an F-15 fighter. Large payloads would be left to the expendable launch vehicles like the Delta 4 and the Atlas 5.

"We don't have millions of trains around, but we have millions of trucks to move things off the trains," Liston says.

Keith Button
buttonkeith@gmail.com

NASA's Next Astronauts

Training to become an astronaut is an honor, and the new class that NASA is in the process of selecting will enter the program at a time of ambitious plans and changes. Some of those who are selected in 2017 will be the first to fly on spacecraft built and owned by commercial companies rather than by NASA. They could also be the first humans to travel to an asteroid or Mars. Retired astronaut Tom Jones spoke to the experts about what NASA is looking for in its incoming class of space fliers.

NASA is adding new talent to its astronaut corps for the first time in four years. The agency was planning to complete its two-month call for new astronaut applicants in February and then turn to selecting its newest group of space fliers by 2017. These candidates will graduate from training two years later and will have the chance to serve on the International Space Station or travel to lunar orbit or near-Earth asteroids around 2030. A fortunate few may even embark on a multi-year journey to the Martian moons Phobos and Deimos or conceivably to Mars itself.

Those chosen to work alongside the 47 active NASA astronauts will first pay their dues on three- to six-month expeditions to the ISS, performing research, robotic operations, extravehicular activities and maintenance tasks. These assignments demand roughly 2 ½ years of intense training and travel, with long stints overseas at international partner facilities, such as Star City in Russia.

To reach the ISS, new hires must qualify as Soyuz flight engineers, and they will also train to fly aboard the SpaceX Crew Dragon and Boeing CST-100 Starliner. These commercial spacecraft are scheduled to begin flight testing in 2017 in preparation

A trio of astronaut candidates undergo land survival training in Maine in 2013. NASA has hired only 338 astronauts since 1959.

for carrying Americans into low Earth orbit through the 2020s.

A few of the newcomers will earn a mission on Orion, NASA's multi-purpose crew vehicle, venturing to the moon and beyond on the 8.8 million pounds of thrust of the Space Launch System. With NASA's current budget, Orion's first crewed flight will occur no earlier than 2021.

Between flight opportunities, astronauts are assigned to support current and future human spaceflight operations. Some will work in Mission Control as capsule communicators, or capcoms, speaking to ISS or other orbital space crews. Others will help NASA engineers solve technical and safety issues in current operations or help design, develop and test future spacecraft. All will serve as high-profile representatives of the agency through frequent public appearances and media interviews.


NASA

Astronaut candidates first undergo three years of intense training and travel, including long stints abroad at international partners facilities such as Star City in Russia. Here, astronauts Nicole Mann and Jessica Meir train for extravehicular activity at NASA's Neutral Buoyancy Laboratory in Houston.

Do you qualify?

NASA's basic hiring criteria are relatively straightforward. Candidates must possess a bachelor's degree in engineering, mathematics or in the biological, physical, or computer sciences. They must also demonstrate three years of increasingly responsible professional experience. A doctoral degree meets this three-year requirement, and teaching experience, either K-12 or in college, is also qualifying. Pilot applicants must have racked up a thousand-plus hours as pilot-in-command of a military or civilian jet.

Duane Ross, who headed the astronaut selection office at Johnson Space Center in Houston from 1978 until last year, told me that he was often asked by aspiring astronauts what they should study in school. Ross advises: "Just get the basic education that we say you have to have. You can't go take 'astronaut' in college — we'll teach you that. Just stick to the basics."

Anne E. Roemer, who succeeded Ross in 2015, says her office "is focused primarily on [hiring for] long-duration missions, with flights lasting anywhere from four [to] six months." For the final decade of planned ISS operations, NASA wants to keep a diverse skill set among its new hires, and is seeking experts in everything from hard science to medicine to engineering to test flying. For example, the eight astronauts hired in 2013 included four test pilots, a flight surgeon, a physicist/aviator, an electrical engineer and a physiologist.

Ross says the agency has not been targeting specific academic disciplines.

"We took the best players from across the board, and we got a pretty good mix of disciplines."

Roemer adds that in addition to academic excellence, an applicant's communication and social skills are highly valued.

Because the height and reach requirements for the new orbital transports like Crew Dragon, CST-100 Starliner and Orion are still fluid, NASA has retained the current Soyuz height standards for this selection: A candidate's height must be between 62 and 75 inches. U.S. crewmembers on the ISS might still fly on Soyuz even after the two commercial spacecraft come online. Although the new craft may eventually allow NASA to apply more flexible height requirements, Roemer reiterated that applicants must still be able to meet the arm reach, torso length and range of motion restrictions of NASA's current Extravehicular Mobility Unit spacesuit.

Successful applicants must pass the NASA long-duration flight physical exam. Acuity in each eye must be correctable to 20/20. Glasses are OK, and NASA has approved certain corrective surgical procedures used to improve vision, including Lasik.

The selection process

NASA in March will begin evaluating the applications received through February. NASA hasn't said how many applied, but about 6,113 applied for the last selection in 2013. An astronaut rating panel reviews the appli-

The Right Stuff
(and degree and height)

For the first time since 2011, NASA is looking to hire U.S. citizens to become astronauts. Flying experience is not necessary, and you can even wear glasses. Statistically, though, it will be harder to join the astronaut corps than to get into Harvard. Here's a look at the job requirements and features:

Applicants: More than 6,000

Number of openings: Eight to 14

Degrees and experience: Bachelor's in engineering, math or in biological, physical or computer sciences. Also need three years of professional experience, which can be met with a doctoral degree, one thousand hours as pilot-in-command of a jet or three years as a teacher, for example.

Age: Open to all

Height: 5 feet 2 inches to 6 feet 3 inches

Salary: U.S. government General Schedule 11 to 14, based on experience. GS-11 for 2016 starts at $66,893 (including a Houston locality adjustment), and GS-14 tops out at $146,468.

Flight rate*:* First spaceflight about five years after hiring, with another flight about every five years.

Sources: NASA; Aerospace America reporting

An Orion crew capsule undergoes welding at NASA's Michoud Assembly Facility near New Orleans. Astronauts selected next year may get a chance to fly in Orion.

cants' academic and work experience and sorts their packets into "qualified" or "highly qualified" categories. Based on their records and outside references, the agency invites 120 of the best qualified applicants for a week-long evaluation at Johnson Space Center. Arriving in groups of 20, the applicants receive a job orientation, a preliminary medical exam, a facilities tour and opportunities to meet and question working astronauts. The applicants are also challenged with a half-day, hands-on outdoor leadership exercise, a chance for the selection team to see how aspirants handle some team problem solving.

The highlight — and the most intimidating — event of each applicant's week is an hour-long interview with the Astronaut Selection Board. Ross has participated in thousands of these make-or-break sessions. He says the board "doesn't have standardized interview questions … We start with, 'Take us back to high school, tell us what you did, and bring us up to speed with today.' Then we'll ask questions along the way, getting at all the things we need to ask, like teamwork and outside activities. We're looking at the whole person, and that's what we get from asking about their outside activities."

The most promising 50 or 60 applicants will be invited back to Houston for a second interview with the board and for the more extensive long-duration flight physical. The finalists identified by this second round of evaluation form the pool from which NASA officials will pick the new hires.

How does the board choose the top applicants? Looking back on his interactions with many boards over the years, Ross says, "You're never going to have a unanimous vote; you go in understanding that."

He always emphasized to board members that "If there's anybody you have a 100 percent problem with, that's what we need to know." Ross adds, "The important thing is not to try to find the best person, but not to get a bad one, and be sure everyone you pick can do the job."

For almost 40 years, this "fail safe" approach has produced astronauts who almost universally met the needs of management, flight directors and fellow crewmembers.

Astronaut school

The agency will announce its new astronaut candidates in about a year. Roemer says NASA hopes to beat that deadline, depending on the number of applications received. The new class will report for work in the second half of 2017.

Astronaut candidates must complete a two-year training program designed to school them in human spaceflight operations at the ISS and on the various orbital transport vehicles. They'll be evaluated on their mastery of station systems, spacewalking skills, their performance as a crewmember in NASA's T-38N Talon jets and proficiency in Russian. Completing the course earns them a silver, astronaut-corps lapel pin and makes them eligibility for a spaceflight assignment.

The tradition is that all qualified crewmembers receive a chance to fly in space, but NASA makes no guarantees. When my Group 13 class, "The Hairballs," arrived in July 1990, the first member of our group launched on a shuttle about 2 ½ years later. With today's slower launch pace, it's likely that the 2017 group will wait nearly five years before the first makes it to orbit.

For deep space, stay the course

Duane Ross says that over four decades the agency has honed the selection process to a keen edge.

"Every time we did a selection and every time we flew a mission, we got a little smarter about what the requirements were. But from 1978 up 'til 2013 [the last cycle Ross ran], the process and the requirements we were looking for basically stayed the same. You want somebody with the required education, obviously, and just good, hands-on operational skills."

NASA has never claimed the selection process is perfect (I got in, after all), but Ross says management has been "pretty happy with the folks we produced. The process took care of itself in terms of its credibility and the kind of people [chosen]. The board had a vested interest in finding good people because that's who they were going to have to work with and depend on."

Reflecting on his years spent selecting astronauts, Ross says "It's a heck of a lot of work but it's also really fun … I don't think there's any reason to look for anything different [this time] over past selections." No matter the spacecraft, he says, "You gotta fly 'em, and you have to know all the stuff you had to know all along."

Simply put, an astronaut's job is the best on the planet. In my latest book, "Ask the Astronaut," I hope to inform and inspire a few more aspiring space fliers. To all the applicants: Good luck!

Tom Jones
Skywalking1@gmail.com

10 questions FOR ANDY WEIR

Andy Weir says he's happy that "The Martian" film is "very true to the book."

The author of "The Martian" spoke to us by email about his fear of flying, the role of commercial space and the Oscar-nominated film based on his novel.

Did you ever think your self-published book would become a bestseller and a Hollywood movie?

By the time I wrote "The Martian," I'd given up on ever being published, so it was purely a labor of love.

I self-published just so more people could get access to it (many of my regular readers didn't know how to manually download an e-reader file and put it on their e-reader). Once it started to sell well online, an agent and publisher approached me. And then Fox approached me for the film rights.

You fantasize about this sort of thing, but you never really think it'll happen.

What role did you have in making the movie?

Mostly my job was just to cash the check. Though they did send me the screenplay to get my opinion. They weren't required to listen to anything I had to say. They kept me updated on the production because they're cool. And in the end, the film is very true to the book, so I'm happy.

How much did you lean on your background as a software engineer?

I've been a space dork my whole life, so I started with more than a layman's knowledge of this stuff. But I'm an enthusiast, not an expert. I did tons of research for the novel. I didn't know anyone in aerospace while working on the book, so all my research was good old-fashioned Google searches. Fortunately, the space industry is very open with their technology and advances. It's all out there online.

My software engineering skills helped a little. I wrote software to calculate the orbital paths taken by Hermes to and from Mars, etc.

What do you and the main character, Mark Watney, have in common?

[He's] pretty much how I talk and act. I'm a terrible smart-ass. I got beat up a lot in high school, and I earned every beating I got. When I come up with something witty to say I just have to say it. Not always the best policy.

Given your fear of flying, is it fair to say you wouldn't go to Mars?

I'm very afraid of flying, though I'm getting better at it. I do regular therapy sessions to work on it and I take anti-anxiety meds when flying. I can do short commuter flights (one to two hours) now without fear.

I would definitely not go to Mars. I wouldn't even go into Earth orbit. I write about brave people; I'm not one of them.

What sparked your interest in space travel?

My father is a space enthusiast, so I grew up with it. I honestly don't remember any point in my past when I wasn't interested in it.

What impact do you think the book and movie will have on exploration?

I think it's part of an overall virtuous cycle of public interest in space

20th Century Fox

A self-professed "space dork," Weir did most of his research for "The Martian" on Google. Here, astronaut Mark Watney, played by Matt Damon, is extracting hydrogen from the hydrazine in rocket fuel to make water.

Penguin Random House

travel. People are taking a renewed interest in space. That drives a market for popular entertainment to make books, TV shows and films with realistic depictions of space. That, in turn, increases public interest even more. It's great!

"The Martian" is just one of several major films that are part of this cycle. I'm thrilled to be part of it, but I don't think "The Martian" by itself renewed public interest. I think it's just part of a really cool resurgence.

If you were to write "The Martian" today, would Mark Watney travel via SpaceX or Virgin Galactic?

No, though I certainly would have had SpaceX be a part of the mission. Maybe the people who made the presupply probes. I'm pretty sure the first manned mission to Mars will be done by governments, not private spaceflight. And, unlike the depiction in my novel, I think the real first manned mission to Mars will be a large, multinational effort like the International Space Station. It will cost a lot, so the more governments that get involved the cheaper it is for everyone.

Commercial space companies will be critical [to] the process, because they'll provide freight service to low Earth orbit. So when the time comes to build something huge like Hermes, they'll need to put like 900,000 kilograms into orbit or something, and they'll need to do it in chunks. That's where SpaceX and other commercial spaceflight comes into place.

Imagine you run a toothpaste factory. Do you build your own trucks from scratch to deliver the toothpaste to supermarkets around the country? No. You pay a trucking company to do that for you. The same will be true of the space industry. NASA will make cool [bleep]; SpaceX will put it into orbit.

What would you like to see a new U.S. administration tackle?

I believe the commercial space industry is the only way forward. There has to be an economic motive. If technology can drive the price point of a trip to low Earth orbit down enough that middle-class Westerners can afford it, we will have a new trillion-dollar industry in the world. Just like the airline industry boom of the mid-20th century.

So I think our space policy should focus on commercial projects. NASA should stop working on delivery systems entirely. They should work on making space stations, probes and spacecraft. But they should contract out the boosters. It might be enough to kick-start a genuine commercial space industry.

What's next for you?

I'm working on a different project. It's another hard sci-fi novel with accurate science. It's about a city on the moon. It should be out in early to mid-2017.

Kristin Davis
kristin.grace.davis@gmail.com

"The forum is a great place for us to make contacts, network with our customers and talk about new, innovative ideas."

—Rob Fuller, Lockheed Martin

"All sorts of things go on in the hallways, in side meetings; and you really need to be here in person to experience that."

—Jeffrey Puschell, Raytheon Company

"Students…when you present a paper and get published, that fact stays on your resume your entire life."

—Kevin Burns, Northrop Grumman Corporation

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Chasing broadband satcom

Customers around the world are no longer amazed by the sheer communications capacity of high throughput satellites. They want unprecedented flexibility to shift capacity where it's needed most. The question is how to give customers that flexibility. Debra Werner visited a factory in California where one proposed solution is taking shape, and she explores rival concepts.

by Debra Werner
werner.debra@gmail.com

I'm standing in the world's largest satellite factory, not far from Los Angeles International Airport. This is where the first geosynchronous communications satellite was built 53 years ago, when this facility was part of Hughes Space and Communications. Today, it is Boeing's Satellite Development Center. I'm wearing a bunny suit along with two other reporters, and we're looking up at a three-story 6.5-metric ton behemoth of a satellite that would dwarf that first geo satellite, called Syncom. This new spacecraft will be launched later this year to a position high over the Indian Ocean where it will join a ring of high throughput geosynchronous satellites that Intelsat plans to set up, called the EpicNG constellation.

The executives with us point out the satellite's digital signal processor, a rectangular box about the size of a microwave oven. Crisscrossing it are aluminum tubes, which the executives explain are filled with ammonia to cool the electronics once they are in space. Devices like this one are a twist in high throughput satellite communications, a revolution that began about a decade ago with the goal of transmitting data 10 times faster than with conventional satellites.

Few would question that the high-throughput trend is beginning to pay off. Villagers in the heart of Africa are

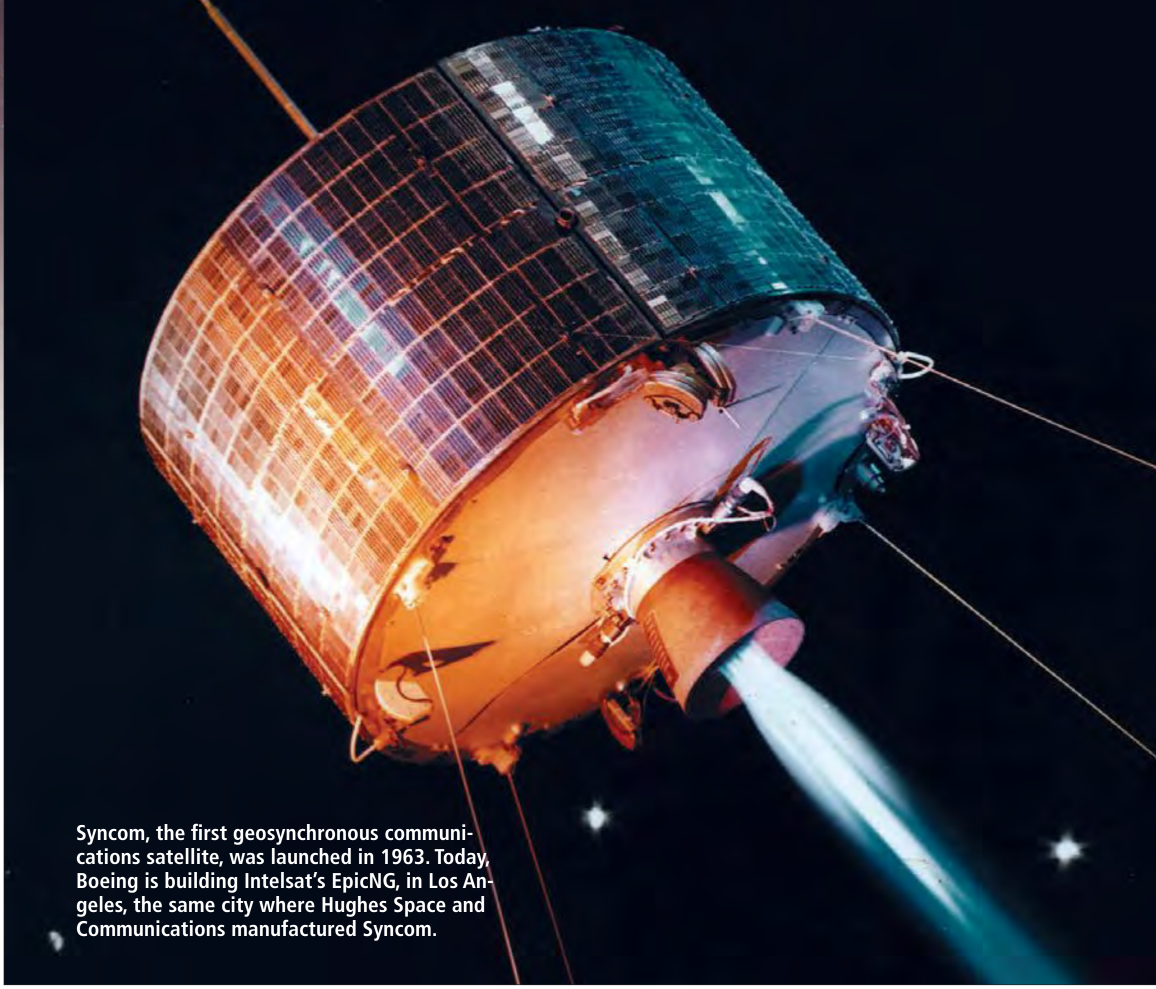
Boeing

Intelsat 29e, the first Intelsat EpicNG high throughput satellite, being loaded with a digital signal processor during testing.

Intelsat

starting to get broadband Internet without waiting for fiber optic cables to reach them. Passengers on cruise ships and airliners are starting to surf the web as they move through a satellite's footprint. The market, however, is a dynamic one. Broadband customers ranging from corporations to networks like Verizon and AT&T are demanding more flexibility than ever. Nearly all want the ability to divert beams to meet a spike in demand. Others want to put multiple regional beams and dozens of spot beams on a single satellite. Still others want the satellite to be able to shift the communications frequency, so that customers with different equipment can communicate. A competition is playing out in the industry over the best technologies to provide this flexibility. What is certain is the company that succeeds in delivering this kind of flexibility at an attractive price could have an advantage in the extremely competitive global market for commercial communications satellites. That market was worth roughly $5.1 billion in 2015, according to Northern Sky Research.

Intelsat is firmly in the digital camp. "It's 2016 and satellites are going digital," says Thierry Guilleman, executive vice president and chief technology officer at Intelsat General, which operates about 50 satellites in geosynchronous orbit from control centers in McLean, Virginia, and Long Beach, California, where the EpicNG



Syncom, the first geosynchronous communications satellite, was launched in 1963. Today, Boeing is building Intelsat's EpicNG, in Los Angeles, the same city where Hughes Space and Communications manufactured Syncom.

spacecraft also will be managed.

Others have a different view. Some geosynchronous satellite manufacturers say onboard processors are too expensive, and these manufacturers say they are providing similar flexibility with analog electronics. Not to be outdone, two new players based in the Channel Islands off the U.K., O3b Networks and OneWeb, plan to set up constellations of smaller satellites in lower altitudes in a strategy to avoid the signal latency of geosynchronous spacecraft. These satellites won't have digital signal processors in orbit either.

High throughput satellites

For decades, geosynchronous satellite designs were strikingly similar. Blueprints called for large dish-shaped antennas to broadcast a unitary analog signal across a region. In fact, most of the communications satellites in orbit still operate that way to some degree. EpicNG satellites, for instance, are equipped with large dish shaped antennas and also cone shaped devices called feed horns that are mounted on an aluminum panel. These feed horns produce multiple spot beams. Power can be modulated to individual feed horns, so that more power can be added where communications capacity is demanded. Digital signal processors on the ground or on the satellite tell these feed horns how to tailor the capacity where it is needed to deliver phone calls, television shows and website content.

Boeing is building five more digital EpicNG satellites in this factory for Intelsat. Over the next four years, these spacecraft will join the first of the EpicNG satellites, called Intelsat 29e, which was boosted into position over the Atlantic Ocean in January.

The cost of digital signal processors has raised eyebrows in some quarters. They make satellites significantly more expensive than their analog counterparts, but advocates of the technology hope that as manufacturers standardize those processors in the years ahead, the cost may come down, making it easier for more satellite operators to adopt the technology. Exactly how widely digital signal processing is being adopted can be hard to judge, because some companies closely guard such innovations in hopes of retaining competitive advantage.

One satellite operator that is willing to speak in depth about its high capacity satellite is Norway's Telenor Satellite Broad-

casting. Telenor's Thor 7 satellite was built by Space Systems/Loral in Palo Alto, California, and launched last year. Thor 7 does not have an onboard digital signal processor, but its spot beams are "switchable," meaning operators on the ground can adjust the satellite's power levels to boost capacity in areas with high demand. Telenor also can steer one of Thor 7's spot beams to focus on an area with high communications traffic. The spacecraft produces Ku-band regional beams to broadcast radio and television programs in Central and Eastern Europe. It also has 25 Ka-band spot beams to provide Internet access, video streaming and links to corporate networks for Europe and ships in the North Sea, the Norwegian Sea, the English Channel and the Mediterranean Sea.

Inmarsat, the London-based satellite operator that specializes in serving customers traveling around the world, also does not have an onboard digital signal processor on its three Global Xpress high throughput satellites, but they nevertheless produce fixed and steerable beams.

"Around the world, over 200 beams are fixed and staring all the time, which means pretty much anywhere you go, you can point at the sky and have access to wide bandwidth Ka-band communications," explains Peter Hadinger, president of the U.S. government business for Inmarsat. "We have added these steerable beams so we can plus up capacity over an area of high usage."

Inmarsat launched the third satellite in its Global Xpress constellation in August and is now marketing that capacity to both commercial and military customers. "When customers need capacity above and beyond what they can get from military satellites in their area, they can come to us and we can point a steerable beam in that location," Hadinger says. "This is all done to make Global Xpress as flexible and capable as possible."

ViaSat, the Carlsbad, California, company that provides broadband to airline passengers over the continental U.S., Alaska, Hawaii and Canada from its ViaSat-1 spacecraft, has not said whether ViaSat-1 carries a digital signal processor or whether the company will install them on the three ViaSat-3 satellites it plans to buy to create a global Ka-band broadband network.

"We are very sensitive about sharing the things we are doing," says Keven Lippert, executive vice president for satellite systems and corporate development at ViaSat. But generally speaking, ViaSat is upgrading not only its satellite design, but also its transmission and reception devices and fiber networks on the ground. "To get to the capacity and flexibility we have in ViaSat-3, we've had to invest a lot of money in developing technologies ourselves," he says.

Flexibility versus capacity

There are different schools of thought over the best way to deliver flexibility, but no one disputes its importance. "To have the ability to move capacity around and focus it in areas is just as valuable as having a lot of capacity, because otherwise you end up having capacity in areas

The Intelsat 29e satellite lifts off aboard Ariane 5 in January from French Guiana. The Intelsat 29e is the first of Intelsat's high throughput EpicNG-series spacecraft, which is being built by Boeing.

New constellations, new orbits

Two startup companies, O3b Networks and OneWeb, are challenging the conventional wisdom that large, geosynchronous spacecraft positioned 36,000 kilometers over the equator are the preferred way to deliver broadband satellite coverage.

One might have thought that the leading geosynchronous satellite operators would view the upstarts as rivals, but two of the industry's dominant players have decided to work with O3b and OneWeb.

Intelsat General of Luxembourg and McLean, Virginia, has joined forces with OneWeb, whose 700 satellites destined for low Earth orbit will weigh less than 150-kilograms each. In contrast, Intelsat's new EpicNG spacecraft weigh 6,500 kilograms.

Intelsat's rival SES of Luxembourg, which operates 50 geosynchronous satellites, is investing in O3b, which has begun launching satellites weighing 700 kilograms each into medium Earth orbit, an altitude of about 8,000 kilometers. This 20-satellite constellation will provide Ka-band broadband connections in underserved parts of the world.

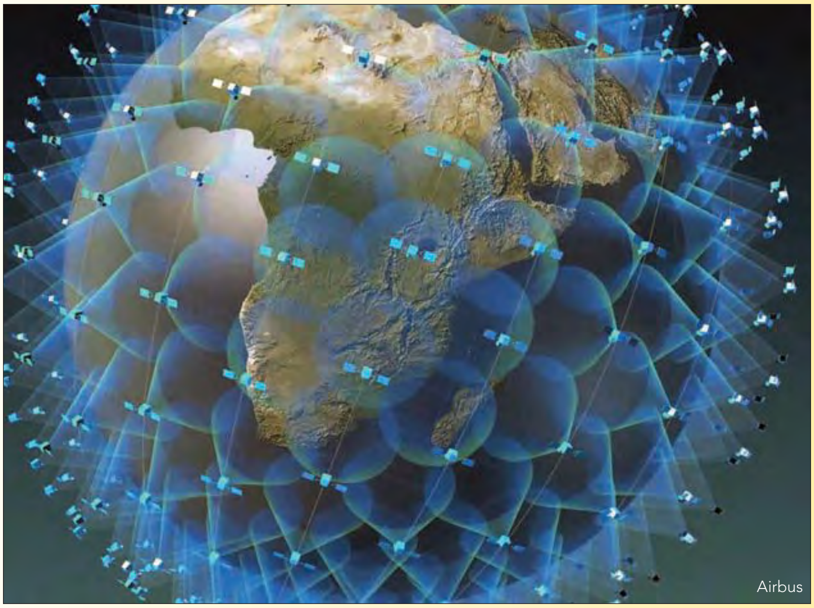
Joining forces offers customers more ways to connect to global networks, says Thierry Guilleman, Intelsat executive vice president and chief technology officer.

In Manhattan or any urban area with tall buildings, satellite antennas often have trouble connecting with satellites in geosynchronous orbit, because they need to be in the satellite's line of sight. Because of orbital geometry, it is easier for antennas to connect with satellites in lower orbits. Also, geosynchronous satellites can reach the polar regions from their positions over the equator. All told, OneWeb's polar orbits and O3b's MEO constellation will expand coverage for their geosynchronous partners.

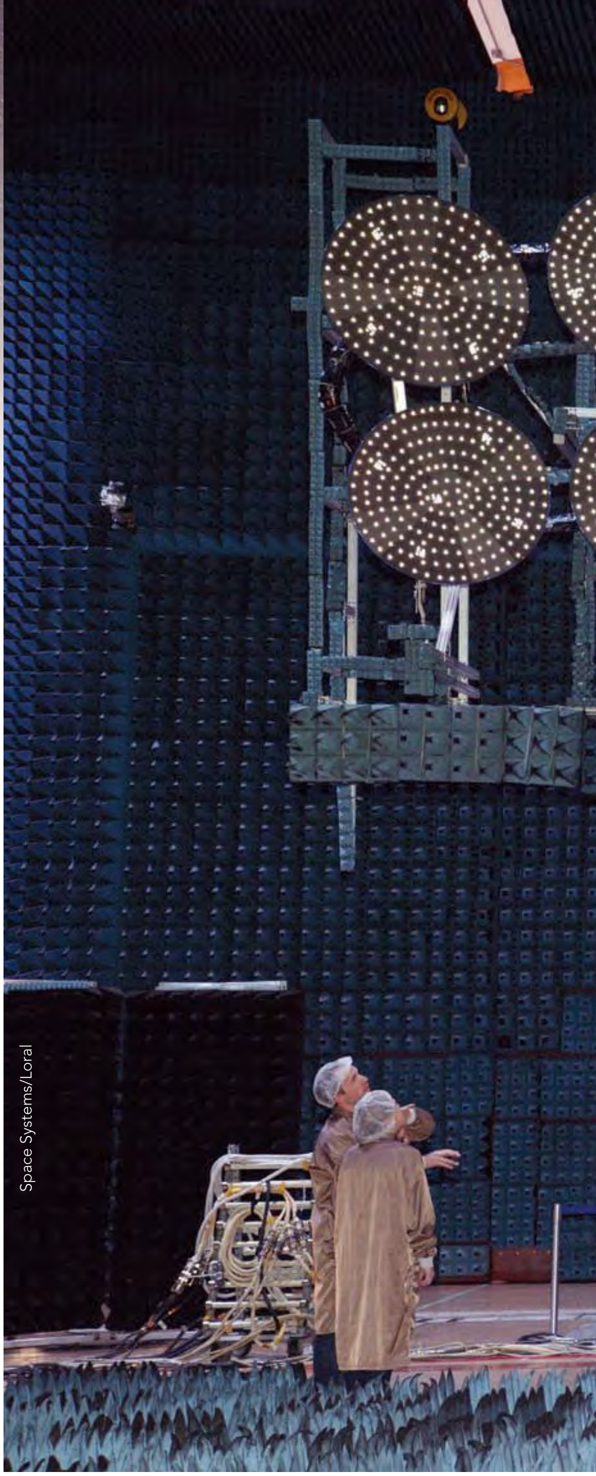
Intelsat's Guilleman says that working with OneWeb to cover urban canyons and the poles will make Intelsat's service truly global.

SES says its partnership with O3b will offer its customers similar benefits. For example, Jamaican telecommunications network Digicel is already using the 12 satellites in O3b's current constellation to relay communications in heavily populated parts of its overage area, which includes American Samoa, Fiji, Nauru, Papua New Guinea, Tonga and Vanuatu. Digicel relies on SES's C-band regional beams and uses O3B's spot beams to augment capacity, according to SES's white paper, "GEO & MEO: Proven. Efficient. Scalable."

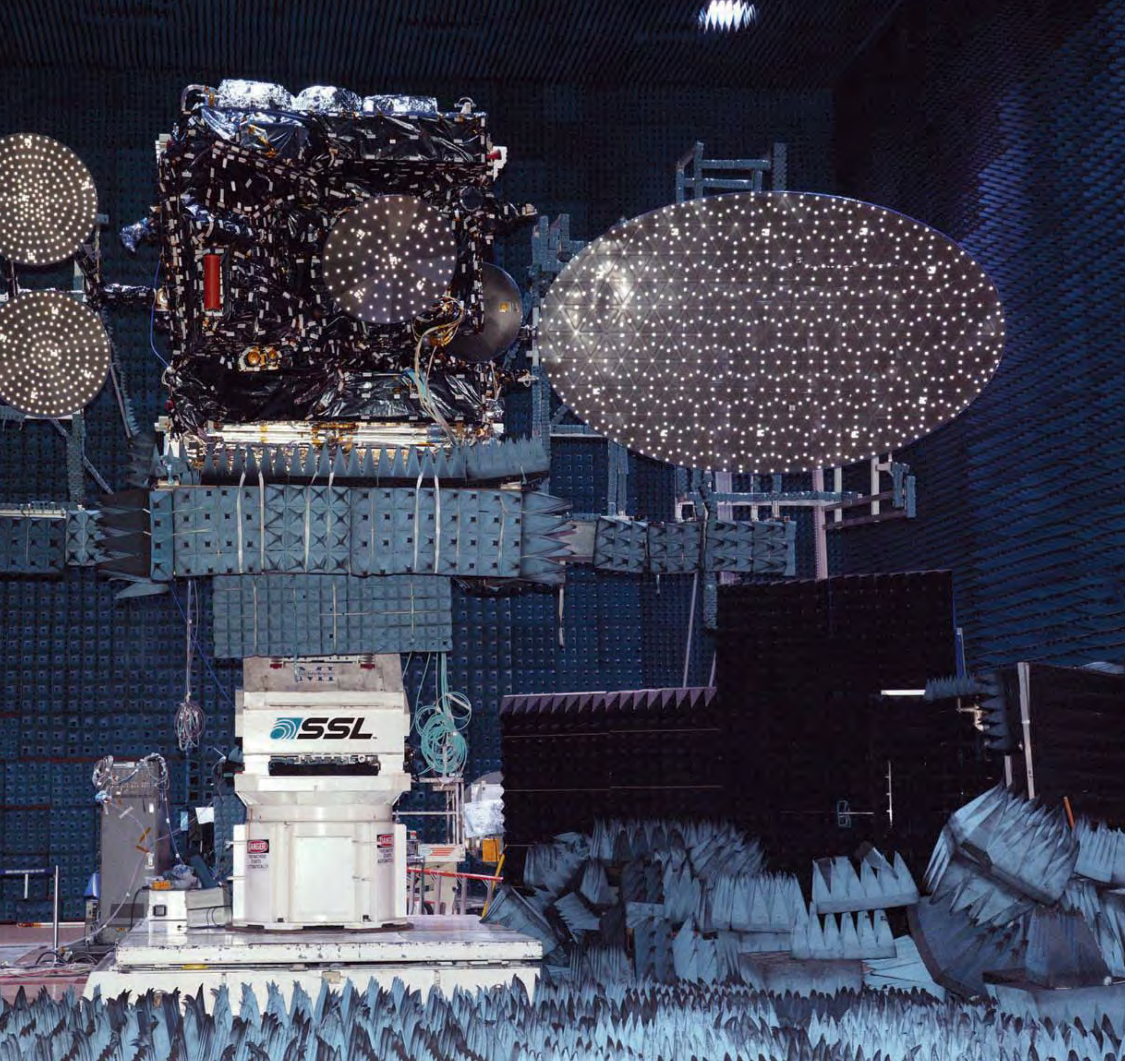
— Debra Werner



Satellite startup OneWeb has picked Airbus Defence and Space to design and build hundreds of microsatellites with the goal of making affordable Internet accessible everywhere around the world.



where you can't use it," says ViaSat's Lippert. That flexibility is especially important in a market prone to changing rapidly. Communications traffic in Latin America and Africa has lately grown more quickly than in Europe, a traditionally strong market. Consumers have grown so attached to their mobile devices that they want broadband connections on boats, trains and planes. Satcom companies are particularly wary of this kind of shifting geographic demand because they often pay hundreds of millions of dollars to buy, launch and insure spacecraft designed to last 15 years or more.



Thor 7 satellite does not have a digital processor on board, but its beams are still "switchable," allowing ground operators to adjust power levels to boost capacity in high-demand areas.

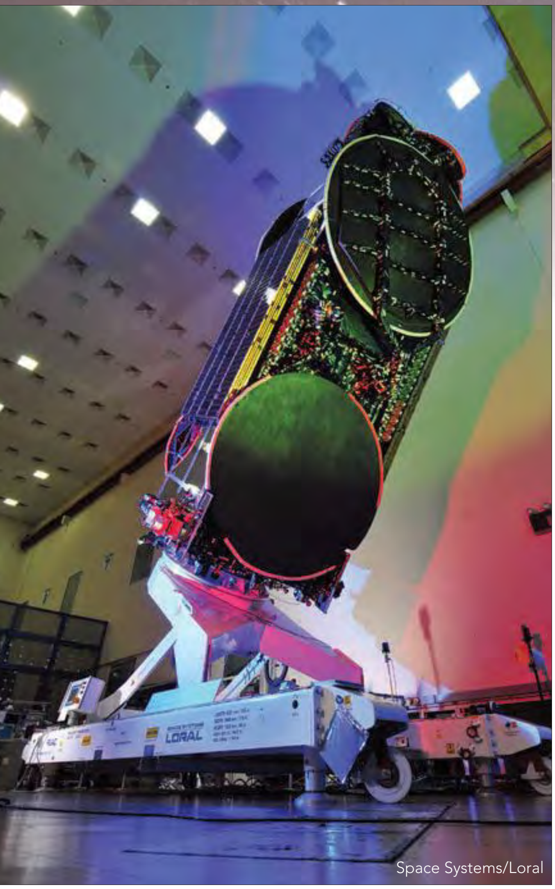
"They want to make sure a satellite designed today and launched in three years will still be viable in 18 years," says Carolyn Belle, a senior analyst for Northern Sky Research, an international market research and consulting firm based in Cambridge, Massachusetts.

Intelsat, for instance, says that with its EpicNG satellites it will be able to observe how communications traffic patterns vary over a 24-hour period and modify its coverage accordingly, sending signals from the satellite to one set of ground antennas in the morning and a different set in the afternoon. Intelsat also can change the frequency of information sent and received by the satellite. "I can uplink in C-band, go through the digital payload and rather than coming down with a C-band transmission, come down in Ku-band," Guilleman says. That capability would be useful, for example, if one of Intelsat's customers wants to transmit in C-band over two-thirds of Africa, but test the reception for Ku-band communications in another region.

Advocates of digital processors say the devices are worth any expense because of the ease of reacting to changes in demand. "We like to joke that it may take satellite operators longer to decide what changes to make than to actually do it," says Mark Spiwak, Boeing Satellite Systems president.

Boeing developed the family of digital processors it is installing in EpicNG satellites to help the U.S. military transmit high-resolution imagery and videos through Wideband Global Satcom-1, a U.S. Air Force-operated satellite launched in 2007. Since then, the Air Force has ordered nine more spacecraft in the Wideband Global Satcom series and Boeing has produced six generations of digital processors for military and commercial satellites.

Another major defense contractor, Lockheed Martin Space Systems, is building a digital signal processor for SaudiGeosat-1, a satellite scheduled to launch in 2018 for the Arab Satellite Communications Organization, a communications satellite operator based in Riyadh, Saudi Arabia. With this processor, operators can redirect the satellite's beams to focus on different ground antennas and change the radio frequency of data to eliminate interference and jamming, Lockheed Martin says.


Space Systems/Loral

ViaSat-1, an all-Ka-band satellite, provides broadband connection to residential customers and airlines in North America.

In another trend, the choice between digital and analog is becoming more than an either-or decision. Some manufacturers are combining analog and digital components on the same spacecraft, says Hampton Chan, vice president and chief architect at Space Systems/Loral of Palo Alto, California. Many traditional broadcasting missions are "perfectly suited" for regional beams and analog equipment, Chan says. Those customers can use the less expensive analog service.

Weight watching

High throughput satellites, whether analog or digital, use spot beams to concentrate radio frequency signals on smaller areas. Because the beams focus more power in those areas, customers can communicate via smaller, less powerful ground antennas. Another benefit is that as long as the beams are focused on different areas, satellite owners and operators can relay many different signals in the same frequency band without causing interference. Also, satellite operators are increasingly opting to purchase satellites equipped with both regional and spot beams. The new multi-mission satellites must be packed with electronics and carry dozens of feed horns to shape the signals each beam sends to the ground.

"It's becoming a careful dance because the increase in weight affects the launch price," says Belle, the Northern Sky analyst.

To keep the weight in check, satellite manufacturers are slimming down other satellite components, like replacing nickel hydrogen batteries that provide power when a spacecraft's solar panels are not illuminated with lithium-ion batteries weighing 30 to 50 percent less. Manufacturers also are focusing on the latest propulsion technologies.

When a communications satellite launches, approximately half its mass is liquid fuel that is burned to move the spacecraft from the transfer orbit where a rocket drops it off at its intended location in geosynchronous orbit and to remain there for 15 years. That is the case for the first EpicNG satellite, which carries 16 hydrazine thrusters. On the second EpicNG satellite, Boeing is reducing the fuel load by adding four electric arcjet thrusters, which produce thrust by forcing propellant heated by an electrical charge through a nozzle at supersonic speeds. Intelsat will use the arcjets thrusters on its second EpicNG satellite, Intelsat 33e, to prevent the satellite from traveling too far north or south once it reaches its intended orbit. Arcjets thrusters use about one third as much fuel as hydrazine thrusters to produce the same force, which means EpicNG can allocate that weight to its communications payload, including its digital brain.

As I gaze up at the satellite towering over me, I can't help but wonder whether giant spacecraft with digital signal processors are the way of the future. EpicNG may soon answer that question.


SPACE 2016
13–16 SEPTEMBER 2016
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2015 Was A Big Year For Space...
That's how NBC News reported it in their December 28 story: "Year in Space: 2015 Pushed Boundaries of Exploration, Habitation." And NBC wasn't the only news outlet to describe 2015 as the Year of Space. On January 4, the Los Angeles Times reported: "When it comes to incredible science, 2015 will be hard to top...But 2016 is shaping up to be pretty intriguing too."
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FACEOFF

Two years after the disappearance of MH370, two rival satellite companies are vying to convince airlines and aviation authorities that each has the best plan to keep airliners from vanishing. Warren Ferster spoke to the architects of each idea.

In a satellite factory near Phoenix, engineers and technicians from Orbital ATK are assembling the final components of the first in a constellation of satellites that will collect position and identification broadcasts from airliners flying hundreds of kilometers below. Those signals, called ADS-B for automatic dependent surveillance-broadcast, were originally meant to be received only by other aircraft and ground towers. But the signals also radiate off into space, which is where a company called Aireon, based in McLean, Virginia, plans to gather them with electronics and antennas on each of the 72 planned Iridium Next satellites.

Aireon's plan isn't the only option for tracking planes when they're cruising over oceans or mountain ranges far from radio towers. London-based Inmarsat says it can meet most of the tracking needs right now by receiving position transmissions directly from the aircraft via its fleet of geosynchronous satellites above the equator.

over airliner tracking

Adobe

Air traffic control can't track airliners wherever they are in the world. Two satellite industry rivals are touting competing options for fixing the blind spots.

It's been a contentious time for these rivals, and for more than the usual reasons of profit, losses and balance sheets. At stake is how best to reduce the risk of more cases like that of Malaysia Airlines flight 370, which vanished two years ago this month with 239 aboard. Playing out in the months ahead will be a race of sorts. Aireon's payloads must arrive in orbit safely and on time to start tracking aircraft in early 2018. Inmarsat has a window to make its case to the airlines and aviation authorities that they should embrace its alternative approach in part because of the potential it creates for receiving a flood of data from airliners, perhaps including cockpit audio.

Wakeup call

The disappearance of the Malaysia Airlines Boeing 777 was reminiscent in one respect of the Air France crash off Brazil in 2009. Investigators searched frantically for the wreckage of that

by Warren Ferster
fersterx@gmail.com

Airbus A330 at the bottom of the Atlantic Ocean before finding it in May 2011, 23 months after the crash. The two tragedies spurred an international outcry for a system that would, at minimum, enable civil aviation authorities to more closely track aircraft flying over oceans and other remote areas.

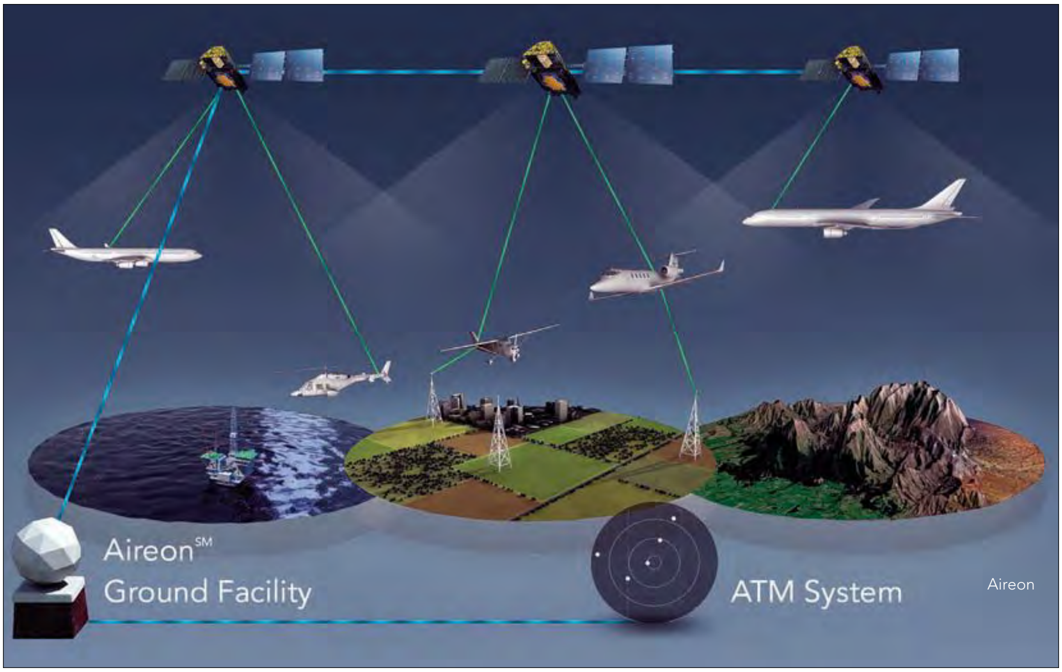
One result was the International Telecommunication Union decision in November to permit satellites, not just airliners, to transmit in the frequency reserved for ADS-B. The decision was good news for Aireon, because it meant that the Iridium Next spacecraft will be able to bounce ADS-B signals from satellite to satellite and into the company's ground network without risk of interference from other transmissions. Before the decision, Aireon did not have primary spectrum allocation and risked compromise of its service. It was an unusually swift decision for the 193-nation telecommunication union, the U.N.-affiliated bandwidth regulatory authority known for lengthy deliberative cycles that culminate every three to four years at World Radiocommunication Conferences, month-long conclaves in Geneva.

"It was huge," says Nancy Graham, who helped get that regulatory ball rolling before leaving her position a year ago as director of the Air Navigation Bureau of the U.N.'s International Civil Aviation Organization. She is now president of Graham International, her consulting firm based in San Antonio. ICAO had urged the ITU to take up the ADS-B-via-satellite matter in response to the MH370 disappearance, and it was placed on the WRC-15 agenda despite opposition from Inmarsat and other geosynchronous satellite operators who cautioned against a rush to embrace satellite-delivered ADS-B.

Part of the mystery of MH370 is that it was equipped with another form of automatic dependent surveillance, called ADS-C, which has been in use since the 1990s. When ADS-C is enabled and functioning, it establishes a satellite link to send data to an air navigation authority under a contract that spells out the kind of information to send and how often. This system was installed but not operating when the jetliner went astray. Were the satellite link operational, authorities might have had a fairly good idea of where the doomed aircraft went.

Inmarsat

Inmarsat's strategy is centered on ADS-C, even though the FAA has mandated that aircraft flying in U.S. airspace must transmit identity and position data by 2020 via ADS-B. Europe's air traffic control authority has issued a similar mandate with a 2017



Starting in 2018, the Virginia-company Aireon plans to track aircraft from space using antennas on the Iridium Next satellites scheduled for launch this year and next. The Aireon payloads will collect identity and position broadcasts from airliners.

effective date, while ADS-B is already in use in Canada and Australia.

But ADS-C remains useful. Until Aireon begins its service, ADS-B information can only enter an air-traffic-control network when the plane is within range of a radio tower. That means aircraft flying through remote regions still rely on ADS-C. These transmissions can be received and relayed by Inmarsat's geosynchronous satellites or Iridium's current constellation, except for planes flying at high latitudes where geosynchronous satellites can't reach. In those cases Iridium is the only option because its satellites cross from pole to pole in low Earth orbit.

Mary McMillan, vice president of aviation safety and operational services at Inmarsat, acknowledged that aircraft flying north of 84 degrees north latitude are beyond the reach of Inmarsat services. But she noted that of the four main polar routes used by commercial airliners, only one falls into that category, numbering fewer than 20 flights per day that are out of Inmarsat's reach for a brief period.

Inmarsat touts the fact that ADS-C service is available today aboard more than 90 percent of commercial airliners flying transoceanic routes. ADS-C piggybacks today on a service called ACARS, for Aircraft Communications Addressing and Reporting System, which packages the GPS-derived position-location data before transmitting it via satellite. The primary function of ACARS is to periodically forward aircraft performance information to the airlines that use it to schedule maintenance procedures.

McMillan says Inmarsat is rolling out a new service dubbed Swiftbroadband-Safety that dramatically improves on the current ADS-C service, known as Classic Aero, by sending large data packages via Internet Protocol. The shift to IP opens the possibility of transmitting all sorts of information in real time, possibly including cockpit data and audio that are today recorded in an aircraft's black boxes and recovered after a crash.

McMillan, who during a 30-year career as an airline pilot witnessed the transition from inertial guidance systems to GPS, characterized the emerging services as a major breakthrough.

"It's actually like going from a rotary dial phone to an iPhone — that's where we are," she says. Swiftbroadband-Safety "retains all of the functionality of Classic Aero but it also is going to enable a whole new class of functionality and capabilities that when I started flying I could only dream about."

Automatic dependent surveillance-broadcast sites like this one in Western Australia receive position and identification broadcasts from airliners and route them to air traffic controllers. Soon, ADS-B broadcasts might be relayed by satellites, too.

Airservices Australia

A tall hurdle stands in the way, and it has little to do with technology. The problem is that ADS-B and ADS-C are safety-of-life services that operate in protected spectrum, which is "extraordinarily limited," Graham notes. If it weren't for that, relaying black box data in near real time is "absolutely" feasible today, she says.

ITU and ICAO have not yet decided whether sufficient spectrum is available for transmitting voice and other data from thousands of airliners in protected frequencies.

McMillan concedes that the bandwidth question is an unknown. "I think there's going to be a lot of work in the industry to determine what is a safety service and what is not."

There also are other questions centered on costs and how those would be divvied up.

In the control tower at Melbourne Airport, a controller from Airservices Australia tests an Inmarsat satellite service that can track planes over the ocean. The service relays position and identification information transmitted by airliners in the Automatic Dependent Surveillance-Contract format.

Airservices Australia

Counting on Russia, Ukraine and SpaceX

Aireon sees big advantages to those who will embrace its service. Don Thoma, Aireon's chief executive, says Iridium Next is tailor-made for delivering ADS-B data to those who need it. The Iridium Next satellites are equipped with crosslink antennas to pass transmissions from one satellite to the next for speedy data delivery. They are also backed up by a network of teleports on the ground.

"Aireon is riding on top of the Iridium network and has been designed from day one to provide an air traffic control safety-surveillance capability," Thoma says.

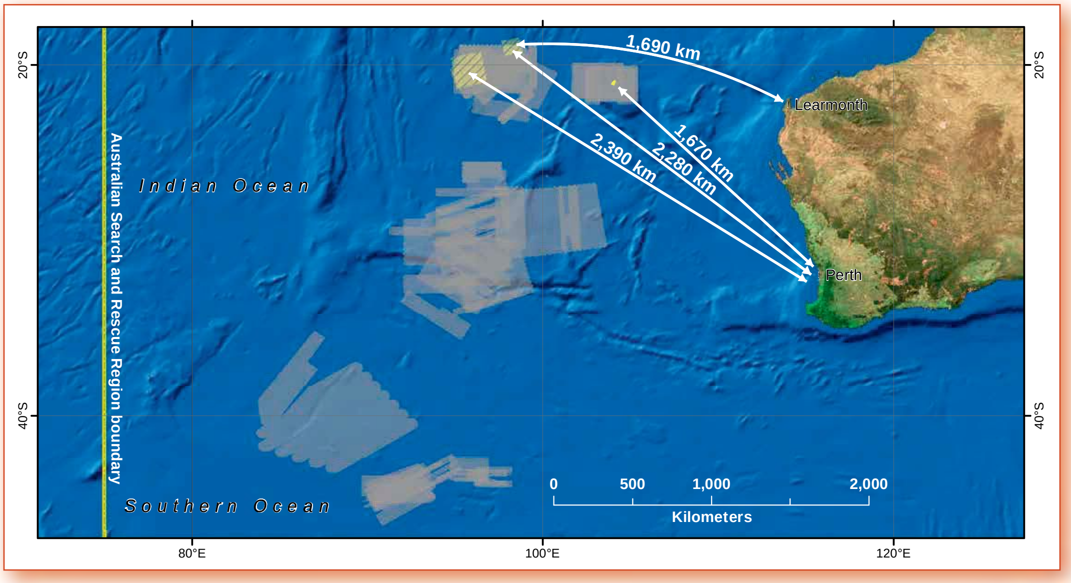
In addition to preventing disappearances, aircraft on transoceanic flights would be able to fly in closer proximity without risk of colliding. Search and rescue authorities could be alerted more quickly if something goes wrong. Economy is the other main benefit: Aireon is expected to enable airlines to fly more fuel-efficient routes over the oceans, thereby saving money.

Aerion has its share of challenges, too, however. The advertised availability date of early 2018 assumes Iridium Next deployment goes off without a hitch, always a big if in the space industry. Plans call for the first two satellites to be launched aboard a Russian-Ukrainian Dnepr rocket and then undergo four months of on-orbit testing before the rest are launched in batches of 10 aboard Falcon 9 rockets from SpaceX. Iridium announced in October that the Dnepr launch would be delayed from December to April 2016 due to satellite component issues.

Iridium says that even with that delay, it's on track to complete the network by the end of 2017 and start operations in 2018. A Falcon 9 failure, though, like the one in June on a resupply mission to the International Space Station, would likely ground the Falcon 9 fleet for several months, throwing off Iridium's timetable.

How often should planes report?

A criticism of ADS-C centers on the fact that its position and identity reports are intermittent, whereas ADS-B is a nearly continuous broadcast. McMillan of Inmarsat says ADS-C



Australian Maritime Safety Authority

When Malaysia Airlines Flight 370 disappeared in March 2014, searchers initially looked for the jetliner in the Gulf of Thailand and the South China Sea. But the hunt gradually shifted to the southern Indian Ocean, with Australia leading the efforts. Brown areas on the map show waters searched between March 18 and April 10 of that year. Areas in yellow with hash marks indicate planned searches on April 11.

transmits position reports once every 14 minutes on average, which is based on the time it would take an aircraft to wander into another's boxed-off space under the current separation standards. Graham, the former Air Navigation Bureau chief, notes that ADS-C providers could negotiate more frequent position reports with their customers.

Still, Aireon executives see the reporting issue as a key differentiator. Today, search and rescue operations might not begin until 42 to 45 minutes after an aircraft has gotten into trouble, says Cyriel Kronenburg, Aireon vice president of aviation services. "So draw a circle of 45 minutes of 500 mile-per-hour flight and that gives you a huge area to work with," Kronenburg, says.

Aireon calculates that ADS-B signals can be delivered to controllers in eight seconds and a search could be initiated 24 seconds after the signal from an airliner is lost.

McMillan, in addition to pointing out that ADS-C transmission rates are negotiable, notes that ADS-C is a two-way service, whereas ADS-B is a one-way broadcast. Two-way communications are needed for many of the FAA's proposed NextGen navigations applications, she says.

A new role for smartphones?

Another question is whether it might somehow be possible to tap the transoceanic broadband satellite connections that might soon become the norm for smartphone-equipped passengers who are willing to pay for the connectivity.

After all, lost smartphones can be located. Why not do the equivalent with an airliner?

The situation is not that easy, however. Unlike satellite-delivered ADS-B or ADS-C, the new broadband satellites do not operate in the protected safety-of-life spectrum. That would appear to rule them out as official surveillance tools for air traffic control authorities, at least for the foreseeable future. Until something else comes along, the choice appears to be between Aireon and Inmarsat, or perhaps even some combination of the two.

FRESH THINKING

For NASA to get humans to Mars in the 2030s, it's going to have to target research wisely and devise a realistic strategy for the journey. Dennis M. Bushnell and Robert W. Moses of NASA's Langley Research Center describe some alternatives going forward.

ABOUT MARS

by Dennis M. Bushnell
dennis.m.bushnell@nasa.gov

and

Robert W. Moses
robert.w.moses@nasa.gov

NASA/Jet Propulsion Laboratory-CalTech

NASA has a timetable for getting humans to Mars. But the mission must be safe and affordable.

Human exploration and pioneering of Mars is a top goal of the U.S. civilian space program. In fact, it might be the most important goal. Today's target date of the 2030s gives us enough time to prepare for such a mission.

NASA over the years has drafted a series of Design Reference Missions describing the primary critical elements. The most recent of these calls for sending about 900 metric tons of equipment and fuel into Earth orbit and then on toward Mars to deliver 10 to 20 metric tons of food, scientific equipment and a crew of four to six astronauts to the surface of Mars.

We have not yet determined the safety-related equipment, procedures or reliability features that would be required for a crew to survive and perform meaningful research in such a harsh environment. Living in micro and partial gravity for years will affect crews in ways we do not fully understand. The same is true for galactic cosmic radiation, which courses through the solar system beyond Earth's protective magnetosphere. Mars is famously dusty, and based on our experiences with robotic missions, the dust infiltrates everything. That will pose a reliability challenge for equipment and a health hazard for astronauts. In short, a Mars mission may not yet be in what program managers call the combined cost and safety box. There may not be enough cost margin to afford safety and reliability.

How do we get into the box? One approach is by rethinking today's Mars architecture to take advantage of unfolding advances in autonomous control and additive manufacturing. We could, for instance, adjust our research and development spending to examine the possibility of sending systems to Mars ahead of human explorers to begin robotic autonomous in situ resource utilization and in situ fabrication and repair.

A role for robotics

Many who think about human exploration of Mars have known for years that in situ resource utilization could be the key. Studies indicate that every 1 kilogram of equipment or supplies produced on Mars reduces the requisite mass that must be sent to low Earth orbit by some 7 to 11 kilograms. A 2012 National Research Council review of the NASA Space Tech Roadmaps concluded that "the use of lunar- and Martian-derived propellants could reduce launch masses by over 60 percent," and the review called this a "game changer for exploration."

ISRU concepts are further described in the paper, "Capability and Technology Performance Goals for the Next Step in Affordable Human Exploration of Space," presented at the AIAA 2015 SciTech Forum.

The new thinking is that robots would take ISRU far beyond gleaning water and oxygen from the ice beneath the Martian surface and at its poles. With extensive ISRU, the robots would turn Martian resources into plastics, metals and other construction materials. Also, sintering processes allow us to produce construction materials from the regolith, in addition to making the plastics and metals feedstocks. Additive manufacturing equipment on the surface would then turn this material into rovers, habitats, life support equipment and piping — in short, nearly everything. This will further reduce dependence on Earth-made logistics. This is described in "Sustaining Human Presence on Mars Using ISRU and a Reusable Lander," presented at the AIAA Space 2015 Forum.

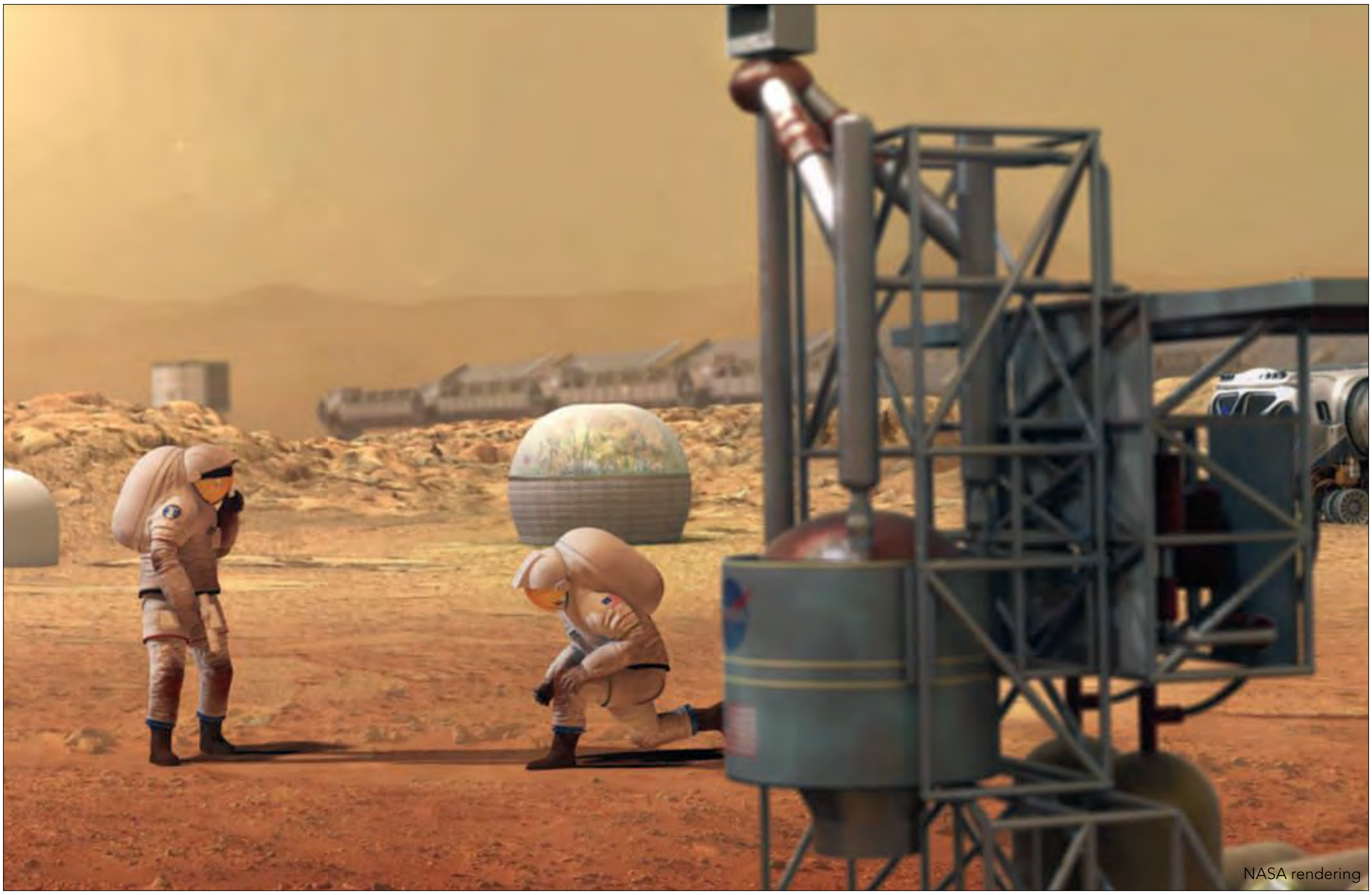
We could send to Mars the equipment that would achieve safety and reliability prior to human arrival. Mars would become a proving ground to demonstrate the reliability of the equipment required by the crew before the crew ever leaves Earth. Robots, after all, don't need paychecks.

There would also be health benefits. Consider again the Martian dust. Without protection, perchlorates in the dust would attack the astronauts' thyroids. There may be lethal components of the dust such as hexavalent chromium. By robotically establishing an operating habitat on the surface, the failure modes of protective equipment could be understood and accounted for prior to the crew leaving Earth. We would effectively be demonstrating safety and reliability on planet. Making and setting a habitat in the ground and covering it with 5 meters of regolith should provide excellent radiation, thermal, micrometeorite and "dust devil" protection. With gravity 38 percent of Earth's, the pressure inside the inflatable is more than sufficient to hold up the few meters of regolith resting on top.

Revolutionary technologies

The current NASA architecture focuses mainly on evolutionary improvements to extant technologies, but it is not clear that those will safely and affordably get us to the Earth independence phase as described in the "Evolvable Mars Campaign" proposed by Jason Crusan, director of NASA's Advanced Exploration Systems Division. EMC suggests we explore Mars in three phases, starting with an Earth Reliant phase, moving to the Proving Ground phase and then to Earth Independence. EMC's proving ground is not Mars, however, but cis-lunar space.

The seeds of a transition to greater resource utilization on Mars have been planted. A 2014 blog on the White House website, "Bootstrapping a Solar System



NASA envisions deriving oxygen, water and fuel from the Martian atmosphere and soil, greatly reducing the supply mass needed to be transported ahead of human exploration.

Civilization," refers to expansive ISRU as "massless exploration," for instance. A public announcement in May 2014 by NASA Administrator Charles Bolden, "Pioneering Space: NASA's Next Steps on the Path to Mars" defines "living off the land" of Mars as one of NASA's top priorities. In October, NASA announced its "Journey to Mars: Pioneering Next Steps in Space Exploration," which aims to align future rover missions with preparations for future human explorers on Mars.

For the extensive ISRU we propose, we'll need revolutionary improvements to the underlying technologies. These revolutionary solutions could, we believe, make Mars exploration even more safe and affordable.

The good news is there is time to do this work. Such revolutionary technologies typically require low technology-readiness-level research and triage of several approaches to determine the most efficacious and viable ways forward. Nominally, technologists require some 10 years to execute the low TRL ideation and research phase, followed by about 10 years of development prior to the mission. Some of the ideation work has been done, so given the target date of the 2030s, the required time frame may be achieveable.

Resource-rich target

The fundamental enabler for this extensive ISRU is the massive amount of resources known to exist on Mars, described for example in the 2009 book, "Mars: Prospective Energy and Material Resources," a compilation by Viorel Badescu of the most recent papers on the resources of Mars and some latest thought on their utilization. The carbon dioxide in the atmosphere can be cooled and collected, providing a supply of carbon and oxygen. There is water nearly everywhere, at the poles, in the regolith and in huge ice lakes. Above 60 degrees latitude, some 40 percent of the regolith is water. Then there is the water tied up in hydrated materials. Estimates indicate there is sufficient water to put an ocean over the whole planet. Estimates vary with respect to the depth of such an ocean, ranging from tens to many hundreds of meters. Much of this water, simplistically, could be vaporized and collected via a cart with a microwave device affixed to it. Alternatives include a greenhouse "solar tent." The resulting supply of hydrogen, oxygen and carbon from the atmosphere, enables the manufacture of major amounts of methane and hydrogen fuel and plastics.

There is increasing evidence that food could be grown on Mars inside greenhouses. Produce could include mushrooms, insects for essential fats, cyanobacteria for protein and duckweed, to name a few.

Also, as a general design approach, equipment produced on Mars just has to work. It does not have to be fancy or finely finished. Studies are needed to determine the minimal initial payload size, weight, cost and composition of the requisite autonomous robotics. These robotic machines could initially replicate themselves to increase productive capacity and capability and then execute resource location, extraction, refining, fabrication and operations. Relatively small initial "seedling" packages of autonomous robotics may be sufficient. Transport of initial ISRU autonomous robotics and printing payloads could conceivably be via solar electric propulsion or "slow boats."

Nearly everything that humans would require on Mars is rapidly becoming feasible to produce on planet. Advances in machine intelligence are pointing the way toward autonomous robotic and 3D printing. By knitting these advances together, a smallish supply package could possibly be sent to Mars some five years or so before humans go.

Getting to the surface

In addition to prepositioning supplies and addressing the many health concerns ahead, there is the physics of landing a crew on Mars. Today's state-of-the-art technology for entry, descent, and landing limits payload mass to around one metric ton, far below the 10 to 20 metric ton payloads anticipated for human missions to Mars.

An enabler for serious ISRU is a reusable Mars Truck, sometimes called a Mars Ferry. The idea is described in the paper, "Sustaining Human Presence on Mars Using ISRU and a Reusable Lander," by our colleague Dale Arney at Langley. The Mars Truck would transport materials and eventually humans to and from the planet to Mars orbit, using Mars-produced fuel, while certifying the vehicle for crew flights. Such a craft could possibly enable inexpensive Mars fuel and products to provide resources for colonization of the inner solar system, effectively turning Mars into Walmart.

Landing the crew is not the only large payload taxing entry, descent and landing capabilities. The nuclear-energy device necessary on the surface to power the ISRU equipment, habitats, and recharge batteries weighs several metric tons. It also requires a heavy cable to transfer the electrical power from the nuclear device to the equipment and habitat. Therefore, more mobile lighter-weight devices are needed.

Energy

The energy to execute serious pre- and post-human-arrival ISRU could be sourced from scaled fission reactors, solar and chemical fuels. This approach also could be applied to in-space and other propulsion applications. However, within a nominal 10-year low TRL research window, there are several other extremely interesting alternative energetics approaches that could be considered, investigated and triaged.

Russian researchers have developed a fluidized bed vortex reactor that is exceedingly compact.

Sang Choi here at Langley has invented a Nuclear Thermal Avalanche Cell approach to dramatically increase RTG (radio thermoelectric isotope generator) energy production.

Researchers also have some 25 years of experiments with Low Energy Nuclear Reactions (LENR), which provides energy with negligible radiation. Large commercial investments are now being made to understand, scale and engineer LENR to be safe. This technology could conceivably power the Variable Specific Impulse Magnetoplasma Rocket designed for fast, in-space propulsion.

There is also the concept of Osmatic Power utilizing solar regeneration.

Energy conversion advances are being made, including in the fields of thermoelectrics, pyroelectrics, thermal photovoltiacs, fuel cells and Sterling cycles.

For Energy storage, there is research on zeolites, which could hold four times more heat than water. Advances are also being made to metal air batteries and flow batteries, and storing either hydrogen or electricity as an ultra capacitor in nanotube structures, skins and chemical fuels.

Martian-derived fuels such as methane and hydrogen could be used for transportation in Mars orbit and for trips to Earth and back, in addition to powering rovers and other surface operations. Mars-derived fuel could be placed in orbits between Earth and Mars, creating the game-changing option of en route fuel depots and refueling. Another use for the fuels would be powered entry, descent and landing. The current state of the art with respect to EDL involves inflatable drag producing decelerators and lower speed systems, but it might also be possible to utilize the plasma generated during entry.

These are just some of the alternative approaches that may get humans to Mars safety and affordably.

Dennis M. Bushnell *is chief scientist at NASA's Langley Research Center in Virginia. He has worked on some of NASA's most groundbreaking missions, including Gemini 3 and the first space shuttle flight. He was selected in January as an AIAA honorary fellow and is a member of the National Academy of Engineering.*

Robert W. Moses *is an aerospace engineer at Langley specializing in developing systems and technologies to enable mission capabilities. Since 2003, he has led studies into a variety of entry, descent and landing techniques for Mars. He serves on the Office of Chief Engineer's Systems Capabilities Leadership Team on ISRU and is an associate fellow of AIAA.*

Choosing, designing and making aerospace parts out of materials has traditionally followed the "make it, break it" approach that can require expensive rework. But integrated computational materials engineering, or ICME, offers a better way to do it right the first time. So why aren't more engineers using ICME's modeling and simulation approach? Michael Sangid and John Matlik explore the obstacles.

ANALYSIS

A better way
to engineer aerospace components

by Michael D. Sangid
msangid@purdue.edu

and

John F. Matlik
John.F.Matlik@rolls-royce.com

Like many aerospace manufacturers, Rolls-Royce aggressively seeks ways to reduce the amount of scrap materials from errors in manufacturing components. In many instances, the company has moved away from the traditional "build it, break it" approach to producing parts, which is expensive, slow and wasteful.

Today, Rolls-Royce can produce 99.98 percent of forged parts for its gas turbine engines correctly the first time. In doing so, Rolls-Royce has cut the time spent on geometric forming trials of turbine discs, the most critical component of the engine, by 90 percent. The company also has worked with suppliers to reduce waste from throwing away defective or otherwise subpar components — which can constitute half or more of manufactured parts — to zero.

Rolls-Royce did that by digitally integrating design and manufacturing, using process modeling maps to virtually represent the components and to simulate the manufactur-

ICME Inside: QuesTek Innovations of Illinois applied integrated computational materials engineering to design parts for the KC-135's landing gear out of ferrium S53, an alloy that does not require toxic cadmium plating to retard corrosion.

U.S. Air Force/Austin M. May

ing process and predict materials performance. This approach gave Rolls-Royce the freedom to tinker with the design as much as it wanted at the beginning, instead of redesigning and replacing parts later.

This method, called integrated computational materials engineering, ICME, has the potential to produce aerospace parts twice as fast at half the cost. Yet the aerospace industry has been slow to embrace ICME. Program managers, fearful of delivery delays, are hesitant to ditch bloated legacy design practices and take a chance on innovative approaches they deem — rightly or wrongly — as risky.

Thus most engineers still follow the trial-and-error recipe for discovering and testing new alloys: scan the tabularized data of similar materials, apply their judgment to select promising candidates, build test parts and continue redesigning until they get it right.

These entrenched design practices stem in part from difficulties in forecasting, or a reluctance to share discoveries about innovations in materials processing in early stages that could benefit everyone. Corporations and organizations have been wary of touting their successes with ICME lest they give away this intellectual property, or "secret sauce," that helps differentiate them from other competitors. This makes it difficult, if not impossible, to quantify the potential benefits of ICME to companies that haven't yet adopted it.

Publicizing ICME's benefits

However, a growing number of publicized success stories from across the aerospace community ought to inspire more serious consideration of ICME.

QuesTek Innovations of Evanston, Illinois, for instance, tapped ICME to design and produce high-strength steel for use in landing gears, gearboxes and helicopter rotor shafts. QuesTek took a systems ap-

Making parts with more prework and less rework

Traditionally, an impeller is first designed, then fabricated. After that, a small specimen is cut out and tested until it fails in order to gauge the material's strength. By contrast, integrated computational materials engineering employs models to simulate stresses in the materials before fabrication. The magnified cube (right rear) shows the propeller's microstructures. The cube in front of it indicates the microstructures' stress points. In general, red means high stress and blue indicates low stress.

Graphic: Purdue University/Andrea Nicolas

proach to apply computational materials design models to search for links between processing structure, properties and performance to calculate the benefits and tradeoffs of various materials.

Similar to baking a cake, QuesTek didn't mix various ingredients and decide after tasting that it needed more flour and less sugar. Instead, the company used ICME to mine the universal database of cake recipes and cross-referenced them with reviews, taste profiles and baking characteristics to formulate an optimal cake mix before putting it in the oven.

QuesTek estimated that getting the cake right the first time — or shortening the alloy development time — yielded almost $50 million in savings. ICME enabled QuesTek to design alloys that are lighter, last longer, and better resist corrosion and high temperatures. The company's ferrium M54 steel is being manufactured into hook shanks for the Navy's T-45 jet trainer and its ferrium C61 is undergoing qualifications for use in the forward rotor shafts of Boeing's Chinook helicopters.

In another case study, General Electric was able to reduce its dependence on rhenium, a rare earth element that is complicated to mine and to process, for its aircraft turbine blades. GE found suitable alternatives with two single-crystal nickel-based superalloys. The hunt took just two years, one-third the time it typically takes to introduce new materials.

In searching for a rhenium substitute, GE opted for modeling and simulation to pinpoint materials with promising composition, which offered environmental stability and resistance to deformation at high temperatures. GE used neural networks, which represent machine learning and pattern recognition software, to identify stable structures that satisfied a list of their requirements based on training data. This approach limited the number of trials to screen.

Overcoming skepticism

Nevertheless, a lack of trust in the materials computational models is hindering acceptance of ICME. Convincing corporate stakeholders of the potential benefits is another challenge.

On top of these cultural impediments, tangible barriers also have slowed the spread of ICME. Engineers do not have all the tools they need to quickly tap ICME to get their questions answered. Data sharing is critical because information about the properties of various materials — such as strength, ductility or fracture toughness — historically has been generated for a single purpose and not stored in such a way to facilitate easy retrieval, rendering the data essentially lost. We need a central repository that would enable us to capture, curate and disseminate the valuable information while compensating those who contribute the data.

Overcoming these challenges may not be easy. Engineering historically has been divided into silos. The different folks working in design or structures or manufacturing don't communicate well, or don't communicate at all. It's critical to have a systems-level understanding of how engineers interact with one another.

Simply put, we are moving beyond the information age and are drowning within infinite data. We are now entering a systems age.

We see some encouraging signs for ICME's future. Large aerospace companies and their suppliers, including ATI-Ladish, a forging company, have formed interdisciplinary teams to accelerate the discovery of materials in a non-competitive format to benefit the broader industry. The U.S. Air Force has identified residual stress as a foundational engineering problem requiring collaborative solutions. When materials are manufactured, internal stresses cause components to warp, undermining their designed geometries and tolerances. These residual stresses combined with in-use loads can lead to catastrophic failures. By relying on computational models validated by targeted measurements of residual stress, the Air Force aims to reduce weight and extend the life of its equipment, and to encourage ICME's adoption across the supply chain.

Rolls-Royce uses computational modeling in designing and manufacturing its gas turbine engines to eliminate scrap waste in manufacturing parts. That includes the engines on the V-22 Ospreys.

U.S. Air Force

In other words, we hope engineers soon break out of their silos to follow a better path for engineering aerospace components. Rolls-Royce, GE and others have already shown the way.

Michael D. Sangid *is an assistant professor in the School of Aeronautics and Astronautics, with a courtesy appointment in Materials Engineering, at Purdue University in Indiana.*

John F. Matlik *is the chief of life cycle engineering and the lead for the Digital Manufacturing and Design Innovation Program at Rolls-Royce.*

Out of the

25 Years Ago, March 1991

March 20 An Iraqi Air Force Sukhoi Su-22 is shot down by a U.S. Air Force McDonnell Douglas F-15 over Tikrit. The Su-22 took off in defiance of the no-fly zone over Iraq following its defeat in the first Persian Gulf War, which ended days earlier. It is believed that the Sukhoi was attempting to attack rebellious Kurdish targets. David Baker, Flight and Flying: A Chronology, p. 484.

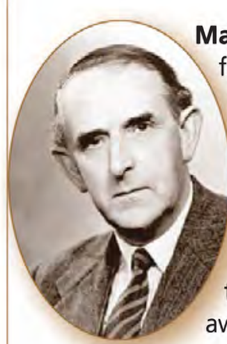
March 20 Major Orestes Lorenzo Perez of the Cuban Air Force defects to the U.S. in a Mig-23 fighter. He takes off on a training flight and makes a dash to Key West, Florida. While he is welcomed to the U.S., his flight embarrasses the Pentagon's air defense, which failed to detect it until the Mig appeared on the radar of an American air traffic controller. David Baker, Flight and Flying: A Chronology, p. 484.

50 Years Ago, March 1966

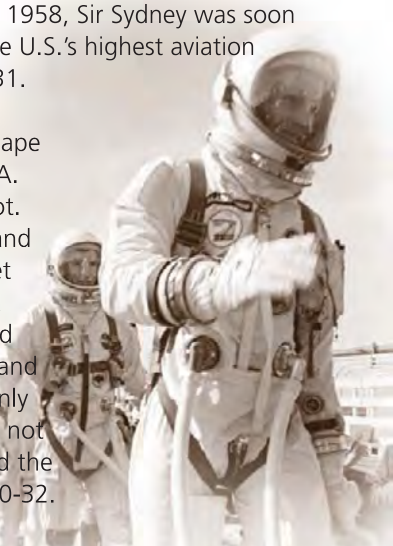
March 1 The Soviet Union's 960-kilogram Venera 3 (Venus 3) becomes the first spacecraft to make contact with another planet, although radio communications were lost just as the probe approached closely to Venus. The spacecraft was to eject and parachute a sterilized scientific capsule on the Venusian surface, then transmit data to Earth. The Soviet probe had been launched from Kazakhstan on Nov. 16, 1965. The previous two Venera probes had missed the planet. On Oct.18, 1967, Venera 4 succeeds in ejecting and deploying its scientific instrument package through Venus' thick atmosphere and briefly transmitting invaluable atmospheric data before its impact. Later, Venera 7 becomes the first space probe to transmit data, if briefly, from the planet's surface on Dec. 15, 1970. It then is destroyed by Venus' harsh environment, with recorded temperature of almost 1,000 degrees Fahrenheit and a pressure of 100 atmospheres. Washington Post, March 2, p. A1 and March 6, p. A14; New York Times, Oct. 19, 1967, p. 1; Washington Post, Dec. 16, 1970, p. A25.

March 3 The NERVA (Nuclear Engine for Rocket Vehicle Applications) system is fired at full power — about 1,100 megawatts — for 94 seconds and reaches a specific impulse of 760 seconds compared to the 430- to 450-second range of advanced chemical rocket propellant systems. Aviation Week, March 21, p. 101.

March 12 Soviet-Armenian biochemist Norair Sisakian, one of the founders of space biology, dies in Moscow at age 59. Born in Ashtarak, Armenia, Sisakian began his career at the Moscow Institute of Biochemistry in the mid 1930s and later made great contributions to the early Soviet space program. He was a member of the Armenian Academy of Sciences, chairman of the Committee of Bioastronautics of the International Academy of Astronautics, won several Stalin prizes for his work and had a lunar crater on the far side of the moon named in his honor. NASA, Astronautics and Aeronautics, 1966, p. 94.



March 12 Sir Sydney Camm, the British aircraft designer of the famous RAF Hawker Hurricane fighter of World War II, as well as the Hunter fighter, the P-1127 VTOL and other combat aircraft, dies in London at age 72. Sir Sydney had a long career in aviation, starting as a carpenter for a small aircraft company before World War I, then joining the Hawker Aircraft Co. in 1923 and becoming its chief designer. The recipient of the Royal Aeronautical Society's Gold Medal in 1958, Sir Sydney was soon to receive the Guggenheim Medal, the U.S.'s highest aviation award. New York Times, March 14, p. 31.



March 16 The Gemini 8 spacecraft is launched from Cape Canaveral by a two-stage Titan 2 with astronauts Neil A. Armstrong as command pilot and David R. Scott as pilot. The primary objective of this mission is to rendezvous and dock with the unmanned, 3,175-kilogram Agena target vehicle that had been boosted into orbit an hour and a half earlier by an Atlas rocket. Using computer data and thrusters, the Gemini capsule pulls off the rendezvous and docking maneuvers, although complications allowed only one of the four planned dockings. Other objectives are not met but overall the mission is considered successful and the spacecraft is recovered. Aviation Week, March 31, pp. 30-32.

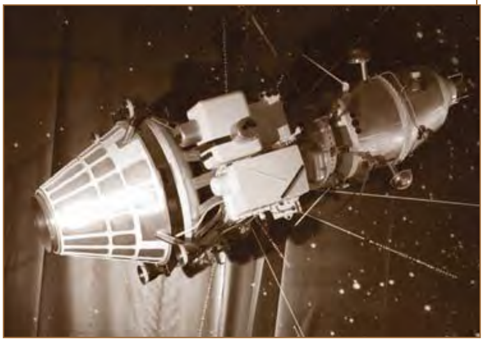
March 16 The Soviet Union's Cosmos 110 spacecraft, launched on Feb. 22 with two dogs, Veterok and Ugolyok, lands safely in the U.S.S.R. The dogs had suffered heartbeat irregularities that became more pronounced toward the end of the 22-day flight but their respiration had changed just slightly. The mission produces much information on the effects of prolonged spaceflight upon living organisms. Aviation Week, March 28, p. 28.

Past

An Aerospace Chronology
by **Frank H. Winter**
and **Robert van der Linden**

March 16 The National Space Club holds a ceremony in Washington, D.C., to mark the 40th anniversary of the launch of the world's first liquid-propellant rocket by the American rocket pioneer Robert H. Goddard. Vice President Hubert H. Humphrey delivers an address. The Robert H. Goddard Historical Essay Award is presented to Airman Second Class Frank H. Winter of the U.S. Air Force, now one of the authors of this Out of the Past column. Four years later in 1970, Winter (above left), then of the National Air and Space Museum, wins the award a second time, but now with a co-winner: John M. Logsdon, a professor at Catholic University in Washington. NASA, Astronautics and Aeronautics, 1966, p. 103; NASA, Aeronautics and Astronautics, 1970, p. 94.

March 31 The Soviet Union launches its Luna 10 that on April 4 is slowed by a retro rocket from an approach speed to orbital velocity in a path around the moon's equator. A 245-kilogram scientific capsule is released and becomes the world's first artificial satellite of the moon. This satellite begins making a survey of the moon's magnetic field, radiation environment and gravitational irregularities and continues to transmit data to Earth for more than 460 lunar orbits until its batteries run out on May 30. David Baker, Spaceflight and Rocketry, p. 193; Washington Post, April 5, p. A12.



75 Years Ago, March 1941

March 14 America's four biggest airlines form Air Cargo Inc. to survey the possibilities of transporting freight and express by air. American, Eastern, TWA and United airlines continue their own passenger services but jointly own Air Cargo, which operates until late 1944. They gather valuable data on air cargo requirements, ground transport problems and related subjects. American Aviation, April 1, pp. 1, 34; R.E.G. Davies, Airlines of the United States Since 1914, pp. 424-425.

March 21 The War Department announces plans for the creation of the "first Negro unit of the Army Air Corps." This is the 99th Pursuit Squadron, which is to be based in Tuskegee, Alabama. It consists of 276 African-Americans from all parts of the country. Subsequently based in Italy, the 99th serves with distinction during the war. American Aviation, April 1, p. 3.

March 22 Maj. C.C. Moseley's Cal-Aero Academy in Ontario, California, becomes the first civilian flying school to conduct basic training for Army Air Corps cadets. BT-15 training planes are assigned by the Army to Cal-Aero for this experimental program to prepare Army fields and officers for more advanced military tactical operations. American Aviation, April 1, p. 8.

March 28 The Royal Air Force announces that its Eagle Squadron, consisting of American volunteer pilots, is fully operational. Subsequently, other groups are formed and serve with distinction. In September 1942, the Eagle Squadrons are formally integrated into the U.S. Army Air Force's 4th Fighter Group. Vern Haugland, The Eagle Squadrons: Yanks in the RAF, 1940-1942, pp. 32-41.

100 Years Ago, March 1916

March 15 America's first tactical aviation unit to become operational is the 1st Aero Squadron consisting of eight Curtiss JN-1s, under Capt. Benjamin D. Foulois. The 1st Aero Squadron subsequently participates in the Punitive Expedition, which attempts to hunt down the Mexican revolutionary Pancho Villa, who had attacked Columbus, New Mexico. Eugene M. Emme, ed., Aeronautics and Astronautics 1915-60, p. 4; Francis K. Mason and Martin Windrow, Know Aviation, p. 18.

March 21 The Escadrille Americaine is formed from a group of adventurous aviators from the U.S. eager to fly and fight for France. Flying Nieuport 11 fighters, they enter combat during the Battle of Verdun. Bowing to pressure from the then-neutral U.S. government, the French air force eventually changes the name of the group to the Escadrille de Lafayette. A. van Hoorebeeck, La Conquete de L'Air, p. 117.

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SYRACUSE UNIVERSITY
Department of Mechanical and Aerospace Engineering
Chair

Syracuse University invites applications and nominations for the position of Chair of the Department of Mechanical and Aerospace Engineering. The Chair will be a respected scholar and a dynamic leader who will join the Department at an exciting time. In the last six years, the Department has achieved significant growth in enrollments in its undergraduate and graduate programs, and it has hired 10 outstanding faculty members. Now, the Department has exceptional opportunities to elevate its research profile and educational mission via a recent commitment from New York State to revitalize the five-county Central New York region, which is envisioned to include strategic investments relating to research, development and manufacturing of “precision sensing technologies and data analytics” with an initial focus on the testing, innovation, and manufacturing of unmanned aerial systems. The University seeks a visionary and strategic individual who will enable the Department to maximize these potentially transformational opportunities.

Mechanical and Aerospace Engineering is one of four departments within the College of Engineering and Computer Science at Syracuse University. The Department offers two ABET-accredited B.S. programs (aerospace engineering, mechanical engineering), three M.S. programs (mechanical and aerospace engineering, energy systems engineering, engineering management) and one Ph.D. program (mechanical and aerospace engineering). The programs currently enroll approximately 500 undergraduate students and 260 graduate students. The Department faculty recently has grown to include 24 faculty members, including 19 tenured or tenure-track faculty members. The Department enjoys a vibrant and rapidly growing research environment with a funding portfolio that includes awards from major federal and state agencies, companies, and foundations. In the last three years, sponsored expenditures have been in the range from $2.9 to $3.5 million annually; the department envisions achieving increases funded research in the near term through support for development of junior faculty and strategic initiatives.

Syracuse University’s College of Engineering and Computer Science is undergoing significant renewal under the leadership of Dean Teresa Dahlberg, with outstanding opportunities for growth and reinvention across all departments. Departments in the College are mutually supportive and the Department Chair will be in a position to foster synergies between departments and between colleges at the University level. In addition, Department Chair benefits from many substantive collaboration opportunities with the Syracuse Center of Excellence in Environmental and Energy Systems, the Center for Advanced Systems Engineering, Syracuse Biomaterials Institute, and many other centers and institutes at the University.

Applicants must have earned a doctoral degree in either mechanical or aerospace engineering or a closely related discipline. The applicant must have a distinguished record of accomplishments in education and research and qualify for the rank of Full Professor. The applicant is expected to teach undergraduate and/or graduate level courses in their field of expertise, supervise graduate level research, develop and grow a strong, externally funded research program and elevate the national profile of the Department. For a more detailed job description visit: http://eng-cs.syr.edu/careers/ .

Interested applicants should submit a detailed curriculum vitae, statements of research and teaching interest, and at least five professional references. Applicants must complete an online Faculty Application and attach, electronically, a cover letter, curriculum vitae, and the names of the five references at www.sujobopps.com . (job number 072331).

Review of applications will start on March 15, 2016 and continue until the position is filled. For additional information, please contact the Chair of the Search Committee, Professor Roger Schmidt, via email at rrschmid@syr.edu .

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DEPARTMENT OF AEROSPACE ENGINEERING

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AIAA Bulletin

For Engineers Week, AIAA staff gathered at AIAA Headquarters to offer thanks to AIAA members and all engineers for their remarkable contributions.

MARCH 2016

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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.

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2016			
5–12 Mar†	2016 IEEE Aerospace Conference	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, Erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
8–10 Mar	AIAA DEFENSE 2016 (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	**8 Oct 15**
16 Mar	AIAA Congressional Visits Day	Washington, DC	
4–6 Apr†	51st 3AF Conference on Applied Aerodynamics: “Thermal Effects and Aerodynamic”	Strasbourg, France (Contact: Anne Venables, secr.exec@aaaf.asso.fr; http://3af-aerodynamics2016.com)	
19–21 Apr†	16th Integrated Communications and Surveillance (ICNS) Conference	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, http://i-cns.org)	
16–20 May†	SpaceOps 2016: 14th International Conference on Space Operations	Daejeon, Korea	**30 Jul 15**
24–26 May†	The Fifth International Conference on Tethers in Space	Ann Arbor, MI (http://tethersinspace2016.com/	
30 May–1 Jun†	22nd AIAA/CEAS Aeroacoustics Conference	Lyon, France	**9 Nov 15**
30 May–1 Jun†	23rd Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (Contact: Ms. M. V. Grishina, +7 812 499 8181, icins@eprib.ru, www.elektropribor.spb.ru)	
13–17 Jun	AIAA AVIATION 2016 (AIAA Aviation and Aeronautics Forum and Exposition) **Featuring:** 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference; 34th AIAA Applied Aerodynamics Conference; AIAA Atmospheric Flight Mechanics Conference; 8th AIAA Atmospheric and Space Environments Conference; 16th AIAA Aviation Technology, Integration, and Operations Conference; AIAA Flight Testing Conference; 8th AIAA Flow Control Conference; 46th AIAA Fluid Dynamics Conference; 17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference; AIAA Modeling and Simulation Technologies Conference; 47th AIAA Plasmadynamics and Lasers Conference; 46th AIAA Thermophysics Conference	Washington, DC	**5 Nov 15**
15 Jun	Aerospace Spotlight Awards Gala	Washington, DC	
16–17 Jun	6th AIAA CFD Drag Prediction Workshop	Washington, DC	
5–8 Jul†	ICNPAA 2016 Mathematical Problems in Engineering, Aerospace and Sciences	University of La Rochelle, France (Contact: Prof. Seenith Sivasundaram, 386.761.9829, seenithi@gmail.com, www.icnpaa.com)	
23–24 Jul	3rd Propulsion Aerodynamics Workshop	Salt Lake City, UT	
23–24 Jul	Advanced High-Speed Air-Breathing Propulsion	Salt Lake City, UT	
23–24 Jul	Electric Propulsion for Space Systems	Salt Lake City, UT	
24 Jul	Detonation-Based Combustors Tutorial	Salt Lake City, UT	
25–27 Jul	AIAA Propulsion and Energy 2016 (AIAA Propulsion and Energy Forum and Exposition) **Featuring:** 52nd AIAA/SAE/ASEE Joint Propulsion Conference; 14th International Energy Conversion Engineering Conference	Salt Lake City, UT	**12 Jan 16**
5–7 Sept†	Advanced Satellite Multimedia Systems Conference	Palma de Mallorca, Spain (Contact: www.asmsconference.org)	
11–12 Sep	Introduction to Space Systems	Long Beach, CA	
11–12 Sep	Systems Engineering Fundamentals	Long Beach, CA	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
13–16 Sep	**AIAA SPACE 2016 (AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA SPACE Conference** **AIAA/AAS Astrodynamics Specialist Conference** **AIAA Complex Aerospace Systems Exchange**	Long Beach, CA	**25 Feb 16**
25–30 Sep†	**30th Congress of the International Council of the Aeronautical Sciences (ICAS 2016)**	Daejeon, South Korea (Contact: www.icas.org)	**15 Jul 15**
25–30 Sep†	**35th Digital Avionics Systems Conference**	Sacramento, CA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)	
26–30 Sep†	**67th International Astronautical Congress**	Guadalajara, Mexico (Contact: www.iac2016.org)	
27–29 Sep†	**SAE/AIAA/RAeS/AHS International Powered Lift Conference**	Hartford, CT	**26 Feb 16**
17–20 Oct†	**22nd KA and Broadband Communications Conference and the 34th AIAA International Communications Satellite Systems Conference**	Cleveland, OH (Contact: Chuck Cynamon, 301.820.0002, chuck.cynamon@gmail.com)	
2017			
9–13 Jan	**AIAA SciTech 2017 (AIAA Science and Technology Forum and Exposition)** **Featuring:** **25th AIAA/AHS Adaptive Structures Conference** **55th 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** **19th AIAA Non-Deterministic Approaches Conference** **58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **10th Symposium on Space Resource Utilization** **4th AIAA Spacecraft Structures Conference** **35th Wind Energy Symposium**	Grapevine, TX	
4–10 Mar†	**IEEE Aerospace Conference**	Big Sky, MT (Contact: www.aeroconf.org)	
18–20 Apr	**17th Integrated Communications and Surveillance (ICNS) Conference**	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, http://i-cns.org)	

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Jonathan How, *Massachusetts Institute of Technology*

C. Russell Joyner, *Aerojet Rocketdyne*

Konstantinos Kontis, *University of Glasgow*

Ping Lu, *Iowa State University*

Walter O'Brien, *Virginia Polytechnic Institute and State University*

T. Kent Pugmire, *Standex Engineering Technology*

Ganesh Raman, *Illinois Institute of Technology*

Ajit Roy, *U.S. Air Force Research Laboratory*

Brian Smith, *Lockheed Martin Corporation*

Marilyn Smith, *Georgia Institute of Technology*

Robert Strain, *Ball Aerospace and Technologies Corporation*

Mark Whorton, *Teledyne Brown Engineering*

- **Ticket Price: $130**
- **Reception: 6:30 pm**
- **Dinner: 7:30 pm**
- **Attire: Business**

Please register online and more information can be found at:
https://www.aiaa.org/FellowsDinner2016/

Or mail your check to:
AIAA/Fellows Dinner
12700 Sunrise Valley Dr. Suite 200
Reston, VA 20191

AIAA
Shaping the Future of Aerospace

16-1018

From the **Corner** Office

SECURING OUR FUTURE – THE NEXT 50 YEARS

Ben Marchionna, AIAA Director-At-Large / Young Professional

This isn't your typical "From the Corner Office" column. And I'm not your typical Corner Office author either. In fact, this is the first time that a young professional has written this column in at least 15 years of collective AIAA staff memory, if not the 50-year history of our Institute. As such, I'm honored to represent the future — of both our Institute and our industry.

A monumentally important decision lies ahead for each and every AIAA member as we prepare to vote on proposed changes to our Constitution starting on 21 March. As a young professional, an elected member of the Board, and a member of the Governance Working Group, I'd like to offer you a unique perspective on the critical importance of voting in favor of the proposed Constitution changes and also the careful consideration and methodical process that has led us to this momentous occasion.

First, let's step back for just a moment to frame our predicament. Over the past decade, it's no secret that our Institute has faced numerous challenges: declining membership; demographics misaligned with those of the modern aerospace industry, let alone the modern high-tech workforce; the advent of several huge and fast-emerging technologies, industry sectors, and trends (e.g., commercial space, unmanned aerial systems, additive manufacturing, cyber, complex systems management, etc.); and especially the recruitment and retention of students and young professionals to maintain the excellent legacy of our most experienced colleagues.

AIAA has more members who are over 60 than under 40. Let that soak in. That's a scary statistic considering that the large majority of student members today elect to forgo AIAA membership a few years after graduation. Our long-standing, outdated structure and practices have gradually created an organization less relevant to the aerospace workforce of the future. Certainly AIAA provides tangible value to some young professionals, but the numbers don't lie – the path that we're on now is not sustainable. Students and young professionals want to engage with a vibrant, *relevant* organization. This cannot be "your father's AIAA" going forward. If we don't change with the times, there may not be an AIAA for young professionals like me to engage with in the future. As the adage goes: adapt or die.

AIAA was formed more than 50 years ago when two organizations merged. Our current governance structure was shaped by the external environment that existed at the time, and it has changed very little since then. Not surprisingly, we have done very well executing activities centered around technologies and topics of interest to the traditional aerospace community, but we struggle with integrating new communities and technologies that have grown to be important to the aerospace industry of the present – and those that will be important to the aerospace industry of the future. With proposed changes to our Constitution on the table, we have a rare opportunity to put in place the tools and governance structure necessary to allow AIAA to evolve into the Institute of the next 50 years.

The proposed Constitution changes and governance modernization steps are the result of an exceptionally disciplined, multi-year investigation. The Governance Project was ideated several years ago under Mike Griffin's leadership, with a Blue Ribbon Panel commissioned by the Board of Directors and the Institute Development Committee (IDC) to review the state of AIAA governance. Under Jim Albaugh's leadership, the Board and IDC then commissioned a Governance Working Group (GWG) to propose a governance model that would meet the strategic, operational, and tactical needs of the Institute going forward. Along the way, Sandy Magnus has tirelessly championed the thoughtful execution of the Governance Project.

Over the past 18 months, the eight GWG members, including myself, have met 125 times in twice-weekly sessions, racking up well over 1,500 total volunteer hours in deep study over the AIAA Governance Project. Options have been exhaustively debated, pros and cons considered, and all possible angles analyzed by a diverse, representative group of AIAA volunteer leaders from multiple levels of experience. An external consultant with special expertise in nonprofit, professional society governance best practices has helped guide us through the process, with AIAA staff providing support as requested by the working group.

Each Governance Project milestone has been reviewed, debated, and endorsed by both the Board and IDC. Nearly every one of our many forum-attending Technical Committees has been visited in the past year by a GWG volunteer or supporting AIAA staff member to discuss and answer questions on the Governance Project. Finally, the general membership has been briefed along the way at AIAA SciTech 2016 and through the *AIAA Bulletin*'s From the Corner Office articles and eNewsletters like Momentum, From Sandy's Desk, Mindjogger, TAC, RAC, Public Policy, etc.

At the direction of the GWG, the Institute has launched a newly updated section of its website containing all the details of the AIAA Governance Project (**http://www.aiaa.org/governance**). Please take a few minutes to check it out! It includes a wealth of information.

Because of the way AIAA was created, much of our current structure and practices are ill-advisedly hardwired directly into the Constitution. This creates a static, inefficient organization that is difficult to tweak. For example, the current Constitution explicitly states which member representatives are allowed on the Board. As such, our newer Program Committees, Corporate Member Committee, Young Professionals, and students have no Group Director representation. This creates a dichotomy of member communities with unequal bottom-up input. To align our governance documents with best practices, the Constitution needs to change. *The only way to change the Constitution is with a vote by 15% or more of the Institute membership, of which 2/3 must vote "Yes"* – and historically, achieving voter turnout of just 10% has been difficult for us.

A "Yes" vote on the proposed Constitution changes is the only way to modernize our governance structure. Without it, our hands are tied and we cannot evolve. Just because we've found a way to Frankenstein certain Institute processes doesn't mean it's the right way to do it. These changes will provide the elected volunteer leadership with the tools and flexibility needed to adjust our strategy and tactics in accordance with a changing world. It's time for us to align our form, fit, and function – just as the system architect of any other complex system would do!

We have to build on our role as the premier technical society of the aerospace professional and profession, but we need to be more than that. In a Corner Office column from a couple years back, Mike Griffin pondered, "How are we going to change so that membership in AIAA, and participation in Institute activities, remains just as attractive to a young woman today who is working in commercial space or on an unmanned aerial system, and to the young entrepreneurs who run those companies, as it was to the Apollo veterans and Cold Warriors of forty years ago?" I believe that the answer to that question, and the very existence of AIAA as a professional society, depends on making this governance evolution.

AIAA should celebrate our storied past, but we must now be laser focused on securing our future! We've been struggling. We need to move forward. I'll be voting in favor of the changes to our Constitution; and I hope you will too. For today, for tomorrow, and for the future of our beloved Institute and industry.

2016 INTERNATIONAL STUDENT CONFERENCE WINNERS

The AIAA Foundation International Student Conference is an opportunity for those students who have won first place in the Regional Student Conferences to present their papers at a professional technical conference. This event is funded through the AIAA Foundation and offers the students a chance to showcase their research while networking with potential employers or colleagues. The 2016 International Student Conference was held on 4 January in conjunction with AIAA SciTech 2016 in San Diego, CA. Awards were given in four categories on 5 January.

Graduate Division

Jan Schneiders, Delft University of Technology, The Netherlands was awarded the prize for best overall student paper in the Graduate Category for his paper entitled "Beyond Nyquist by Pouring Space into Time."

Undergraduate Division

Joshua Castagnetta and **Robert Larson, U.S. Air Force Academy,** were awarded the prize for best overall student paper in the Undergraduate Category for their paper entitled "Aerodynamic Evaluation of the NASA Microgravity Unmanned Aerial Vehicle."

Undergraduate Team Division

Jason Wolf, Erick Shelley, and **Daniel Stralka, Cleveland State University, Cleveland, OH,** were awarded the prize for best overall in the Undergraduate Team Category for their team paper entitled "Design of an Engine Air Particle Separator for Unmanned Aerial Vehicle Applications."

Community Outreach Division

Lauren Brunacini, Arizona State University, Tempe, AZ, was awarded the prize for best overall in the Community Outreach Category for her presentation entitled "Daedalus Astronautics @ ASU: Outreach Program."

For more information on the AIAA Foundation International Student Conference, please contact Rachel Dowdy at 703.264.7577 or at racheld@aiaa.org.

Shelly Corbets, Chair Student Paper Competition; Jim Albaugh, AIAA President; Jan Schneiders, Graduate winner; and Steve Gorrell, AIAA Vice President–Education.

Shelly Corbets, Chair Student Paper Competition; Jim Albaugh, AIAA President; Jason Wolf, one of the Team winners; Steve Gorrell, AIAA Vice President–Education.

Shelly Corbets, Chair Student Paper Competition; Jim Albaugh, AIAA President; Joshua Castagnetta, Undergraduate winner; Robert Larson, Undergraduate winner; and Steve Gorrell, AIAA Vice President–Education.

Shelly Corbets, Chair Student Paper Competition; Jim Albaugh, AIAA President; Lauren Brunacini, Community Outreach winner; Steve Gorrell, AIAA Vice President–Education.

Sydney Section Chair Evan Smith welcomed South Australia Senator David Fawcett in November.

AIAA SYDNEY SECTION HOSTED LECTURE ON "MAINTAINING AUSTRALIAN INDUSTRY & DEFENCE ENGINEERING TECHNICAL MASTERY" IN NOVEMBER

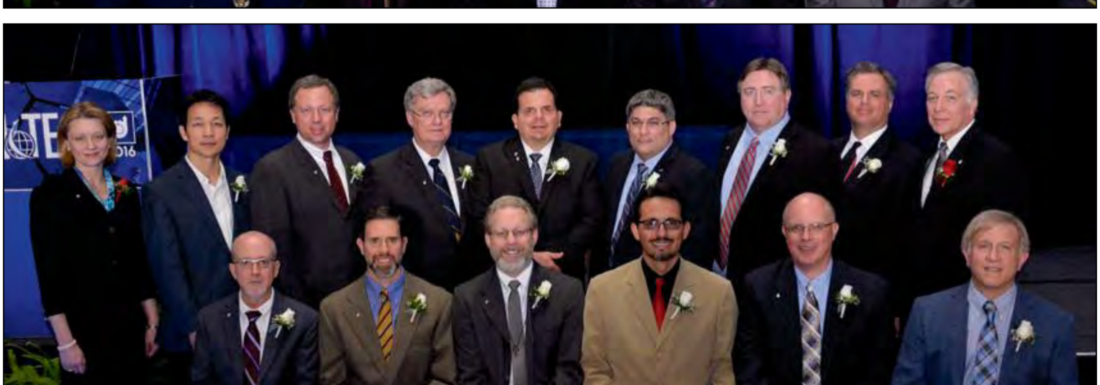
On 12 November, AIAA Sydney Section hosted a networking evening followed by a lecture by Senator David Fawcett. Over 30 people from defense, industry, and academia were in attendance. Senator Fawcett, a former Army test pilot; member of the Joint Standing Committee on Foreign Affairs, Defence and Trade; and current chair of the Defence subcommittee, spoke about the challenges of maintaining technical mastery in defense and industry. Senator Fawcett noted the sovereign need for technical mastery, and proposed methods through which it could be maintained and grown in Australia.

CLASS OF 2016 AIAA ASSOCIATE FELLOWS HONORED

The Class of 2016 AIAA Associate Fellows were honored at the AIAA Associate Fellows Recognition Ceremony and Dinner on 4 January at the Manchester Grand Hyatt, San Diego, CA, in conjunction with AIAA SciTech 2016.

Top: Class of 2016 Associate Fellows.

Left: Region I Class of 2016 Associate Fellows.



Bottom left: Region II Class of 2016 Associate Fellows.





Top left: Region III Class of 2016 Associate Fellows.

Top right: Region IV Class of 2016 Associate Fellows.

Middle left: Region V Class of 2016 Associate Fellows.

Middle right: Region VII Class of 2016 Associate Fellows

Bottom left: Region VI Class of 2016 Associate Fellows.

AIAA K–12 STEM ACTIVITIES

Supriya Banerjee and Angela Diggs, AIAA K-12 STEM Section Engagement and Best Practices Committee

Our role is to maintain awareness of K–12 STEM activities in the sections and communicate those activities to sections/regions to promote strong K–12 STEM programming across AIAA. Each month we will highlight an outstanding K–12 STEM activity; if your section would like to be featured, please contact us directly.

AIAA Delaware Section and Cecil County STEM Academy Partnership

Breanne Sutton, AIAA Delaware Section Chair, AIAA K-12 STEM Section Engagement Committee, and Elishabet Lato, AIAA Delaware Section STEM Officer

The AIAA Delaware Section is a strong supporter of the Cecil County STEM Academy in Maryland. The Cecil County STEM Academy is an educational program at all five county high schools with a rigorous curriculum designed for students planning to attend college to pursue a math, science, or engineering degree. In addition to accelerated courses, the students are required to complete a capstone project. The AIAA Delaware section supports the STEM Academy program by encouraging their professional membership to volunteer at topic defense presentations, attending the final poster sessions to talk with the students about what their completed project, and most importantly, the AIAA Delaware section provides volunteers to mentor the students throughout the school year. The AIAA Delaware section, in partnership with Orbital ATK, also hosts the students for a day on site at Orbital ATK's Elkton, MD, facility.

The summer after their freshman year, the STEM Academy participants can attend a three-day summer day camp to visit various STEM companies in the area. AIAA Delaware and Orbital ATK host an Introduction to Rockets and Engineering for the students. Last year, the camp was so popular that AIAA Delaware offered two sessions. A typical schedule starts the students off with an introduction to engineering, design, rockets and Orbital ATK. The students also go on a tour of the manufacturing area of the plant and participate in an engineering design challenge. Past design challenges have included building and landing a straw rocket on a target, and creating a transportation system to move a space shuttle (toy) out to the launch pad – across the room. In 2015, the challenge was to design, build, and test a system for safely landing an "eggstronaut" on "Mars." The students were split into teams and given restrictions designed to

mimic a real engineering problem: time constraints, material constraints, and schedule. After splitting into three teams, the students could only brainstorm with paper and pencil for the first 10 minutes. After brainstorming, they retrieved materials and started building. After working on their own, the students interacted with AIAA and Orbital ATK Young Professionals and received advice on the design. Lastly, the students tested their designs. The designs were scored based on weight, decent time, eggstronaut survivability, and eggstronaut orientation. After the design competition, the AIAA Delaware Section led a recap discussion on the lessons the students learned and how the activity related to an engineer's job.

Each year the AIAA Delaware Section tries to improve on the previous year's STEM Academy visit. In addition to giving the students feedback on their design, the organizers ask the students and educators candidly to give them advice on what to improve for future students. With this advice, the presentations and design challenge morphs and grows each year – keeping it fresh and exciting for the volunteers and engaging the students better every time. After the event the students typically send thank you notes to AIAA or Orbital ATK. Below are some quotes from the 2015 letters:

"I loved the STEM Activity we did at this camp. What you guys do is so cool!"

"I had a lot of fun and learned a lot about rockets, which was something I didn't know about before."

"I look forward to considering you as a possible employer"

CREATIVE SPACE TOURISM THINKING FROM MIDDLE SCHOOL STUDENTS IN AIAA SPACE SYSTEMS TECHNICAL COMMITTEE ESSAY CONTEST

Since 2011, the Space Systems Technical Committee (SSTC) has run an annual middle school essay contest to meet the TC's commitment to directly inspire students and local sections. The members work with their local sections each year to start parallel contests to feed into the selection of a national winner awarded by the SSTC, with increasing section participation each year.

In 2015, eight sections had official entries to the SSTC contest, from which students in the AIAA Los Angeles/Las Vegas and Hampton Roads Sections were selected to receive $100, plus $250 for their classroom toward STEM materials or activities. The 2015 topic was "As a Future Space Tourist, Where Would You Go, and What Would You Do?"

The 2015 winners are 7th grader **Jack Hutchinson** and his teacher Mr. Pat Hillard at Nansemond-Suffolk Academy, Suffolk, VA, and 8th grader **David Hindman** and his teacher Victoria Lawson at Palos Verdes Intermediate School, Palos Verdes Estates, CA. The SSTC also recognized 8th grade runner-up **Micah Robinson** and his teacher Charlene Cooper of Rusheon Middle School, Bossier City, LA, because the scores were so close. Ms. Lawson will be using the award money to purchase art supplies and design technologies for 6th and 7th grade students.

The topic for 2016 is "Discuss How Either a Moon Base or a Mars Base Could Help Us Learn about the Earth and Space," and we expect at least seven sections to participate. If your section is interested in participating in this contest in 2017, please contact the committee: Samantha Infeld, s.infeld@ama-inc.com; Anthony Shao, ant.shao@gmail.com; and Erica Rodgers, erica.rodgers@nasa.gov.

Below is Jack Hutchinson's essay. David Hindman and Micah Robinson's essays can be found at www.aerospaceamerica.org, under Bonus Content.

Hampton Roads awards ceremony: From left to right: Karen Berger (AIAA Hampton Roads Schools [HRS] K–12 STEM Outreach Co-Chair), Bradley Friedman (3rd place), Vishwa Malaisamy (2nd place), Hampton Roads 7th grade winner and national winner Jack Hutchinson, and Sally Viken (former AIAA HRS Chair)

Above left: AIAA Los Angeles/Las Vegas 8th grade winner David Hindman (center); above right: Vicki Lawson, teacher of David Hindman

Right: AIAA Greater New Orleans 8th grade winner and national runner-up Micah Robinson

Destination: Europa

By Jack Hutchinson

Since space travel was first possible, man looked to the moon. When humans first stepped onto the moon, they did what every pioneer in history has done: they looked for life. But in the search for extraterrestrial life, were they really looking in the right place? Maybe instead of looking at Earth's moon for evidence of life, another planet's moon should be considered. Specifically the second Galilean moon closest to Jupiter, a moon smaller than our own, but with a good chance of life. As a future space explorer, I would go to Jupiter's moon Europa.

Like any great vacation, Europa has much to explore. Sure, when one thinks the word: Vacation, they would think of a warm, sandy, beach and not a frigid ice planet. I would not go to Europa for the climate and the weather on the surface, but for what lies 100 kilometers beneath. The surface of Europa is made up of silicate rock and what scientists are fairly certain is water in its solid form. Thanks to flybys of Europa from the Galileo mission scientists have determined the existence of a subsurface liquid water ocean on Europa. A strong chance of a liquid water ocean, a source of energy called tidal heating, and and the chemical composition of Europa's subsurface ocean could provide the chemistry needed for life.

As a space explorer, one of the first things that I would do after arriving on Europa, would be to drill down below the ice layer and search for any form of life. This is not all of what this tiny moon has to offer. Due to tidal force modelling predictions, scientists have theorised the existence of plumes of water shooting out of Europa's poles, which I would observe as part of my vacation plan. Another thing that I would like to investigate and study on Europa is its energy force called tidal heating. Tidal heating is when the gravity of Jupiter, the other moons and Europa's elliptical orbit cause the tides on Europa, which causes the moon to expand and contract like a rubber ball. This creates friction which creates heat that warms the planet, melts the innermost parts of the ice layer, and creates a sub-surface ocean. If we learned how this works, we could harness a new source of energy. Another thing that I would like to see is Europa's seasonal locations. Europa is tidally locked with Jupiter, meaning that one hemisphere is constantly facing Jupiter. This may make one side of Europa consistently warmer than the other half, due to reflective light. This would mean that a certain part of Europa would have not one but two sources of energy, possibly raising the chance of life in that specific hemisphere, depending on what form of energy an archaebacterial creature adapted to Europa's environment might require. In my opinion, one of the coolest geological figures that I would want to see on Europa would be the penitentes found along its equator. Penitentes are icy spikes or ice or hardened snow that can reach 10 meters in height.

Europa is a fascinating place with much to see. It is incredible how a celestial body so unlike our own, is also so similar. From the geographical features on its icy surface to the deepest parts of its sub surface ocean, Europa is a very interesting place. This is why if I were a future space traveller, I would definitely go to Europa.

Important Announcement: Editor-in-Chief Sought for AIAA's Newest Publication, *Journal of Air Transportation* (*JAT*)

AIAA is seeking an outstanding candidate with an international reputation to assume the responsibilities of Editor-in-Chief of the *Journal of Air Transportation*, which was originally published by the Air Traffic Control Association as *Air Traffic Control Quarterly*. Journal operations are transitioning to AIAA in 2016 with Vol. 24, No. 1, and a permanent editor is being sought. Under the new name and with a broader scope, *JAT* is devoted to the dissemination of original archival papers describing new developments in air traffic management and aviation operations of all flight vehicles, including unmanned aerial vehicles (UAVs) and space vehicles, operating in the global airspace system. The scope of the journal includes theory, applications, technologies, operations, economics, and policy. The chosen candidate will assume the editorship at an exciting time as the journal moves to an online-only format and new features and functionality intended to enhance journal content are added to Aerospace Research Central, AIAA's platform for electronic publications.

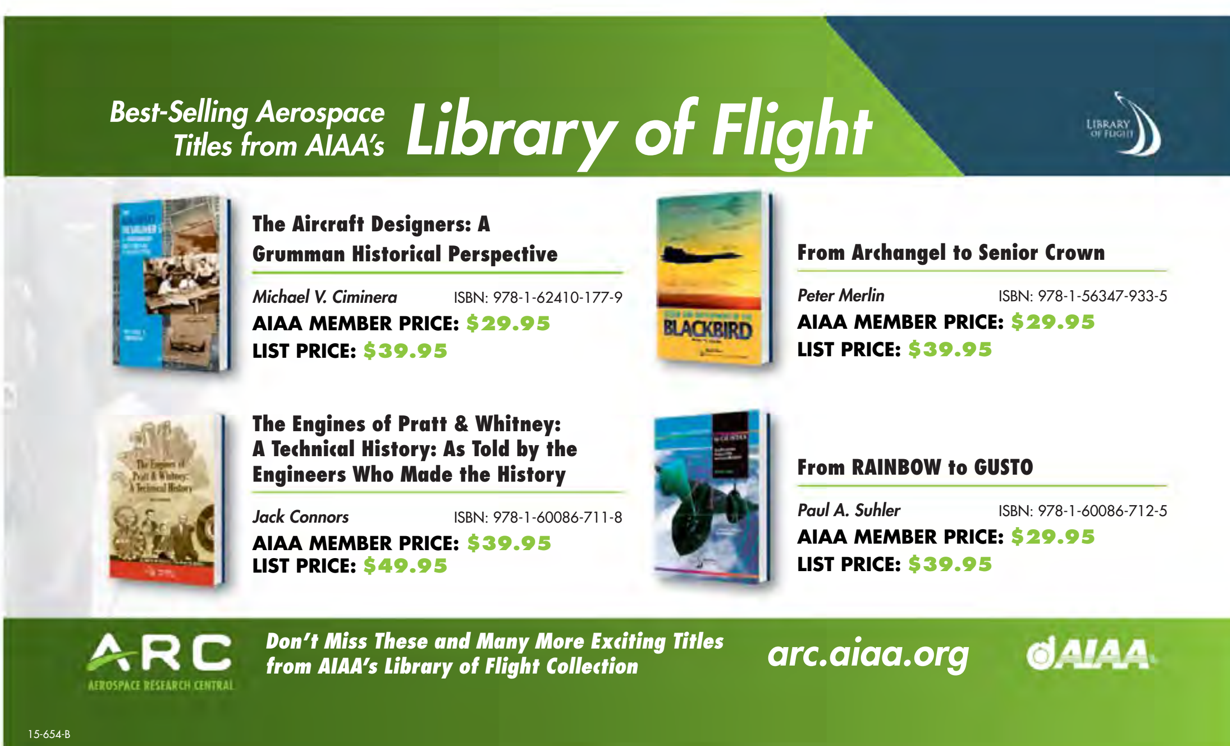
The Editor-in-Chief is responsible for maintaining and enhancing the journal's quality and reputation as well as establishing a strategic vision for the journal. He or she receives manuscripts, assigns them to Associate Editors for review and evaluation, and monitors the performance of the Associate Editors to ensure that the manuscripts are processed in a fair and timely manner. The Editor-in-Chief works closely with AIAA Headquarters staff on both general procedures and the scheduling of specific issues. Detailed record keeping and prompt actions are required. The Editor-in-Chief is expected to provide his or her own clerical support, although this may be partially offset by a small expense allowance. AIAA provides all appropriate resources including a web-based manuscript-tracking system.

Interested candidates are invited to send letters of application describing their reasons for applying, summarizing their relevant experience and qualifications, and initial priorities for the journal; full résumés; and complete lists of published papers, to:

Heather Brennan, Director, Publications
American Institute of Aeronautics and Astronautics
12700 Sunrise Valley Drive, Suite 200
Reston, VA 20191-5807
Fax: 703.264.7551 • Email: heatherb@aiaa.org

A minimum of two letters of recommendation also are required. The recommendations should be sent by the parties writing the letters directly to Ms. Brennan at the above address, fax number, or email. To receive full consideration, applications and all required materials must be received at AIAA Headquarters by **1 April 2016**, but applications will be accepted until the position is filled.

A selection committee appointed by the AIAA Vice President–Publications, Frank K. Lu, will seek candidates and review all applications received. The search committee will recommend qualified candidates to the AIAA Vice President–Publications, who in turn will present a recommendation to the AIAA Board of Directors for approval. All candidates will be notified of the final decision. This is an open process, and the final selection will be made only on the basis of the applicants' merits. All candidates will be notified of the final decision.



CALL FOR NOMINATIONS

Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 July** unless indicated otherwise.

Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines carefully to view nominee eligibility, page limits, letters of endorsement, etc. Please note that nominators must submit the nomination form, related materials, and the three required AIAA member one-page letters of endorsement to AIAA by the nomination deadline.

AIAA members may submit nominations online after logging into www.aiaa.org with their user name and password. You will be guided step by step through the nomination entry. If preferred, a nominator may submit a nomination by completing the AIAA nomination form, which can be downloaded from **www.aiaa.org**. Nominators are reminded that the quality of information is most important.

Awards are presented annually, unless otherwise indicated. However AIAA accepts nomination on a daily basis and applies to the appropriate award year.

Nomination Deadline 1 April 2016

Faculty Advisor Award presented to the faculty advisor of a chartered AIAA Student Branch, who in the opinion of student branch members, and the AIAA Student Activities Committee, has made outstanding contributions as a student branch faculty advisor, as evidenced by the record of his/her student branch in local, regional, and national activities.

Nomination Deadline 1 June 2016

AIAA-ASC James H. Starnes, Jr. Award presented In honor of James H. Starnes, Jr., a leader in structures and materials, to recognize continued significant contribution to, and demonstrated promotion of, the field of structural mechanics over an extended period of time emphasizing practical solutions, to acknowledge high professionalism, and to acknowledge the strong mentoring of and influence on colleagues, especially younger colleagues. Nomination form and instructions are located at **http://www.aiaa.org/starnesaward**/.

Nomination Deadline 1 July 2016

Aerospace Design Engineering Award recognizes design engineers who have made outstanding technical, educational or creative achievements that exemplifies the quality and elements of design engineering. (Presented even years)

Aerospace Guidance, Navigation, and Control Award recognizes important contributions in the field of guidance, navigation and control. (Presented even years)

Aerospace Software Engineering Award presented for outstanding technical and/or management contributions to aeronautical or astronautical software engineering. (Presented odd years)

Ashley Award for Aeroelasticity recognizes outstanding contributions to the understanding and application of aeroelastic phenomena. It commemorates the accomplishments of Prof. Holt Ashley, who dedicated his professional life to the advancement of aerospace sciences and engineering and had a profound impact on the fields of aeroelasticity, unsteady aerodynamics, aeroservoelasticity and multidisciplinary optimization. (Presented every 4 years, next presentation 2017)

Children's Literature Award presented for an outstanding, significant, and original contribution in aeronautics and astronautics. (Presented odd years)

de Florez Award for Flight Simulation is named in honor of the late Admiral Luis de Florez and is presented for an outstanding individual achievement in the application of flight simulation to aerospace training, research, and development.

Excellence in Aerospace Standardization Award recognizes contributions by individuals that advance the health of the aerospace community by enabling cooperation, competition, and growth through the standardization process. (Presented odd years)

Gardner-Lasser History Literature Award presented for the best original contribution to the field of aeronautical or astronautical historical nonfiction literature published in the last five years dealing with the science, technology, and/or impact of aeronautics and astronautics on society.

History Manuscript Award presented for the best historical manuscript dealing with the science, technology, and/or impact or aeronautics and astronautics on society.

Information Systems Award presented for technical and/or management contributions in space and aeronautics computer and sensing aspects of information technology and science. (Presented odd years)

Intelligent Systems Award recognizes important fundamental contributions to intelligent systems technologies and applications that advance the capabilities of aerospace systems. (Presented even years)

Lawrence Sperry Award presented for a notable contribution made by a young person to the advancement of aeronautics or astronautics. The nominee must be under 35 years of age on **31 December** of the year preceding the presentation.

Losey Atmospheric Sciences Award presented for recognition of outstanding contributions to the atmospheric sciences as applied to the advancement of aeronautics and astronautics.

Mechanics and Control of Flight Award presented for an outstanding recent technical or scientific contribution by an individual in the mechanics, guidance, or control of flight in space or the atmosphere.

Pendray Aerospace Literature Award presented for an outstanding contribution or contributions to aeronautical and astronautical literature in the relatively recent past. The emphasis should be on the high quality or major influence of the piece rather than, for example, the importance of the underlying technological contribution. The award is an incentive for aerospace professionals to write eloquently and persuasively about their field and should encompass editorials as well as papers or books.

Structures, Structural Dynamics and Materials Award presented for an outstanding sustained technical or scientific contribution in aerospace structures, structural dynamics, or materials. (Presented even years)

Survivability Award recognizes outstanding achievement or contribution in design, analysis implementation, and/or education of survivability in an aerospace system. (Presented even years)

Summerfield Book Award is named in honor of Dr. Martin Summerfield, founder and initial editor of the Progress in Astronautics and Aeronautics Series of books published by AIAA. The award is presented to the author of the best book recently published by AIAA. Criteria for the selection include quality and professional acceptance as evidenced by impact on the field, citations, classroom adoptions and sales.

Sustained Service Award, approved by the Board of Directors in 1999, recognizes sustained, significant service and contributions to AIAA by members of the Institute. A maximum of 20 awards are presented each year. A special nomination form and scoresheet is required; contact AIAA for further details.

James Van Allen Space Environments Award recognizes outstanding contributions to space and planetary environment knowledge and interactions as applied to the advancement of aeronautics and astronautics. The award honors Prof. James A. Van Allen, an outstanding internationally recognized scientist, who is credited with the early discovery of the Earth's "Van Allen Radiation Belts." (Presented even years)

For further information on AIAA's awards program, please contact Carol Stewart, Manager, AIAA Honors and Awards, carols@aiaa.org or 703.264.7538.

To submit articles to the *AIAA Bulletin*, contact your Section, Committee, Honors and Awards, Events, or Student staff liaison. They will review and forward the information to the *AIAA Bulletin* Editor. See the AIAA Directory on page **B1** for contact information.

NEW AIAA STUDENT BRANCHES

AIAA would like to announce that as of 8 January 2016, we have increased the number of student branches located throughout the world. The AIAA Board of Directors has approved the following universities to host an AIAA Student Branch (**http://www.aiaa.org/StudentBranches.aspx?id=3268**).

University of Vermont
University of Maine
Metropolitan State University of Denver
University of Alaska, Fairbanks
Milwaukee School of Engineering

These universities join over 200 other schools who currently are an active part of the AIAA community. The branches engage in activities ranging from STEM events on their perspective campuses to participating in AIAA Student Programs such as Design Competitions (**http://www.aiaa.org/DesignCompetitions**) and Student Conferences (**http://www.aiaa.org/StudentConferences**).

We welcome the new student branches and look forward to seeing how their activities shape the future of aerospace.

To Ka band and beyond!

The future is Ka band. Now, there's a rugged, dependable handheld designed to deliver precise, lab-grade measurements up to 50 GHz. At only 7.1 lbs., it's an all-in-one cable and antenna tester (CAT) + vector network analyzer (VNA) + spectrum analyzer and more. Which means, now you get comprehensive system performance insight at higher frequencies. Plus with easy upgrades and multiple configurations, you'll be ready to go where no handheld has gone before – today and beyond.

Keysight FieldFox Handheld Analyzers

- 6 new models to 50 GHz
- MIL-PRF-28800F Class 2 rugged
- Agrees with benchtop measurements
- CAT + VNA + spectrum analyzer

KEYSIGHT TECHNOLOGIES

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Explore FieldFox.
Get app notes, webcasts & more.
www.keysight.com/find/KaAndBeyond

USA: 800 829 4444   CAN: 877 894 4414

Agilent's Electronic Measurement Group is now **Keysight Technologies**.