October 2015

# AEROSPACE AMERICA

# Safety in the New Exploration Age

## Assessing the risks to astronauts

Page 18



A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

# AEROSPACE AMERICA

*October 2015*




## DEPARTMENTS




## FEATURES



## BULLETIN



**ON THE COVER**
Delta 4 Heavy carrying Orion crew capsule lifts off for unmanned flight test in December 2014.
Credit: United Launch Alliance

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**LETTERS AND CORRESPONDENCE**
***Ben Iannotta***, *beni@aiaa.org*

**QUESTIONS AND ADDRESS CHANGES**
*custserv@aiaa.org*

**ADVERTISING MATERIALS**
***Craig Byl***, *craigb@aiaa.org*

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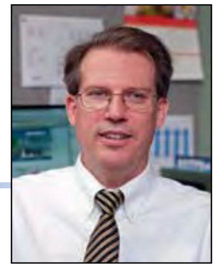
## *Editor's* Notebook



# Risk aversion

In the novel "The Martian," stranded astronaut Mark Watney clings to hope for a rescue, writing in his journal that the next crew is due to arrive in four years. Of course, as Watney notes, that scenario assumes the mission isn't canceled because of his "death" in the same ferocious sandstorm that drove his crew mates to flee back to Earth and leave him for dead.

It's an insightful moment in this technical and well-told story, and one that touches on a reality of human space flight: Continued exploration teeters on a precipice between tragedy on one side and unaffordable safety measures on the other. That balancing act makes our cover story about astronaut protection, "Maximum Safety," especially compelling. Our contributors explore in detail how NASA calculates risk and how it plans to keep those risks to acceptable levels on the deep-space missions to come.

The article made me realize that safety at all costs is a nonstarter in space, just as it is on Earth. Americans are willing to get into automobiles and hurtle down the highway at 70 mph, among drivers of various skill levels, protected only by seat belts, airbags and crumple zones. The auto industry could make cars even safer, but at some point those measures would make them unaffordable. So, drivers calculate that their destinations are worth the risks.

And so it is in space.

Americans take responsibility for each other, even if it might not seem like it on the Washington, D.C., Beltway. We don't like to see our friends or colleagues die in car accidents or spaceship accidents. We delegate lots of oversight power to government agencies and congressional committees for matters of transportation. In the space business, an unfortunate result of this oversight can be a tendency toward excessive aversion to risks. Experts in the industry know they must guard against this tendency.

Former astronaut Frank Culbertson, now an executive at Orbital ATK, spoke eloquently about risk at AIAA's Propulsion & Energy Forum in July. He said aversion has trickled down even to the unmanned R & D stages of technology development, such as when his company struggled to get approval to conduct an unmanned test on a new kind of solid rocket motor.

"It took us 30 days to get clearance from our customer to actually do that test," he said. "If we had just done that test, and it failed, we could have had it going again in two weeks," he said. "This is a part of our business that's very important: We are going to have failures, we can't afford to let them stop us."

It's true that risk aversion must be kept at bay, but history suggests Americans and their leaders are actually pretty tenacious and accepting of risk in space exploration. Astronauts walked on the moon a little over two years after the deadly Apollo 1 launch pad fire in 1967. When the shuttle Challenger exploded in 1986, President Ronald Reagan addressed the nation hours later and reminded us that "the future doesn't belong to the fainthearted," and that the "Challenger crew was pulling us into the future, and we'll continue to follow them."

In 2003, when the Columbia crew perished over Texas, a second shuttle tragedy did not mark the immediate end of the program, as some had predicted.

I see no reason to think that our national resolve has frayed to the point where all that has changed and Americans would elect to stay home rather than to go out and explore.

**Ben Iannotta**
Editor-in-Chief

# Producing carbon aerospace parts from thin air

**Researchers at George Washington** University in Washington, D.C., say they have converted carbon dioxide in the air into carbon nanofibers, a demonstration that — if it moves out of the laboratory into manufacturing — could lead to wide applications for carbon aerospace parts.

George Washington University

Researchers at George Washington University in Washington, D.C., used solar-generated electricity to convert carbon dioxide in the air to carbon nanofibers that could be used for aerospace parts.

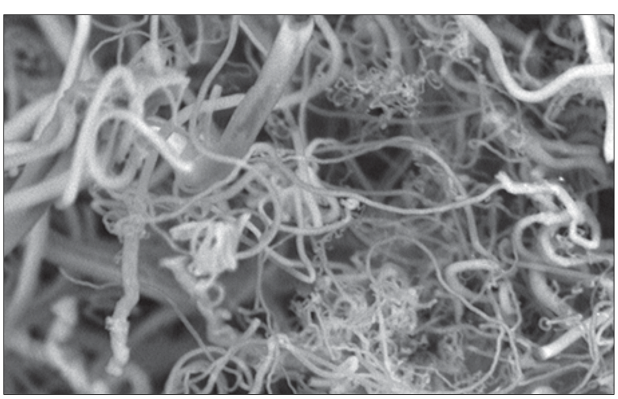
Chemistry professor Stuart Licht and his team announced in August that they used solar-generated electricity to pass a small current through an electrode into a tank of hot, molten salt. The salt started to absorb the carbon dioxide in the atmosphere, triggering a chemical reaction that caused carbon fibers to form at the base of the electrode. The researchers say the process of converting a greenhouse gas into an industrial material can be replicated on factory floors without major hurdles.

Licht says his team easily scaled up the experiment in the lab, going from producing .1 gram of nanofibers per hour to 10 grams per hour using the same low-energy nickel and steel electrodes.

"There are no evident technical challenges to scaling, and the process seems to be ready for industrializing," Licht says by email.

Bojan Boskovic, director of the U.K.'s Cambridge Nanomaterials Technology, says it would take time to make the shift to full-scale commercialization. But Boskovic says by email that "We can start dreaming about aircraft and automotive vehicles that would be converting emission gases into nanocarbon materials which could then be used to produce light-weight composites for new aircraft and automotive vehicles, decreasing emissions further."

Carbon nanofibers — fibers whose diameter is less than 100 nanometers, or thinner than 0.0000001 of a meter — are cylindrical structures made up of layers of graphene molecules. The material could be used to produce lighter and stronger aerospace composite parts.



Stuart Licht/GWU

View of carbon nanofibers made by removing CO2 from the air, magnified 8,700 times.

Researchers at the Massachusetts Institute of Technology in 2010 found that carbon nanotubes — which could also be produced using the process pioneered by Prof. Licht — can produce up to a 10-fold increase in the amount of power delivered by electrodes in a lithium-ion battery.

Carbon nanotubes are tube-shaped material made of carbon with the thickness of an atom, and are smaller than nanofibers. They are also more than one million times more electrically conductive; this suggests that this new structure could provide considerably enhanced protection from lightning strikes.

Other potential carbon nanotube applications include flat-panel displays, micro-electronic communications and radar-absorbing coatings.

But traditional methods of producing carbon nanofibers and nanotubes are expensive, requiring 30- to 100-fold higher production energy consumption than aluminum production. However, the conversion process researched at George Washington uses inexpensive nickel and steel electrodes to produce the carbon structures so production costs for commercial applications should be considerably lower than current methods.

**Philip Butterworth-Hayes**
phayes@mistral.co.uk

# Tiltrotor certificate sought

**AgustaWestland is accelerating flight** tests in hopes of receiving type certification for the AW609 tiltrotor from the FAA by the end of 2017, which would clear the way for commercial sales of the long-delayed aircraft.

The AW609 combines the speed, range and high-altitude capabilities of a fixed-wing turboprop with the vertical takeoff and landing capabilities of a helicopter. The aircraft's unconventional design requires pilots to switch from operating it as a fixed-wing aircraft in level flight to a helicopter during takeoffs and landings. The aircraft, which has been tested in prototype form, is similar to the Bell Boeing V-22 Osprey military tiltrotor. In fact, Bell helped develop it before selling its share to AgustaWestland in 2011.

Developing the flight-control software took longer than expected because of the complexity of transitioning from vertical to forward flight. Making the tiltrotor's fly-by-wire control systems safe enough to meet FAA standards also turned out to be challenging. The FAA has required the AW609 to be certified for both helicopter and fixed-wing rules, while new certification standards have had to be developed to cover the 30 or 40 seconds of flight during which the aircraft shifts from flying as helicopter to flying in fixed-wing mode.

The AW609 made its first flight in March 2003. The 2007 target date for certification was delayed by both industrial and technical reasons.

Clive Scott, AW609 program manager, says the aircraft is now on track to meet the 2017 certification deadline. AgustaWestland is nearly finished building a third prototype to join the first two that have been used for flight testing. Work on a fourth prototype will start next year in the company's new Philadelphia plant, where an assembly line is under construction.

Scott says the AW609 has logged nearly 1,300 hours of flight testing, and completed autorotation trials, in which the aircraft must land safely after an engine shut-down in level flight.

"These trials have been instrumental in allowing us to make improvements in the aerodynamic and aircraft systems to best meet the operational needs of our committed and prospective customers," Scott says by email.

AgustaWestland has not revealed the tiltrotor's purchase price but market analysts estimate each will cost $20 million to $25 million. That's slightly more than twice the price of a Bell 412 twin-engine helicopter or Sikorsky S-76 helicopter, which have comparable cabin sizes but have shorter flight ranges and slower cruise speeds.

AgustaWestland has received orders for more than 60 AW609s, with the first customers likely to be business aviation operators. The company is not identifying the customers.

With first delivery to customers anticipated for early 2018, the focus now is on the AW609's commercial prospects and whether sales will justify AgustaWestland's financial investments.

Richard Aboulafia, vice president of analysis at the Teal Group, an aerospace consulting firm in Fairfax, Virginia, expects the AW609 "will find itself in a narrow civil niche."

"It isn't promising for emergency medical services missions. The offshore market would be very limited — oil rigs remain too close to shore for more than a token number of offshore sales, and the 609 cabin is too small for this role," Aboulafia says. "Corporate is probably the most promising civil application, but that's a conservative market."

**Philip Butterworth-Hayes**
phayes@mistral.co.uk

AgustaWestland

In 2018, AgustaWestland's AW609 could become the first tiltrotor to enter civil operation.

# A lifeline for venerable Twin Otter

**Canada's Viking Aircraft** is hoping to sustain a revival of the rugged Twin Otter turboprop on the strength of an order for 50 Series 400 versions from Reignwood Aviation, a Beijing company specializing in operations, maintenance and medical-transport services.

The June order — worth nearly $350 million based on a list price of $6.95 million for the 400 Series — was announced just two months after Viking laid off 116 people, or almost 20 percent of it workforce, due to slow sales. The Twin Otters are famous for serving remote areas, but  the planes have faced sagging demand from the oil and gas market, currency fluctuations, and economic troubles in Russia and other key markets.

China's order for 50 Twin Otter Series 400, built by Canada's Viking Aircraft, has revived slowed production of the rugged turboprop.

Viking Air

Now Viking is forecasting orders for several hundred Twin Otters not only from China, but from India, Brazil, Chile, Mexico and elsewhere.

"We believe that the current Series 400 aircraft has a 15- to 20-year production time line in its current format," says Evan McCorry, Viking's vice president of international sales and marketing, by email.

The Twin Otter first flew in 1965. De Havilland Canada, the original manufacturer, ceased production in 1988. Viking resumed building the 19-seat aircraft in 2007. Before the relaunch, Viking made more than 800 modifications to the original design, including adding Pratt & Whitney Canada PT6A-34/35 engines and Honeywell avionics. Deliveries for the re-branded Series 400 resumed in 2010 following certification from Transport Canada.


The Twin Otter first flew in May 1965.

Canada Aviation and Space Museum

The Twin Otter, equipped with skies, floats and wheels, can operate from grass, gravel, dirt, concrete, mud, sand, ice, snow and water. That versatility makes the aircraft suited for passenger and cargo operations, military work, medical emergency services and private operations. The aircraft is used extensively for sightseeing tours in Alaska, the Caribbean and the Grand Canyon.

Some 500 Twin Otters are flying today, split between the Series 400 and legacy aircraft. The 400 Series is certified in 76 countries, and the company expects to receive Brazilian certification early next year.

The first two Twin Otter deliveries to China will be made later this year, one to a float-plane operator and the other to a commuter airline. In all, Viking expects to make at least 20 deliveries to customers this year.

The deal with Reignwood was the first major outcome of the Bilateral Aviation Technical Arrangement signed between Transport Canada and China's Civil Aviation Authority in June, which made it easier for Canadian aircraft and parts to be certified in China, and vice versa.

McCorry of Viking says the legacy Twin Otter has a solid base of customers in Chile and Argentina. Peru is the world's largest operator of the new model. McCorry says the company is actively pursuing potential sales in Mexico, the Caribbean, Colombia and Brazil. He also named India as another promising untapped market.

Viking is planning to make further design and system changes to the aircraft over the next few years. The most imminent of these is an upgrade to the avionics system to add new autopilot features, a synthetic vision landing aid and an automatic dependent surveillance-broadcast transponder, to make it compatible with new mandatory air traffic control surveillance equipment standards being introduced around the world.

**Philip Butterworth-Hayes**
phayes@mistral.co.uk

# Hardware cost an issue for turbine engine prize


Air Force Predators run on piston engines requiring aviation gasoline. The Air Force is seeking a Jet A-powered turbine engine that could power similar-sized unmanned aircraft as well as ground vehicles and ground power units.

**The Air Force's promise** of a $2 million prize for a revolutionary turboshaft jet engine has drawn five competitors to date, but question remains whether the prize pot will be enough to induce the competitors to build demonstration hardware for the prize's verification phase.

The entrants for the Air Force Prize have submitted data for basic design concepts to build an engine that would be twice as fuel efficient as current jet engines and three times more powerful for its weight than piston engines. Winning will require passing a verification test.

The Air Force Research Laboratory opened the competition in May. The service wants a turboshaft engine for use on Predator-sized small and medium unmanned aircraft, as well as ground vehicles and ground power units. The engines must run on Jet A fuel, which makes up 96 percent of the service's fuel.

The Predators, which the Air Force intends to phase out in 2018, have piston engines that require aviation gasoline. Such specialty fuel makes up a tiny fraction of the Air Force's fuel supply, and eliminating it would simplify logistics and lower expenses. The prize money will go to the first team to meet all the engine requirements. Entries can be submitted any time, but the Air Force must select a winner by Sept. 30, 2018.

The winner must bear the costs of building an experimental engine that can pass the verification test.

Lt. Col. Aaron Tucker, program manager for the Air Force Prize, says the cost of developing and building test hardware can be justified by the potential payoff in the commercial market for the new engine. He notes that the winner will retain full rights to the engine design. At stake is the kind of shift that marked aviation's transition from piston to jet engines during the 1940s and 1950s, he says.


An F-15 Eagle is readied for a biofuel test. The U.S. Air Force relies on Jet A for 96 percent of its fuel supply.

"We acknowledge that the cost of producing a successful system can exceed the prize purse," Tucker says.

Tucker adds that the contest is already tapping into the ingenuity of people who are not typically involved in military research.

So far, five teams have qualified to potentially advance to verification testing at Wright-Patterson Air Force Base in Ohio. Confirmed entrants are a mechanical engineer employed by Lockheed Martin Missiles and Fire Control; a Miami entrepreneur; Volta Volaré, an electric hybrid aircraft maker based in Portland, Oregon; an aviation expert and a team of individuals with backgrounds in engine and airframe designs.

Mike Heil, a former director of the Air Force Research Laboratory's Propulsion Directorate, has been following the contest closely. Heil, now president and chief executive of the Ohio Aerospace Institute, says the winning engine could be the most significant milestone in propulsion technology since the recent leaps made with turbofans.

Heil says the challenge facing competitors is to both increase the compression of incoming air to the engine and raise the combustion temperature. Those design changes generally would make the turbine more efficient and increase its power output — yet potentially at the expense of making the engine heavier and less reliable.

"It's a challenging issue, but I think it's achievable," Heil says.

**Kyung M. Song**
kyungs@aiaa.org
@kyungmsong

# Orion’s heat shield gets upgrade


Lockheed Martin

The Orion crew module arrived at Lockheed Martin Space Systems in Littleton, Colorado, after its first exploration test flight in December 2014. The space vehicle’s heatshield held up well.

**The next Orion crew capsule will have** a redesigned heat shield made under a new industrial relationship between Orion’s prime contractor Lockheed Martin and its partner, Textron. NASA hopes to avoid a cracking problem encountered during manufacturing of the shield tested on last year’s unmanned Experimental Flight Test-1 mission. That shield performed well enough, but the next missions will be more challenging, NASA says.

For Orion’s next flight, the unmanned Exploration Mission-1, tentatively scheduled for late 2018, contractors will affix the shield’s Avcoat epoxy-resin material in a new manner.

“Instead of using honeycomb we’re going to use blocks of Avcoat, and bond directly to the composite,” says NASA’s Mark Geyer, the Orion program manager. The block architecture will make for a stronger heat shield, he explains.

Lockheed Martin also will license the Avcoat from Textron. Each company will fabricate some of the Avcoat blocks on the EM-1 shield. Then, for EM-2 and beyond, Lockheed Martin will fabricate and install all of the Avcoat blocks itself. This is a switch from the EFT-1 shield. Lockheed Martin fabricated that structure, including the stringers and composite, and Textron installed the Avcoat.

“We knew if we didn’t fix the strength issue [the heat shield] wouldn’t work for EM-1,” Geyer says.

On EM-1, Orion will swing around the moon and slam into Earth’s atmosphere at 24,000 mph, generating heat-shield temperatures of up to 4,500 degrees Fahrenheit, compared to 4,000 degrees for EFT-1. On that mission, Orion circled Earth twice, reaching a maximum altitude of 3,600 miles and entering at 20,000 mph.


Lockheed Martin

The American flag painted on one of the Orion’s thermal protection tiles returned from the first exploration test flight with minor scratches.

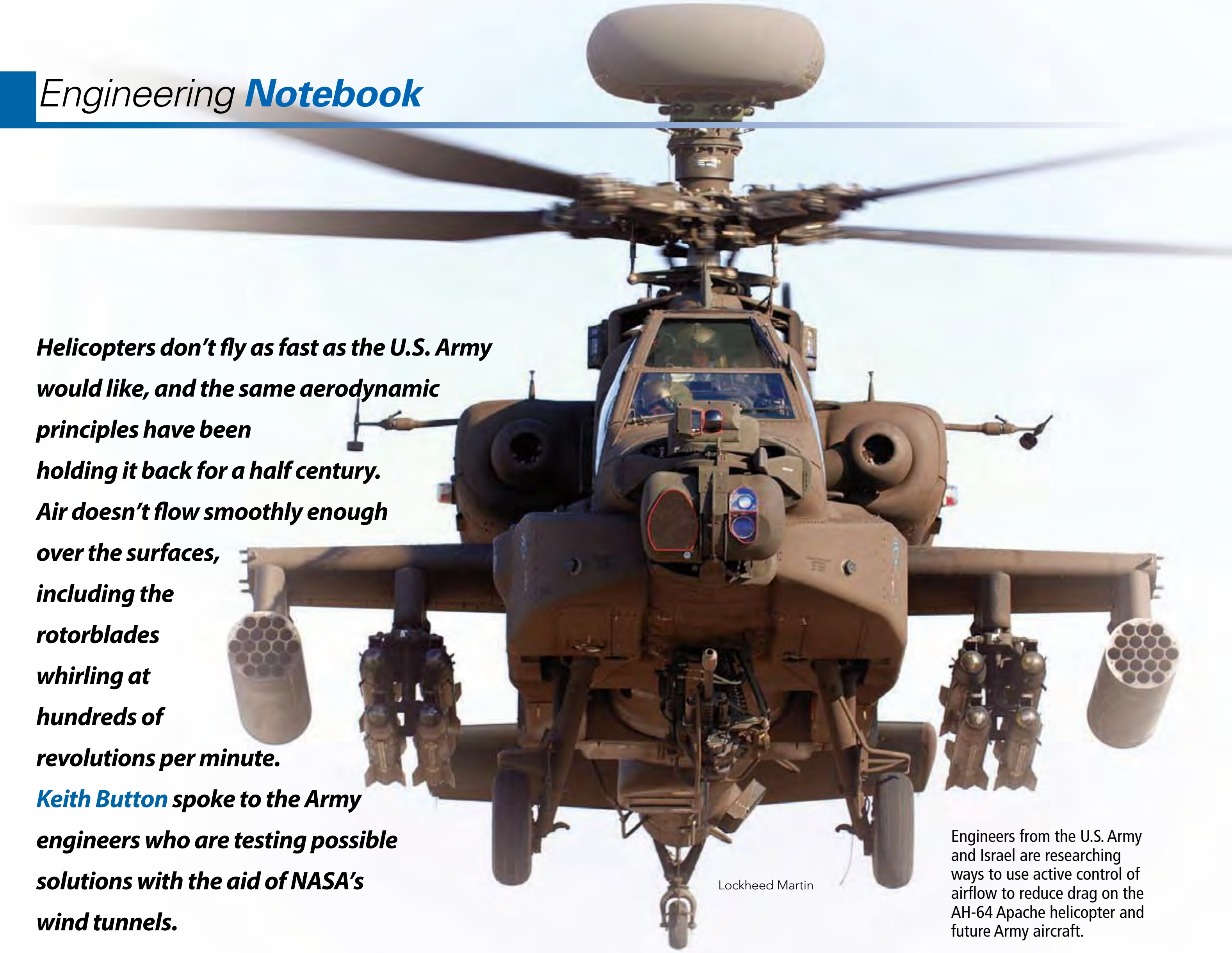
During oven curing on the EFT-1 shield in 2013, cracks developed between the dish-shaped bottom, made of titanium and carbon fiber, and the honeycomb structure filled with Avcoat, an upgraded version of the Apollo-era epoxy resin material designed to shed heat by vaporizing or ablating.

The Government Accountability Office, in a 2014 report, cited the cracks as a chief concern. The cracks were repaired by bonding in Avcoat plugs. Then the shield was put through stress tests to assure it would hold up during EFT-1.

“On the [EFT-1] flight itself, [the heat shield] performed close to what we expected,” Geyer says.

In addition to more strength, there should be cost savings to switching from honeycomb to the block structure: Every honeycomb had to be caulked by hand, a time-consuming, expensive process. The blocks will be easier to manufacture, Geyer says. Each can be tested individually, before it is bonded to the base. The honeycomb structure had to be tested all at once following assembly.

**Natalia Mironova**
natalia.mironova@gmail.com



Lockheed Martin

Engineers from the U.S. Army and Israel are researching ways to use active control of airflow to reduce drag on the AH-64 Apache helicopter and future Army aircraft.

***Helicopters don't fly as fast as the U.S. Army would like, and the same aerodynamic principles have been holding it back for a half century. Air doesn't flow smoothly enough over the surfaces, including the rotorblades whirling at hundreds of revolutions per minute. Keith Button spoke to the Army engineers who are testing possible solutions with the aid of NASA's wind tunnels.***

**It's a problem familiar to helicopter** pilots: Push the aircraft to its maximum speed, and it will begin to shake.

As the rotor blades spin, they go from high lift on the advancing side of the spinning disk to low lift on the retreating side. The faster the aircraft moves forward, the greater the imbalance grows between high lift and low lift, until the retreating blade loses lift and starts to twist and flap.

Pilots call the phenomenon rotor roughness or retreating-blade stall.

"You can feel it," says Preston Martin, an aerodynamicist in the U.S. Army's Aeroflightdynamics Directorate. When a helicopter reaches this point in flight, the pilot must reduce speed. "Otherwise the aircraft will begin shaking violently to the point where you cannot really focus your eyes on the instruments."

Martin heads the Army's research into active flow control devices at NASA Langley Research Center in Hampton, Virginia. These devices can take a variety of experimental forms, from electrically powered air blowers on flight surfaces to patterns of holes for suctioning and blowing air or circuits to heat air into plasma. The job of Martin's team is to weigh the technical trade offs of each concept and figure out which one would be best for keeping the airflow from separating.

When air stops flowing smoothly along the surface of the aircraft, or separates, it creates turbulence and produces drag. Active flow control devices mounted on the underside of an aircraft's surface add momentum to the flow to keep air from separating.

Active flow control devices could potentially be refined and used in the rotors of future helicopters to solve the retreating blade stall problem — blowing air from tiny holes in the rotors, for example, to give the retreating blade more lift and allow the aircraft to fly faster. The devices could also be used on other surfaces of helicopters to make the aircraft more aerodynamic or to reduce drag. Because helicopters have an extremely low lift-to-drag ratio relative to other aircraft, they offer a great opportunity to apply active flow control technology, Martin says.

"The fundamental barriers for helicopters are speed and aerodynamic efficiency," Martin says, noting that maximum speeds of commercial and military conventional helicopters today are not much faster than those from 50 years ago.

Army aeronautical engineers are performing wind-tunnel tests with an example of active flow technology — a rectangular, metallic contraption about 65 millimeters long and 18 millimeters wide with a pattern of small

# Better helos

## through active flight control

holes in it and a short, U-shaped flexible tube joined at both ends. Compressed air, possibly generated by the aircraft's engine, would be blown from beneath a flight surface to the exterior, such as on a rotor blade, to alternately suck and expel air out through the holes. This would alter the momentum of the flow across the surface. These Suction and Oscillatory Blowing actuators, or SaOBs, might someday be used in rotor blades.

In theory, SaOBs would improve the lift and efficiency of the rotors at various points in their rotation, allowing the aircraft to fly faster. In reality, Army engineers know it will be challenging to make the concept work. For one, extreme forces are generated when SaOBs are added to a blade moving at 760 miles per hour at its tip on the advancing side at cruise conditions. Plus, getting air or electronics connected from the fixed part of the helicopter to the spinning part would be difficult.

"There's a lot of room for innovation and ideas, and I think we're just getting to the beginning of that right now," Martin says.

Army researchers are working with sub-scale helicopter fuselage shapes in a wind tunnel at NASA Langley Research Center in Hampton, Virginia. Their goal is to graduate to more complex scale models and then full-sized fuselages. For starters, they are blowing air through holes in flat plates to gather data for use in computational fluid dynamics predictions. SaOBs might eventually be included in the initial designs of future helicopters, says aeronautical engineer Jacob Wilson, a counterpart of Martin's who heads the active flow control testing for the Aeroflightdynamics Directorate at the Ames Research Center in California.

In their testing of potential active flow control devices for use on helicopters, Army researchers started with synthetic jet actuators, which are devices with electrically driven pistons, like subwoofer speakers, that drive up and down to make pulses of air come out of a slot about 3 millimeters long on the designated surface of an aircraft. Because they are electric, they don't require an air compressor to supply the air, which other active flow control devices would require. That's an advantage.

The downside: The actuators use magnets.

"Magnets are really heavy, so adding that weight to a helicopter is a big drawback," Wilson says.

If devices using magnets were to be used on the spinning hub that the rotors attach to, they might create electrical fields that could affect the electronics of the aircraft, or they could create tensions or forces on the spinning parts that could damage them.

"You have all these moving components that wouldn't work quite so well there," Wilson says.

Army engineers have also tested fluidic oscillators, also called fluidic amplifiers. Fluidic oscillators are small devices, typically made from machined aluminum or plastic, with internal air channels and holes cut into them. They have no moving parts, are palm sized and lightweight and create the same kind of pulsating jet that synthetic jet actuators do. Like SaOBs, they use compressed air instead of electricity. Fluidic oscillators create that pulsing jet from compressed air that rushes into a diverging channel, where the air tries to attach itself to one side of the channel or the other, oscillating between the two sides, as designed. A feedback tube that goes from one side of the chamber to the other allows the pressure to equalize as the jet of air goes back and forth, driving the air flow to be unsteady at a certain frequency, creating the desired pulsing effect.

Fluidic oscillators have their roots in 1990s research on unsteady flow control with synthetic jets. Fluidic oscillators took the concept a step further, adding pulsing to the air flow. The SaOB device combines suction and blowing in one device, to go a step beyond conventional fluidic oscillators.

In the SaOB device, suction takes the air off the surface through a port. The device has an internal injector nozzle, so that when compressed air is fed to the device, the air first runs through the injector nozzle, which creates a low pressure and pulls air in through the suction port. The air pulled in is combined with the compressed air to go through the fluidic oscillator. Air pushed out of the device goes through an angled slot on the surface, about 1.6 millimeters to 3.2 millimeters long.

The SaOB was developed by Avraham "Avi" Seifert, a mechanical engineering professor at Tel Aviv University, starting in 2003 and shared with the Army in 2008 as part of a 25-year-old joint rotorcraft research program between the U.S. and Israel.

Seifert invented the SaOB as an

Active flow control devices located on the rear ramp area of a model of a helicopter fuselage undergo a wind tunnel test at NASA Langley Research Center in Hampton, Virginia, in 2013. The red dots are used to indicate and measure the fuselage model's changes in position.

NASA

improvement on flow-control actuators that added too little flow control, especially for aircraft traveling at higher speeds, or were too complex or too heavy or that used too much energy.

The SaOB isn't the only type of active flow control device that the Army is considering. The service has also funded research by external partners, such as the University of Notre Dame in Indiana and Georgia Tech, into plasma or combustion-powered devices that could improve air flows around the surfaces of helicopters. Army researchers have developed actuators that can operate in dust, rain and ice conditions, and at the level of vibration typical for military helicopters.

The aerodynamic benefits of the flow control devices, as tested in wind tunnels, are weighed against other issues, such as their power draw, electromagnetic interference, and any acoustic or infrared signatures they create. With the SaOB, creating a source of compressed air on a helicopter could be an issue if that means adding weight to the aircraft.

"Each type of actuator has advantages and disadvantages," says Martin. "Our job is really to answer the question: What does it buy you? How much drag has been reduced, or how much more lift can you get?"

If an active flow control device creates more lift or other aerodynamic benefits than the cost of its own weight and power draw, then it would probably be worthwhile to add to an aircraft.

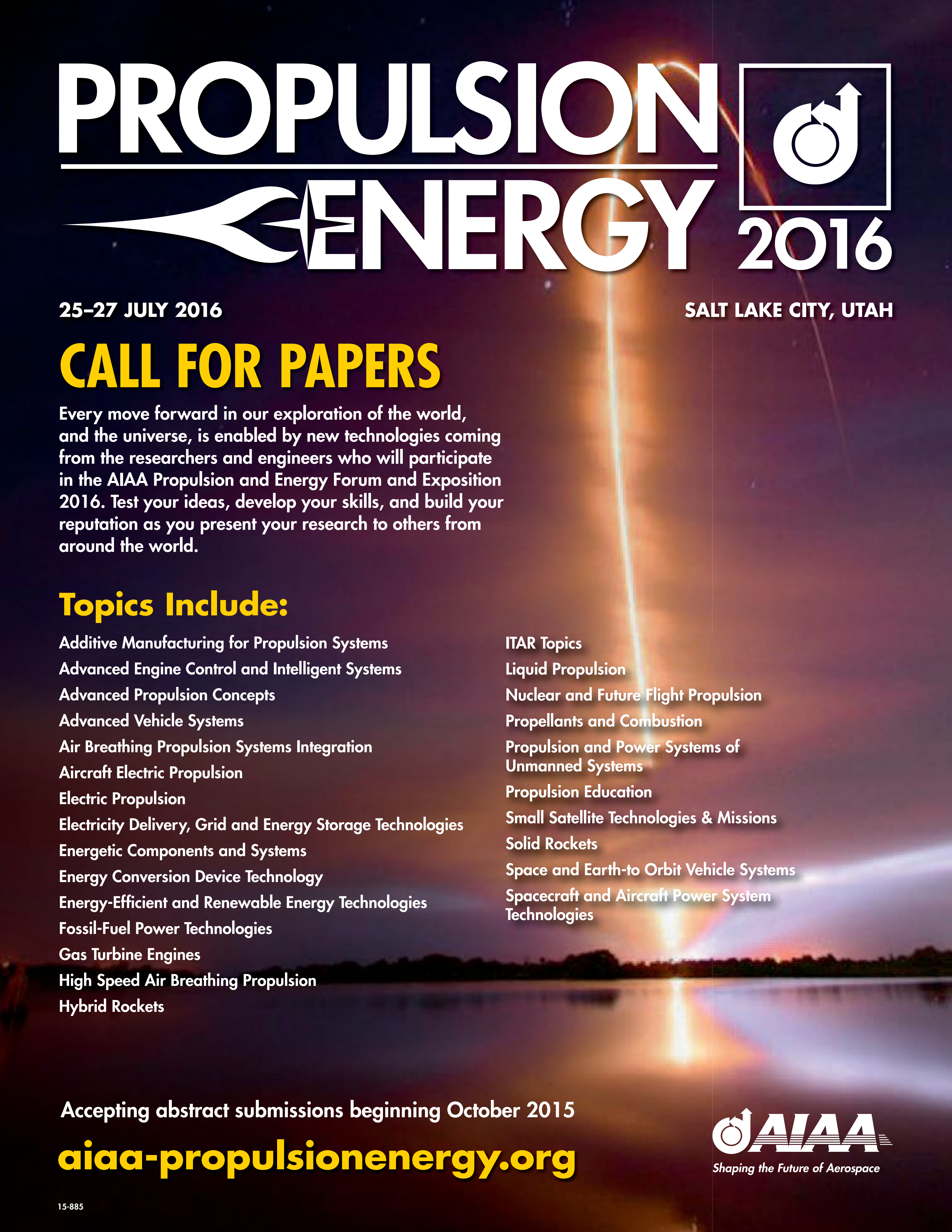
Most of the aerodynamic drag on a helicopter is created by the rotor hub, including the main drive shaft that comes out of the transmission and everything attached to the spinning center. But because of the difficulties associated with applying active flow control to the spinning parts of a helicopter, including mapping the airflows around the hub and understanding how they would be changed with active flow control measures, the researchers have focused so far on the fuselage and other parts of the helicopter that do not spin, says Wilson. Objects such as external fuel tanks or other attachments to the fuselage are easier to test in wind tunnels for analysis for potential flow control measures. Computational fluid dynamics modeling is not yet advanced enough to predict how active flow control devices will affect the air passing over an aircraft's surface.

Another challenge for helicopters is the downward force, called download, of airflow on the fuselage during hover. Rotors push air down onto the aircraft, creating a vertical drag problem, Martin says. Any effective use of active flow control on rotorcraft will probably have to address flow issues both in forward flight and during hover.

Sometimes flow control measures are more effective when they push air flow away from the surface. In a paper published by Martin and Wilson last year, they reported on wind tunnel tests performed by Army researchers on a transport helicopter shaped like a CH-47 Chinook with a ramp at the back. Using active flow control to keep the air flowing smoothly along the back surface actually created suction, or an area of low pressure that pulled the aircraft backward and increased download.

In that case, researchers found that the better use of flow control was to direct the air flow in a more streamlined shape at the back, like water flowing around the tail end of a boat, which achieved a 20 percent or more reduction in drag and download.

**Keith Button**
buttonkeith@gmail.com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## No firm date yet for U.S. crew capsule launch to space station

NASA's Kathryn Lueders had a quick answer when pressed by a digital questioner whether either of the commercial crew capsules in development by Boeing and SpaceX will be ready in time to get America back to launching astronauts to the international space station in 2017 as planned.

"The goal is to fly when it's the right time," Lueders said.

SpaceX's Hans Koenigsmann, vice president of mission assurance, and Boeing's John Mulholland, vice president and general manager for commercial space programs, each offered an upbeat assessment of progress on their respective crew capsules without definitively promising that the 2017 date could be met.

NASA and its commercial contractors are building the privately designed vehicles with a mix of NASA and private funds. NASA and its contractors are facing questions about the viability of the 2017 date because of recent changes to program milestones.

Koenigsmann said SpaceX's goal remains to "restore the U.S. crew-carrying capability by 2017." He said an unmanned launch pad test in May was a "major, major milestone" in development of the company's Crew Dragon spacecraft.


Kathryn Lueders, manager of NASA's Commercial Crew program

AIAA

As for Boeing's CST-100 capsule, Mulholland said the team has "adjusted some of our milestones to be more efficient." But he said "the team has largely produced to plan."

Mulholland said work is progressing on a structural test article: "The first piece of integrated, fully flight-designed hardware is coming together. That'll be shipped out to California, and we'll do our structural testing at the Huntington Beach facility here in the Los Angeles area starting in the early spring."

Before the Boeing and SpaceX capsules can carry astronauts, their safety must be certified. "You can't cut corners in that activity, and so there isn't a difference between the certification philosophy" for commercial craft compared to other human spaceflight, Mulholland said.

**Ben Iannotta**
beni@aiaa.org

## No trip to Mars without reusable orbiters

Space launches in the future will be reusable, cooperative and cheaper, with Mars being the key destination for exploration.

But that assessment from leaders from government and commercial space industry came with the warning that the success of future missions will require sustainable funding that keeps pace with inflation, as well as better promotion of the space industry to key decision makers.

A factor for future space exploration will be reusability, said Gwynne Shotwell, president and chief operating officer of SpaceX.

"We won't get to Mars, or other destinations, without reusable systems," Shotwell said during a plenary session. Otherwise, "it's a one way trip."


Gwynne Shotwell, president and chief operating officer of SpaceX

The panelists all agreed expenses have to be contained while funding must keep pace with inflation. Robert Lightfoot, associate administrator at NASA, said: "We have a plan that will close [for future exploration], but you have to take into account inflation. We've been flat for a long time, but you still [when planning future missions] have to take inflation into account."

Lightfoot said he doesn't expect to ever face a scenario in which someone comes into his office and says "I have too much [money], take some of it back."

Wanda Sigur, vice president and general manager for civil space at Lockheed Martin Space Systems, said keeping costs low forces the community to think about issues such as advanced manufacturing techniques, which reduce time and effort in developing new systems.

**Duane Hyland**
duaneh@aiaa.org

# Transformative tech


Dan King, director of business development at MDA Robotics & Automation, left, with moderator Gregory P. Scott, an aerospace engineer with the U.S. Naval Research Laboratory.

On-orbit satellite servicing, which can breathe new life into inoperable spacecraft, could transform the space industry.

From satellite inspection, to supporting a spacecraft launched into the wrong orbit, to active servicing tasks such as refueling or hardware replacement, spacecraft with the capability of rendezvousing and docking with other satellites could deliver enormous savings.

That was the main theme echoed by civil, defense and commercial space experts discussing this developing technology at the AIAA Space 2015 Forum.

Dan King, director of business development at MDA Robotics & Automation, said his company is conducting a study with DARPA to explore satellites that could be self-assembled in space, particularly with large antennas and apertures.

DARPA and MDA are planning to demonstrate a new payload orbital delivery service, "using hosted payload capacity, to have regular payloads launch into the higher orbits," King said.

David Markham, president of commercial launch at Lockheed Martin Space Systems, called for a transition from the current "launch, operate, and plan to re-procure" strategy. He said that there needs to be more "thinking about the capability to insert new and powerful performances into mission."

Benjamin Reed, deputy project manager in the satellite servicing capabilities office at NASA Goddard Space Flight Center, said an estimated 1,040 legacy satellites are currently in orbit. Citing the potential in the satellite servicing market, Reed said that while not all are great candidates for servicing, "a large portion of them are."

Brook Sullivan of Sullivan Analytics and Technical Services, a consultant for DARPA, said the agency is interested in transforming how work is done in space, or as Sullivan put it, "the way we do space architecture."

DARPA's aim is "to have a persistent dexterous robotics capability in geostationary orbit that has near-term real utility for U.S. government satellites," he said.

Sullivan called robotics the "core technology for transforming the entire space architecture," maintaining that once the transformation occurs, a timeline for an on-orbit upgrade will be "measured in months, maybe years, rather than portions of decades."

The future in satellite servicing "is very, very bright," said Craig Weston, CEO and president of ViviSat. Weston highlighted his company's coming "Mission Extension Vehicle, or MEV," which will dock with its client spacecraft, providing auxiliary propulsion to a satellite running low on propellant or that may have a damaged propulsion system.

**Lawrence Garrett**
lawrenceg@aiaa.org

***"Anybody who says we are ready to go to Mars right now is not to be taken seriously."***

John B. Charles, NASA's Johnson Space Center, on prospects for near-term human exploration of Mars.

***"If you Googled comet landing in 2014, a cartoon came up because there were no good images of a comet."***

Art B. Chmielewski, NASA's Jet Propulsion Laboratory, on the lack of high-resolution imagery before the Rosetta mission made the first landing on a comet.

***"I hope to see boots on Mars before I die."***

Robert Lightfoot, NASA headquarters.

***"We need to listen to the public because that's who pays our bills."***

Glen Fountain, of the Applied Physics Laboratory, speaking about the years-long effort to get a spacecraft to Pluto.

# Grasping the relationship between humans and machines

## Our Robots, Ourselves: Robotics and the Myths of Autonomy

**Reviewed by Meaghan Mulholland**

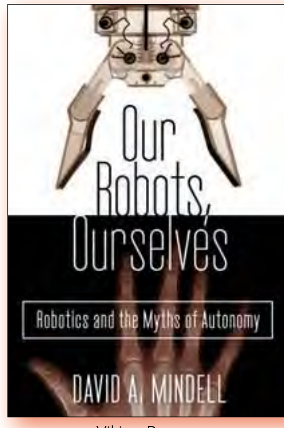
**The introduction of robotics** technology into human activities has always been accompanied by controversy, and this phenomenon predates an obvious recent example, the advent of armed drones. In the 1980s, some archaeologists and oceanographers objected to the use of remote cameras in the search for shipwrecks. "Some actually declared you had to physically visit the seafloor to be a real oceanographer," writes David A. Mindell in his new book, "Our Robots, Ourselves."

It is the relationship between humans and machines that Mindell explores in this comprehensive and captivating book. By showing how robotic technology is being used in various present-day environments, he hopes to reshape the public's sometimes suspicious view of how this technology will affect human endeavors. Semantics are important to Mindell. He avoids the word drone, explaining that it obscures the fact that robots are reflections of their human designers.

Rebooting how the public thinks about robotics and automation is Mindell's quest. He combines the latest robotics research at MIT and elsewhere with expert interviews and firsthand accounts to make a convincing case that robots should be viewed as neither replacements for humans nor fully independent, autonomous beings. They are parts of an interconnected system of human-driven exploration.

Mindell is a professor at MIT focused on aeronautics and astronautics and the history of engineering and manufacturing. He has taken part in numerous oceanographic expeditions, and the book includes riveting accounts of his riding a submarine through the Tyrrhenian Sea off Italy in search of ancient shipwrecks.

Mindell examines the way robotic assistance is used in extreme environments — in space, under water, in the skies and at war — and attempts to dispel the persistent myths he sees about the future of autonomy (think "robots taking our jobs," or the "Terminator" movies).




Viking Press

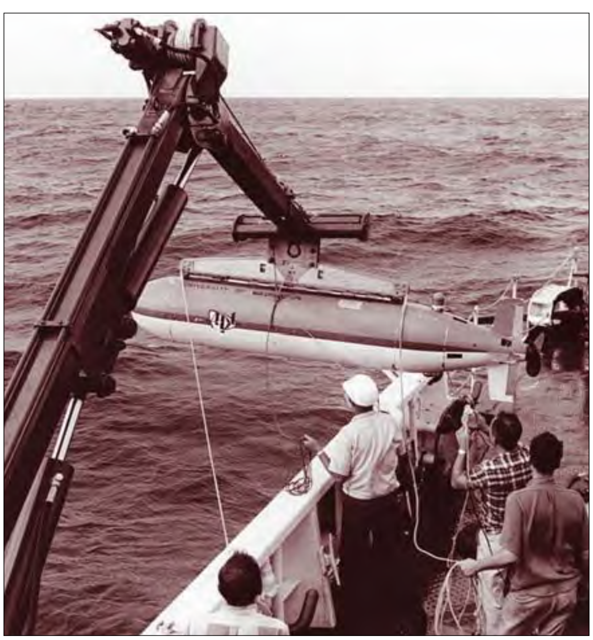
Mindell reminds readers that it is humans who control advances in robotics. Today, undersea explorers send tethered submersibles to depths too dangerous for humans, so that oceanographers can draw detailed maps of previously inaccessible ocean floors. He describes the robotics "choreography" that took place in the 1993 Hubble repair mission and the subsequent servicing missions by spacewalking astronauts. He talks in depth about NASA's experience with the "mobile robots" Spirit and Opportunity on Mars.

In the field of robotics, "It is not 'manned' versus 'unmanned'," Mindell argues, "but rather, where are the people? Which people? What are they doing? And when?"

Mindell believes in automation. But he also wants us to rethink how we relate to technology. Mindell sees the crash of Air France Flight 447 as an example of the perils of disconnect: Disoriented by an autopilot complication, the pilots crashed into the Atlantic Ocean off Brazil. The disaster was due less to a failure of technology than to an inability of humans to engage with it effectively. Ironically, advanced robotics would prove crucial in later recovering the plane's wreckage from the ocean floor.

Mindell quotes an Air Force major general warning after investigating a Predator drone strike gone wrong that robotics can also give a "false sense of security," as though "you can see everything, that you can hear everything, that you know everything."

Despite the social and ethical challenges robots present, Mindell writes that the public should embrace the relationship. No robot is a being unto itself; all owe their very existence to human programmers, technicians and scientists. The sooner we recognize the connected nature of all machines, Mindell says, the sooner we can begin to embrace the promise that robots hold "as extenders and expanders of human experience."

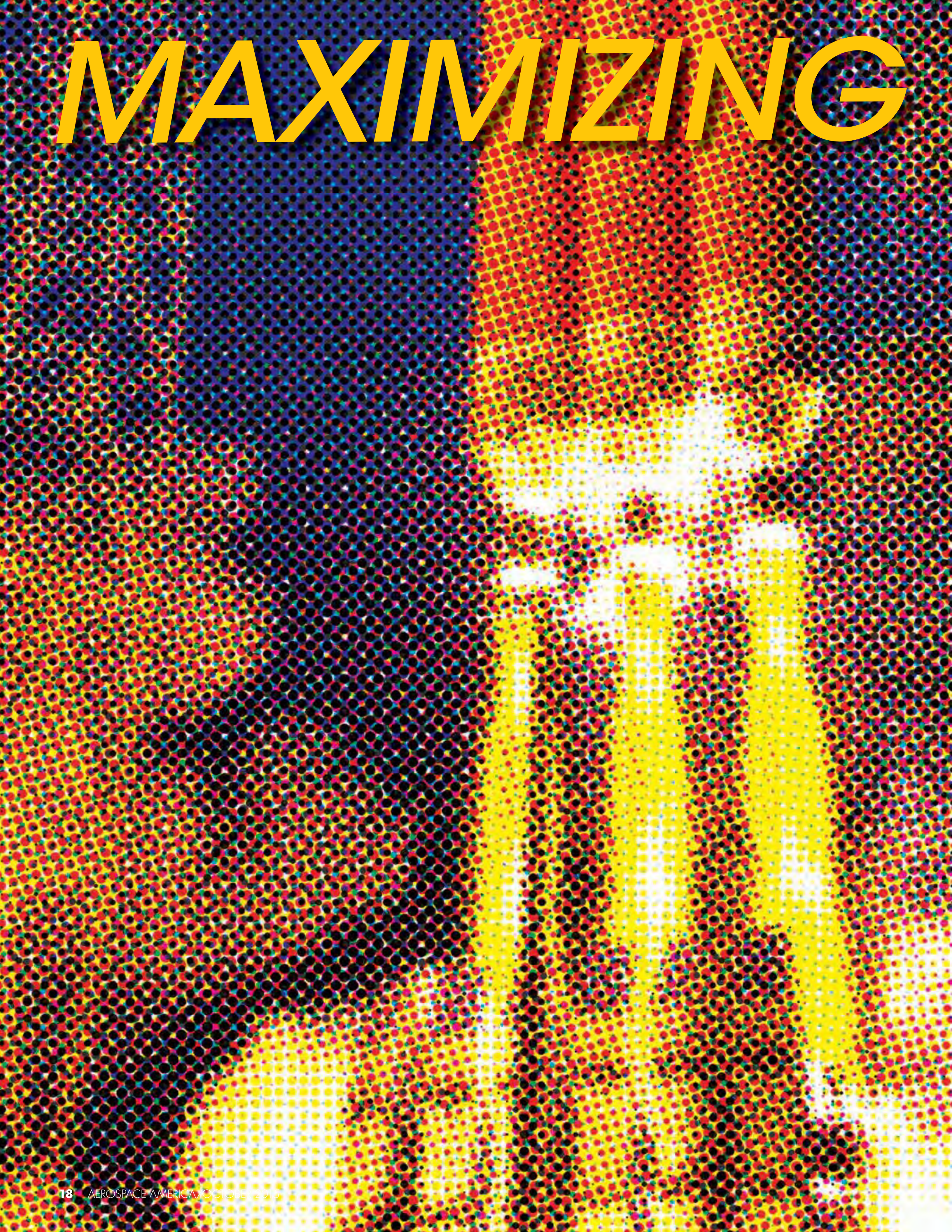


University of Washington

The Navy's first underwater vehicles, such as this one shown in 1957, enabled safer deep-sea research.

**Meaghan Mulholland**
meaghan.mulholland@gmail.com

# MAXIMIZING



# SAFETY

**Nothing is more tragic or paralyzing to space exploration than the deaths of a crew of astronauts. With the U.S. making bold plans to send humans to an asteroid and Mars, Debra Werner and Anatoly Zak set out to understand the odds of deadly accidents or illnesses — and how NASA and the industry aim to keep those risks to acceptable levels.**

When the Space Shuttle Columbia broke up high over east Texas in 2003, killing all seven astronauts, flight safety advocates turned it into a watershed moment to push for toughened safety standards. It was the second loss of a crew in just 113 flights, including the 1986 Challenger explosion. In 2004, President George W. Bush stood at a podium at NASA headquarters and announced that the shuttle fleet would be retired in 2010, a date later shifted to 2011. NASA followed with an ambitious goal proposed by the Astronaut Office: Why not develop a successor that would bring crews home safely 999 times out of 1,000 missions?

The goal, however, was short lived, waylaid by the realities of launching spacecraft atop thousands of pounds of explosive propellant, circling Earth amid bits of spent rocket stages and exploded satellites and blazing back into the atmosphere at hypersonic speeds.

In 2010, NASA quietly accepted a lower threshold for the shuttle's successor of 1 loss of crew in 270 missions to low Earth orbit. Any greater risks and NASA would cancel the program. Then, in an unexpected twist, NASA's safety experts factored in the risks of traveling to Mars or an asteroid, as the agency plans to do in the 2030s with the Space Launch System rockets. NASA determined the loss-of-crew rate on that type of mission would be 1 in 75.

The numbers suggested that flying on SLS and Orion would be riskier than one of the last flights on the shuttle. That assessment upset the Aerospace Safety Advisory Panel, a group of experts tasked by Congress in 1968 to periodically assess safety after the Apollo 1 launch-pad fire that killed three astronauts. The technology executives

**by Debra Werner**
werner.debra@gmail.com **and**
**Anatoly Zak**
agzak@russianspace web.com

and retired military officers on the panel had pressed NASA for months to share its assessment of risk on Orion and SLS flights. Calculations that new human spaceflights would not be significantly safer than with the shuttles did not sit well.

"It was the ASAP's hope that the inherently safer architecture of the SLS and Orion as compared to the Space Shuttle, including full abort capability, separation of energetics from the crew module, and parachute reentry instead of aerodynamic, would greatly improve inherent safety," according to ASAP's 2014 annual report.

Against that backdrop, astronaut safety is a paramount focus from the Kennedy Space Center in Florida, where Lockheed Martin is building the next Orion capsule and Boeing will assemble its CST-100 capsules, to Hawthorne, California, where SpaceX is building Dragon-2. Even as NASA works to study the safety risks of missions aboard these spacecraft and their rockets, officials know that there is only one way to prove the safety merits of NASA's decision to launch relatively simple capsules on conventional rockets: Start the new era of human spaceflight with them.

NASA cautions against the temptation to make misleading comparisons. Orion, the agency's flagship human spaceflight program, can't be easily compared to the space shuttle in terms of risk, because of their drastically different missions. The shuttle was intended strictly for flights in low Earth orbit, while Orion is being developed for still-undefined deep-space missions.

"The actual loss of crew value will vary depending on the mission," William C. Hill, NASA deputy associate administrator for exploration systems development, says by email. "This makes the loss-of-crew number one example where it is difficult to compare shuttle with Orion/SLS."

To evaluate safety, NASA analyzes risk for specific elements of a mission and aggregates those numbers. Launch and ascent gets a rating. In-space activity gets another. Atmospheric entry, descent and landing gets a third.

For launch and ascent, NASA will require Lockheed Martin to show that Orion poses no more than a 1-in-1,400 risk of loss of crew. Boeing must show that SLS poses no more than a 1-in-550 risk. For Orion's entry, descent and landing, the risk must be no more than 1 fatal accident in 650 missions.

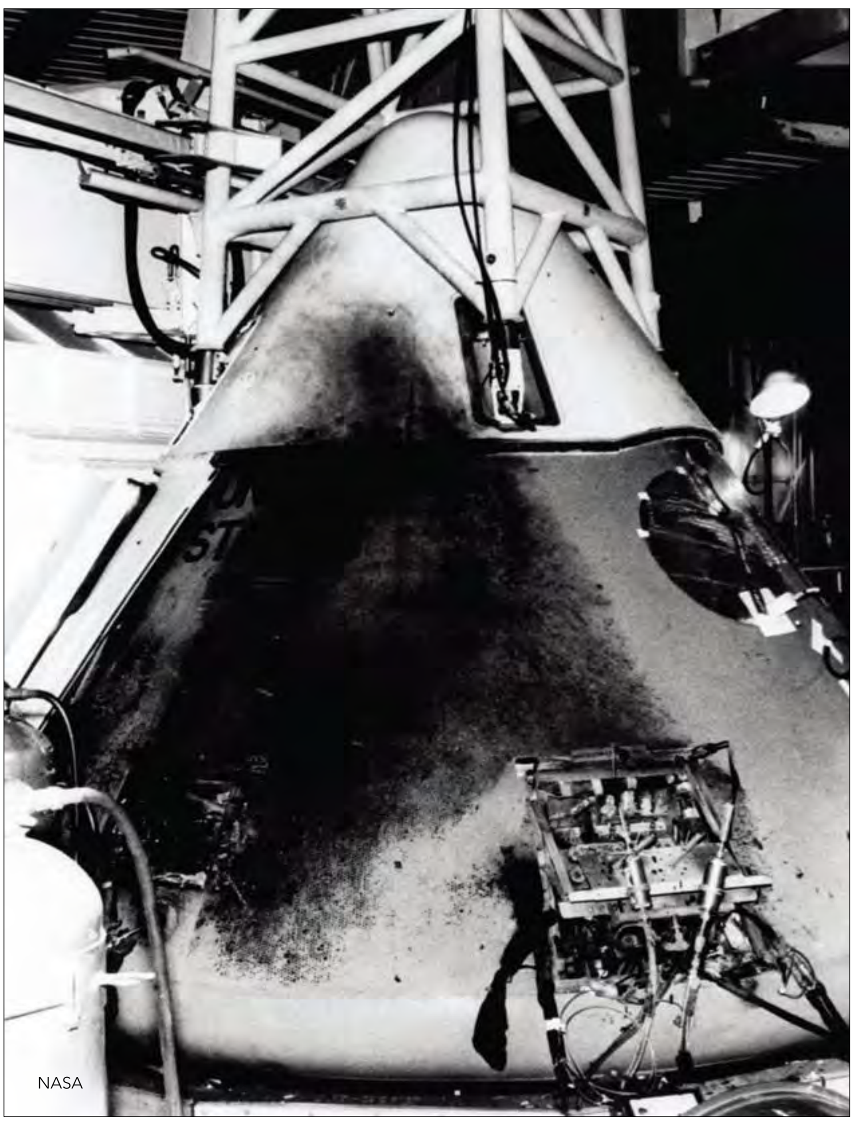
But until the actual mission has been specified, it's impossible to determine the precise risks astronauts will face. Missions can vary significantly in duration and exposure to hazards including micrometeoroids, radiation and orbital debris, Hill says.

"The initial test flights will enable us to gather hard data and learn how to improve systems," Hill adds. "We expect to continue making safety enhancements as we learn more."

### Radiation, meteoroids and debris

One NASA safety expert, who was not authorized to speak on behalf of the agency, says comparing Orion to shuttle "is comparing apples to kumquats. It is not that the [Orion] spacecraft is more dangerous. It is what we are asking the crew to do."

Apollo 1's command module the day after a flash fire during a 1967 launch pad test killed astronauts Roger Chaffee, Gus Grissom and Edward White.


NASA


A SpaceX Crew Dragon lifts off during a pad-abort test in May. The unmanned test demonstrated how the capsule would save astronauts from a failing launch vehicle.

Low Earth orbit was the destination for the shuttle orbiters. But for Orion, it will be only the first stop. An upper stage, or space tug, must fire with more than twice as much force as the most powerful double-engine Centaur upper stage on the Atlas 5 rockets. The extra power will be necessary to escape Earth's gravity and traverse through space junk, meteoroids, the Van Allen radiation belt and the galactic cosmic radiation beyond Earth's magnetosphere.

Orion's carbon composite shell, which surrounds its titanium honeycomb crew compartment, will shield astronauts from enough radiation that long-term health effects are more of a concern than losing a crew member due to acute radiation sickness during a mission. If astronauts eventually travel in deep space for two or three years, radiation might take a toll on their central nervous, cardiovascular or immune systems that would be seen later in the mission.

"We only have hints of that, but it is enough to be concerned," says Ronald Turner, an analyst at Anser, a nonprofit research institute in Falls Church, Virginia.

The first Orion missions are expected to last 21 days at most, which means astronauts would not have to worry too much about radiation. A bigger concern would be a collision with meteoroids or human-made debris. If an object were to pierce Orion's upper stage before it expended its propellant, the stage could be disabled or the force of the escaping gases could cause Orion and the stage to tumble violently and require immediate separation, creating risk of a collision. A similar uncontrolled tumble occurred during the 1966 Gemini-8 mission, but the crew returned home safely.

So, starting with Exploration Mission-2 in 2021, which will be the first time Orion carries a crew, the capsule will be boosted by a more powerful upper stage designed from the start for protection from impacts. This Exploration Upper Stage will give SLS power to boost additional payloads, such as a habitation module, an airlock or, if NASA changes its exploration goals, even a lunar landing module.

Debris turned out not to be a problem

Rick Stiles/NASA Columbia Accident Investigation Report


**Fatal vulnerability:** A chunk of foam like that on the shuttle's external tank pierced a section of reinforced-carbon-carbon material during testing at the Southwest Research Institute in Texas. Investigators concluded that foam fell from Columbia's tank during its 2003 ascent and damaged the orbiter's left wing, causing Columbia to burn up when the crew tried to return home after the mission.

on Orion's first flight, the unmanned Experimental Flight Test-1, despite the Delta 4 Heavy's less-protected Interim Cryogenic Propulsion Stage. After studying whether to add protective materials, "the team deemed that the increased risk did not really drive you to change the design," says Mike Hawes, the Orion project manager at Lockheed Martin.

Because the new Exploration Upper Stage won't be ready, the interim stage will be used on the first flight of SLS, the unmanned Exploration Mission-1 Orion mission, currently scheduled for late 2018.

On EFT-1, the NASA-Lockheed Martin team was able to mitigate the impact risk by cutting the time spent in lower orbit as Orion simulated an ejection into translunar orbit.

## Getting home

Once Orion leaves Earth's orbit, an emergency return will be a lengthy and propellant-hungry affair. If a mishap occurs far enough from Earth, Orion would need to loop around the moon before heading back to Earth a la the Apollo 13 Command/Service Module and Lunar Lander.

Unlike Apollo 13, Orion won't have a lunar module to serve as a lifeboat. The Bush administration had included a lunar lander called Altair in its Constellation exploration plan, but in 2010 the Obama administration canceled Constellation and the lunar lander. While there would be no lifeboat for the crew, Hawes stresses that more advanced internal systems currently designed for the Orion would make the Apollo-13 scenario itself much less likely.

"The mission configuration is different, the mission definition is different, and, frankly, the reliability of the systems is very different," Hawes says. "Data and computing systems are all built with extra levels of redundancy and [Orion] incorporates all that the space community learned through Mercury, Gemini, Apollo, Skylab, Shuttle and space station."

## Launch abort

Whether the destination is the station or deep space, the ascent phase of a mission is always among the riskiest steps.

During the shuttle program, few astronauts had faith that the escape mechanism added to the orbiters after the 1986 Challenger explosion would work. The astronauts were suppose to blow a hatch, install an escape pole, then one-by-one hook their parachute harnesses to the pole, slide down it and off the end toward the ground. Another problem was the shuttle's architecture. Attaching the orbiter to the side of the external propulsion tank meant that any material shed upstream of the orbiter during launch could potentially hit it, which is exactly what happened to Columbia. Foam insulation from the external tank broke off and struck the orbiter's left wing, fatally damaging the wing's heat shield.

Orion will ride atop its rocket to avoid the Columbia debris scenario, as will the Commercial Crew vehicles in development for transportation to and from the International Space Station. In addition, all will have abort systems requiring little or no action on the part of the crew.

In an emergency on the launch pad or before main engine cutoff, a United Launch Alliance Atlas 5 emergency detection system would direct CST-100 computers to activate four Aerojet Rocketdyne RS-88 Bantam engines to lift the crew capsule from the booster. The flight crew can also activate the same emergency system, as can flight controllers on the ground if necessary.

"If we have a horrible day, we're going to get the crew back to safety," predicts Chris Ferguson, a former space shuttle commander and Boeing's crew and mission operations director.

SpaceX chose a similar approach. The company's Dragon 2, an updated version of the Dragon capsules that carry supplies to the space station, is equipped with eight SuperDraco launch abort engines with a combined 120,000 pounds of thrust. After the SpaceX Falcon 9 rocket broke apart minutes following liftoff in June, Gwynne Shotwell, SpaceX president and chief operating officer, said in a NASA briefing, "The escape system slated for the second version of Dragon certainly should have taken the astronauts to a safe place after an anomaly like this. In fact, it's designed to take a far more energetic event and get the astronauts safely away."

For Orion, Lockheed Martin chose to attach a rocket assembly at the top of the capsule's aeroshell to pull it away from a failing launch vehicle and position the capsule for a safe landing under a parachute. The approach is similar to those used for Mercury, Apollo and Soyuz.

### Orbital debris

NASA's plans to pay Boeing and SpaceX to keep their new commercial space taxis docked at the space station for six months to serve as emergency shelters or lifeboats will make them vulnerable to debris. By contrast, shuttle orbiters typically spent about 12 days in orbit.

"One of the most significant drivers to risk is micrometeoroid and orbital debris environment exposure time," says Phil


NASA

Technicians assess data collected during vibration tests on Orion's Launch Abort System. The inert, 16-meter-long assembly was tested in 2009 at the Orbital Sciences facility in Dulles, Virginia.

McAlister, NASA director of human spaceflight development. "There's a little bit more debris up there than there was 10, 20 or 30 years before. So the length of time you are on orbit is a significant driver to risk."

The danger is that a micrometeoroid or bit of a spent rocket body could strike an unoccupied, docked vehicle without anyone noticing.

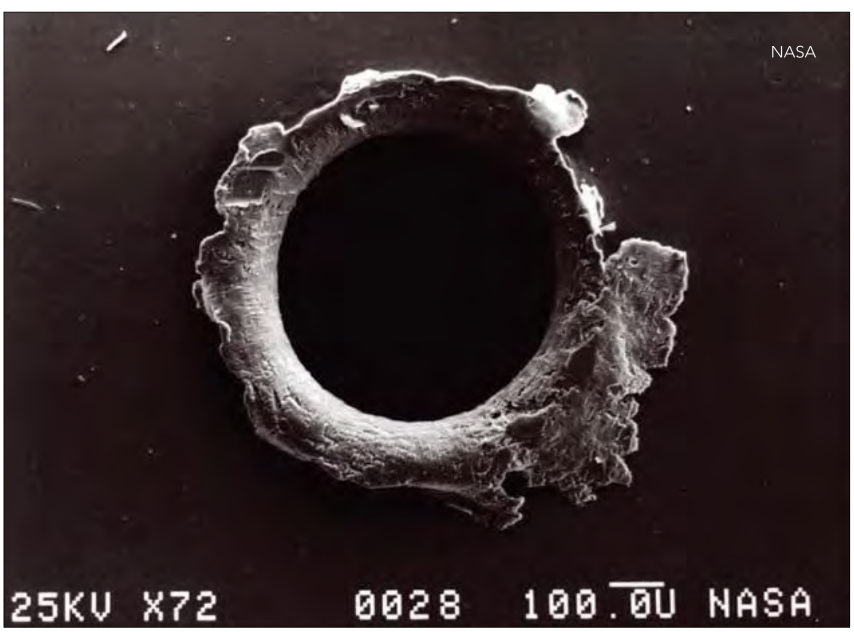
"As the space shuttle taught us, even minor damage to the thermal protection system can be catastrophic during reentry because of the extreme environment that it must withstand," says John Frost, a member of the safety panel and a former head of the Army Aviation and Missile Command's safety office.

Meteoroid or debris impacts are inevitable if a spacecraft stays up long enough, so NASA is considering technologies or strategies for inspecting the space capsules while they are docked at the space station. NASA could instruct astronauts to inspect the capsules during a spacewalk or to use one of the space station's robotic arms to survey the extent of any damage.

Boeing designed the CST-100 to deflect or absorb debris with its composite outer shell, thermal protection system and interior pressure vessel. SpaceX did not respond to requests for comments on its debris protection.

"We stacked up things that could cause loss of crew or loss of mission," Ferguson says. "Rocks and stuff in orbit ended up being the number one thing. We take great measures to protect astronauts from small particles."

This impact mark was discovered on a component of the Solar Max scientific satellite after the space shuttle Challenger crew repaired the spacecraft in 1984. It is about the size of the period at the end of this sentence.




### Closing the safety gap

No one is sure whether the commercial capsules or Orion, if used for low-Earth-orbit missions, can achieve the 1-in-270 threshold for loss of crew due to the micrometeoroid hazard. So NASA has directed Boeing and SpaceX to ensure that their vehicles can provide a one in 200 chance of loss of crew, while the space agency takes additional measures, such as inspections or shortened missions, to close the safety differential.

"We believe operational considerations will help us get to that 270 number," NASA's McAlister says. "How exactly we are going to do it, we haven't defined yet."

That 1 in 270 number, which would make Orion roughly three times as safe as the shuttle at the end of the program, "is certainly something we all hope can be achieved," says George Nield, FAA associate administrator for commercial space transportation and a member of the safety panel. "But in fairness, it's very, very difficult to predict ahead of time exactly what risks are present and exactly how and when those risks will show themselves. The intent when we started flying the shuttle was that it would be as safe as an airliner and we were going to have regular people — teachers and others — fly on it. As it turned out, it wasn't quite as safe as we hoped."

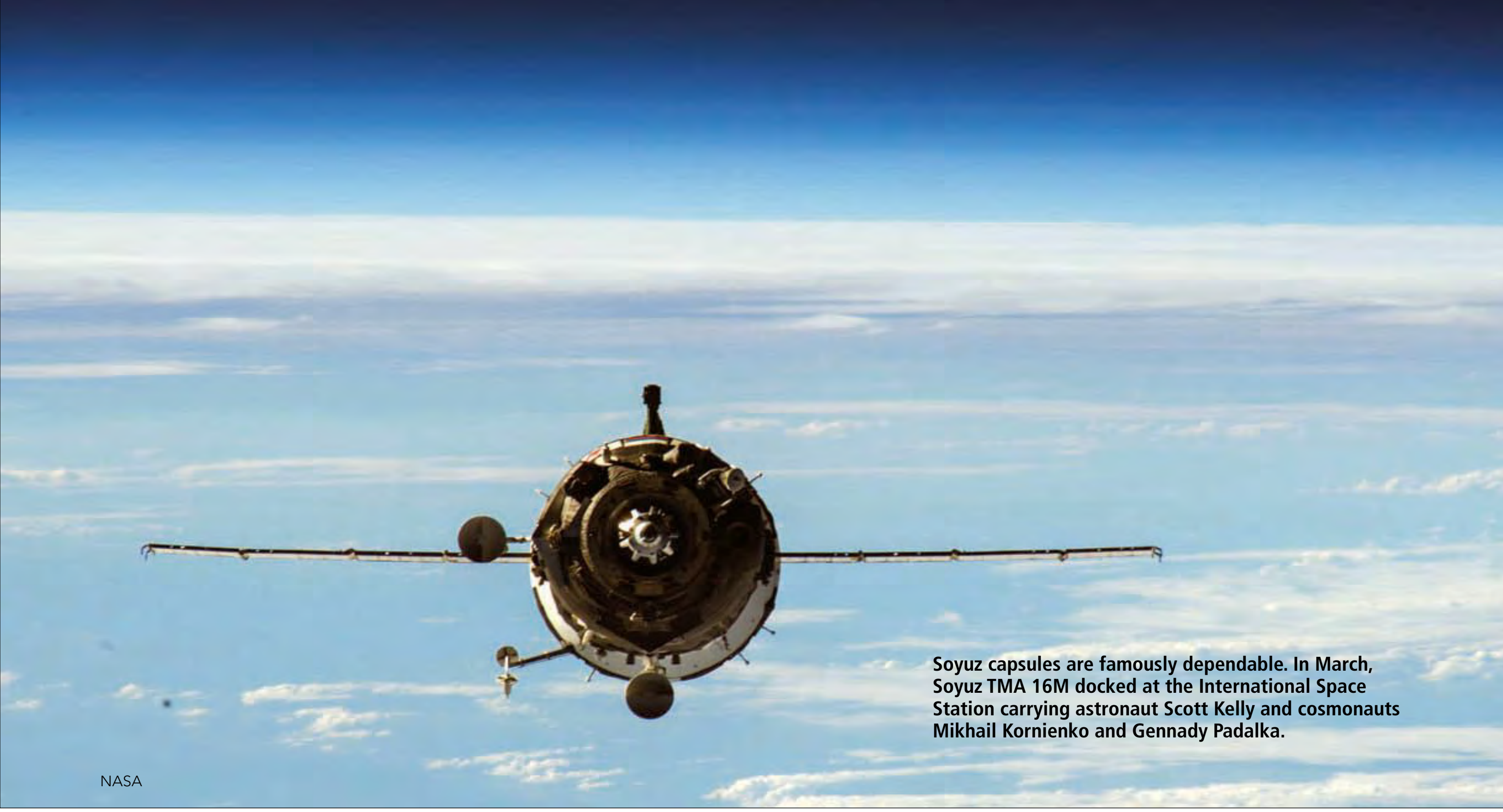
In retrospect, the loss-of-crew risk at the outset of the shuttle program was closer to 1 in 12, according to ASAP's 2011 annual report.

History is on the minds of NASA officials as they look to the future. By the time of the shuttle's inaugural launch in 1981, the Apollo-1 fire that killed astronauts Roger Chaffee, Gus Grissom and Edward White was a distant memory. Fresher were the memories of the Apollo moon landings and the Apollo 13 rescue.

"We were pretty much bullet-proof," a NASA official remembers. "We could do no wrong!"

That sentiment evaporated with the shuttle disasters, after which NASA's culture grew more risk-averse.

Under the latest safety criteria, Lock-



NASA

Soyuz capsules are famously dependable. In March, Soyuz TMA 16M docked at the International Space Station carrying astronaut Scott Kelly and cosmonauts Mikhail Kornienko and Gennady Padalka.

heed Martin engineers are evaluating 23 different safety parameters for Orion missions, including health risks to the crew, meteoroids, heat shield problems and parachute failures. As a result, each discipline has to bring its own risk assessment, which then ends up in the melting pot of an overall estimate.

"Sometimes these numbers are driven by many, many factors that I, a little sarcastically, refer to as a car's equivalent of a check-engine light," Hawes says. Lockheed Martin has to consider human health factors ranging from disease to radiation and all of the life support functions of the spacecraft, and then put those risks together into a single number.

Kidney stones are more likely in space than on Earth, for instance, because zero gravity causes bones to atrophy, which causes kidneys to absorb more calcium.

"You can look at those issues differently when you are in low Earth orbit on the space station than when you are going to the moon and you are several days away from home, or if you are going to Mars, where you are several months away from home," Hawes says. "We need to have better understanding and better processes to handle these kind of problems."

## Safe as Soyuz

NASA and its contractors hope Orion, CST-100 and Dragon 2 will eventually prove themselves to be as safe or even safer than Soyuz, which has carried U.S. astronauts to the space station since the shuttle stopped flying in 2011. The new capsules have more meteoroid protection than Soyuz and improved heat shields. Key will be operational experience. CST-100 and Dragon 2 have not yet flown and Orion has made only one unmanned test flight. Then again, Soyuz missions in the mid-1960s were plagued with potentially fatal problems whereas an early version of Orion splashed down just as planned in the program's first flight last December.

Looking to the future, space safety experts in the U.S. and elsewhere hope to someday achieve the 1-in-1,000 loss-of-crew goal once envisioned for the shuttle fleet, but they say it will be difficult.

"If we had the possibility of building more reliable rockets, we would already have done this because no one has an interest in losing rockets," says Tommaso Sgobba, executive director of the International Association for the Advancement of Space Safety and former head of the European Space Agency's flight safety office. "There is no magic formula."

The only way to improve reliability is to fly the same rocket and space capsule repeatedly. Sgobba points to the Soyuz booster, which has flown more than one thousand missions and has not experienced a fatal accident since 1971.

# Revive the space shuttle

***Not everyone is content to let the space shuttle recede quietly into history. Don Nelson, a NASA veteran of the Apollo and shuttle programs, argues the agency's Space Launch System rockets and Orion crew capsules will turn out to be financially untenable and not as safe as promised. He is among the experts who are advocating for development of a fleet of privately operated Commercial Space Shuttle freighters.***

VIEWPOINT

**by Don A. Nelson**
dnelson005@comcast.net

**There are two** basic options for ferrying humans between the ground and low Earth orbit as part of a deep-space transportation system: construct a heavy-lift Saturn 5-class launch vehicle with an Apollo-like module, or build a vehicle similar to the space shuttle.

The country's space-launch visionaries have long wrestled with this choice. In 1990, with the loss of the Challenger crew a vivid memory, NASA and the U.S. Air Force proposed building a family of expendable rockets called the Advanced Launch System, including a version for human transportation to LEO. After ALS was abandoned, NASA began an Access to Space study, which recommended developing a reusable, single-stage-to-orbit vehicle that was meant to lead to a privately operated replacement for the space shuttle fleet. This was the ill-fated X-33 Venture Star.

NASA's current space transportation plan abandons reusability and private operations, the exceptions being the two Commercial Crew capsules that will serve as space station ferries. For deep-space missions, the agency is leading development of the Space Launch System rockets and Orion

# ...but with a commercial twist

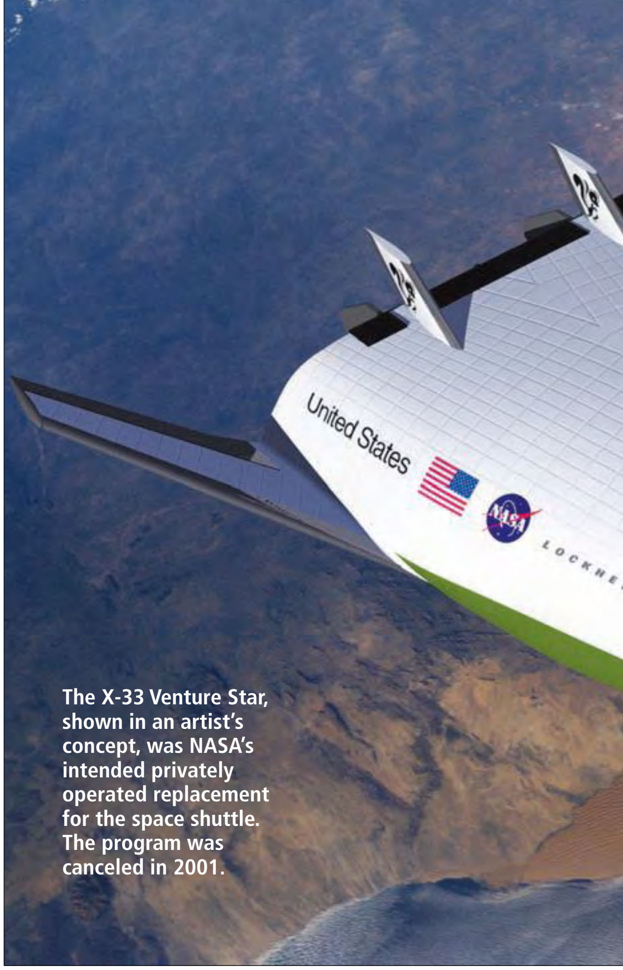
NASA

crew capsules, and it plans to operate them when they are completed.

Unfortunately, this plan, like those before it, is based on flawed economic and safety assumptions. A human launch transportation system cannot be operated by the government because there is no incentive to control costs. An affordable, sustainable and safe 21st-century space transportation system must consist of commercially operated, reusable vehicles, derived from existing technologies.

In light of this situation, I am working with an informal group of current and former aerospace engineers to advocate for development of a small fleet of Commercial Space Shuttle freighters. An initial fleet of three would be operated as a commercial venture similar to Europe's Ariane 5 rockets or United Launch Alliance's marketing of services to the U.S. Air Force. We are convinced that the CSS is the only option that can provide safe and affordable LEO transportation for astronauts on their way to deep space via space tugs and deep-space cruisers.

It's important to keep history in mind. The Saturn 5 and Apollo flew their last mission in 1972. The space shuttle fleet was




The X-33 Venture Star, shown in an artist's concept, was NASA's intended privately operated replacement for the space shuttle. The program was canceled in 2001.

retired in 2011. Despite those operational experiences, NASA continues to promise that its Space Launch System rockets will be safe, affordable and sustainable. A reasonable person must wonder: How can SLS be affordable given that all previous U.S. heavy-lift, human-rated systems have proven to be unaffordable?

Here is a difficult reality that NASA's plan ignores: Neither the 70-metric-ton nor the 130-metric-ton version of SLS has any significant military or commercial applications. But such launches would be needed to cover the enormous annual operating costs. On deep-space missions longer than 21 days, a still-to-be-developed habitation module would be required, making the Orion capsule dead weight for those missions. SLS will be sustainable only as long as Congress is willing to provide funding.

Regarding costs, NASA says the 70-metric-ton version will cost $7 billion to develop, but it has not publicly given an estimate for the 130-metric-ton version that would be required to send humans to Mars in the 2030s. If those costs were made public, the resulting sticker shock would kill the program.

On the issue of crew safety, Orion will be equipped with small rockets called the Launch Abort System that would boost the capsule away from a failing launch vehicle. That addresses the Challenger scenario of an emergency during ascent. But what about the Columbia scenario of a mishap during entry? Orion won't have an escape system for that phase. The Orion entry systems must work correctly or the crew dies.

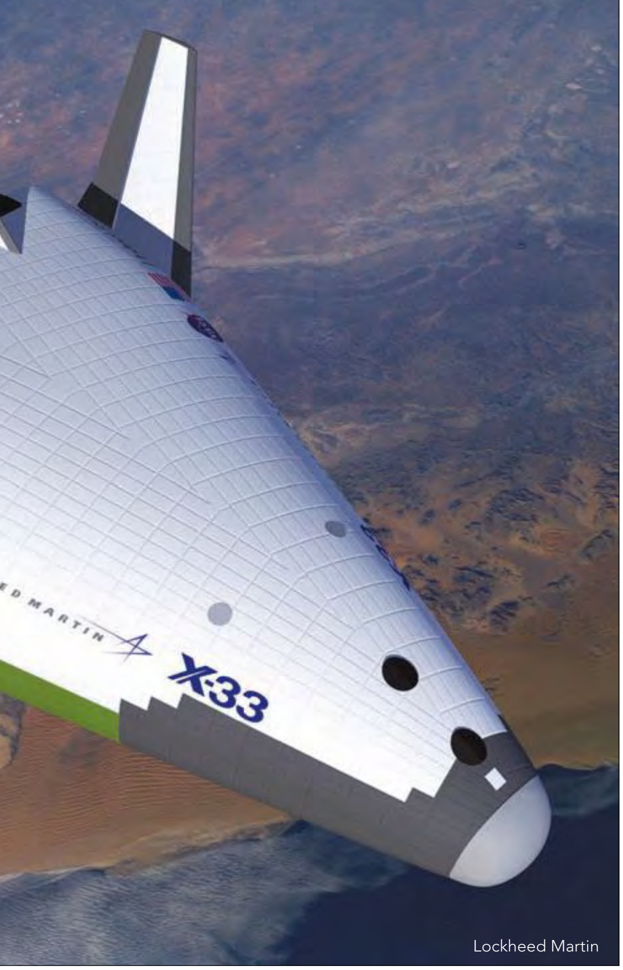
NASA's statement that Orion will be 10 times safer during ascent and entry than the shuttle orbiters was challenged in January by the Aerospace Safety Advisory Panel, a group of non-NASA employees assembled by NASA to examine matters of safety. The panel's 2014 annual report, released in early 2015, predicts that the SLS-Orion combination will not be significantly safer than the shuttle since there is no crew escape system for entry failures.

The Commercial Crew program's privately developed crew capsules have the same safety weakness. Only a crew escape pod would increase survivability, but neither Orion nor the commercial capsules are large enough to accommodate such a pod.

All told, the CSS would be more affordable because it would target commercial, military and international launches. It would be safer because of its crew escape pod. Our mission design copies the decommissioned space shuttle's maximum payload and orbital mission, calling for delivery and return of 20 metric tons to a circular orbit of 240 nautical miles at 28.5 degrees inclination. The CSS freighters would be developed with existing technologies and have a launch turnaround capability of five days. Each CSS freighter would resemble the shuttle orbiters, but their construction and operation would be vastly different.

The orbiter, external tank, and solid rocket booster will be constructed primarily of composite materials, which results in a significant weight savings and reduces manufacturing costs for the expendable tank and booster motors. The freighter will be designed for maximum affordability. All subsystems are to be modular with a plug-in replacement capability. It will maneuver in space with environmentally friendly green propellants instead of hydrazine. It will have upgraded main engines, long-life batteries and solar arrays.

The launcher will be assembled at the




Lockheed Martin

pad and the freighter will accommodate ship-and-shoot payloads and crew escape pods for manned flights. The thermal protection system will be fourth-generation tiles designed to be repaired or replaced on-orbit. In this configuration and with no civil service overhead, it can provide safe, affordable launches for civil, military and commercial near-Earth missions. With the addition of space tugs and cruisers, CSS could enable missions beyond LEO. The CSS would compete strongly in the international launch market and would have the unique capability in the commercial world to return payloads from LEO.

The concept capitalizes on the nation's operational history with the shuttle program. The shuttle's role in assembling and supporting the space station proves the concept for the CSS freighters. The fast turnaround could help the Air Force respond quickly to foreign threats or a dangerous asteroid or comet, avoiding the almost unimaginable price of failing to meet such threats. Looking to possible competitors, the China National Space Administration reportedly is considering development of a space shuttle, and China appears determined to secure natural resources in space, as shown by the country's lunar program. At the moment, only the U.S. has the reusable technology to accomplish that goal. We should not let that go to waste. The only obstacles for a CSS freighter are political.

**Artist rendering of a Space Launch System rocket.** NASA

✈✈✈

*Aerospace engineer Don A. Nelson retired from NASA in 1999 after a 36-year career. He worked on the Gemini, Apollo and Skylab projects and was a member of the space shuttle design team. He is coordinator for the Commercial Space Shuttle freighter group, www.spacetran21.org.*

# Honoring Achievement: An AIAA Tradition

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We celebrate our industry's discoveries and achievements from the small but brilliantly simple innovations that affect everyday lives to the major discoveries and missions that fuel our collective human drive to explore and accomplish amazing things. For over 75 years, AIAA has been a champion to make sure that aerospace professionals are recognized for their contributions.

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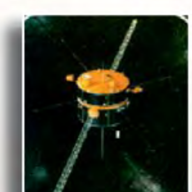

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**Thank You, Nominators!**
AIAA appreciates your time and effort in preparing the nomination package!

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Adobe

by Philip Butterworth-Hayes
phayes@mistral.co.uk

In April, pilots aboard a China Eastern Airlines Airbus A321 and a Shandong Airlines Boeing 737-800 made a pair of unusual landings. The planes, which carried no passengers, were equipped with three different navigation technologies to touch down at Shanghai's Pudong International Airport in Southern China automatically on their own. The pilots merely monitored.

The trial was an example of a trend among airlines. Today's pilots land at major airports in bad weather mainly by putting the aircraft on autopilot, so that the plane locks onto radio signals broadcast from antennas near runways. These signals provide straight-line lateral and vertical guidance. Now, however, the competition among airlines to save fuel and stay on schedule even in rough weather is prompting technologists to look beyond these conventional ILS, or instrument landing systems, to technologies that promise ILS levels of precision beyond a straight-line approach. This means, for the first time, aircraft will be able to avoid noise-sensitive areas or mountains and still execute automated landings.

Specifically, they are experimenting with "mix and match" approach and landing procedures using several different types

# All-weather landing

*The global air transportation industry has historically been slow to embrace new technology but not so for precision landing these days. Airlines are vying to find the best mix of technologies. Philip Butterworth-Hayes analyzes the options and the stakes ahead.*

Airports and airlines are testing their own customized procedures for automated precision approaches and landings instead of waiting for regulators.

of navigation technologies; some already fly these kind of approaches in operational service, though none, as yet, has been cleared for fully-automated landings.

But many industry experts are concerned about the safety aspects inherent in the complexities of blended automated approaches and landings. They worry that some safety certification agencies, especially outside the core traffic areas of the world, might underestimate the complexity of the technologies and procedures involved.

"If you are doing low-visibility approaches using autopilot, you don't want a wake vortex encounter close to the ground because the autopilot can't put in the same level of response to recover that a human pilot can," says David Gleave, a U.K. air traffic management safety consultant. "Then you have to understand what navigation system the aircraft is using at a particular time. For example, you may have a blend of different systems — inertial navigation, GPS, distance measuring equipment, instrument landing systems. You have to know which system is being used, how the aircraft is using it and what happens if one of these systems fails or disagrees with another."

Airlines for years have been looking at ways to exploit the precise navigation capa-


China Eastern Airlines Airbus A321

China Eastern Airlines


Shandong Airlines Boeing 737-800

Boeing

bilities provided by global navigation satellite systems, or GNSS, such as GPS. Opportunities are now growing for airlines and airports to develop tailored automatic precision approaches to save fuel and flying time, bypass noise-sensitive communities and steer planes into airports surrounded by mountains, even during bad weather.

The April trial at Pudong airport was the first part of a program to convince the Civil Aviation Administration of China to license the procedure for landings with paying passengers. The planes employed a required navigation performance procedure. GPS signals were fused with location readings from the aircrafts' own inertial navigation system to fly a precise, predefined route. A ground-based augmentation system validated the GPS signal to guide the aircraft along a range of non-linear approaches. The airport's conventional ILS signals provided guidance to the autopilot for an automatic landing.

Blending these technologies and procedures into seamless and safe landing practices is technically complex.

"The pilots need to know what mode the aircraft is operating in," says Steve Landells, flight safety specialist at the British Airline Pilots' Association. "In the Shanghai trials, for example, they are testing over 20 different approaches with variable glide paths and curved approaches and this opens up the possibility for errors — for example, by programming the flight management system with the wrong approach path."

These issues are currently being examined by the Chinese aviation authorities and other aviation safety regulators around the world. But the vulnerabilities of satellite navigation are complicating the certification job. The primary navigation aid, GPS, is susceptible to solar flares and storms and intentional jamming.

At a minimum, these can degrade accuracy and reliability. To provide sufficient accuracy and integrity for category three — or fully automated — landings, the avionics must tap into augmentation systems that monitor the accuracy and integrity of the satellite signal. These can be either ground-based or space-based, but space-based augmentation alone cannot provide enough integrity or accuracy for a fully-automated landing.

Inside the cockpit, any new GPS-based approach or landing procedure must be displayed to pilots in a manner that will be familiar to them, given their experience with ILS approaches, Landells says.

"This means that if you are on an ILS approach and you get a warning at 150 feet, you can simply press the go-around button and that takes you into a fully-automated go-around procedure."

Until now, ILS has been the main navigational aid certified for category three landings. At London's Heathrow Airport and at Amsterdam Airport Schiphol, microwave landing systems have been installed as an alternative to ILS. But these are very rare. Almost all the world's major airports use ILS to provide automatic landing capabilities during bad weather.

But this is old technology. ILS was introduced in 1939, and although it is possible to buy a modern solid-state version, the equipment is relatively expensive to purchase, operate and maintain. It has limited coverage in mountainous areas, where pre-


LHR Airports Ltd

At Heathrow Airport in London, the first of four new enhanced Instrument Landing Systems began operating in August to help with landing during low visibility.

cise navigation approaches are most urgently needed. ILS units offer only straight-line in approaches. The localizer signal, which provides lateral guidance, is sensitive to obstructions in the signal broadcast area, such as tall buildings. This sensitivity limits construction around airports.

Augmented GNSS, to replace ILS, is a technology that has a growing number of advocates. A ground-based augmentation system, or GBAS, ground station comprises a number of satellite signal reference receivers. Antennas installed at precisely surveyed points to monitor the accuracy and integrity of satellite signals. Corrections and approach path information are broadcast via VHF data link.

GBAS holds the promise of using satellites to guide an aircraft to a category three automatic landing via an approach path that can weave its way through mountainous terrain or on a path to avoid overflight of towns and cities in the vicinity of the airport. One single ground station can provide over 20 different approach path options. There are other cost benefits.

"The cost benefits can be seen in both the upfront acquisition costs as well as the annual maintenance costs," says Michael Underwood, director of business development at Honeywell Aerospace, by email. Honeywell was one of the technology partners in the Shanghai demonstration. Underwood gives an example: "ILS serves one end of one runway. GBAS can serve all ends of all runways at a given airport."

At the Sydney Kingsfield Smith International Airport, there are three runways, which equate to six runway ends. Sydney maintains at least six ILSs. The single GBAS system installed at Sydney provides the same category one, an automated approach that brings the aircraft to within 150 feet of the runway, precision-landing capability as the six ILSs. Additionally, the ILSs must be calibrated every six months and this takes a special aircraft and special procedures and the ILS is unusable to the airline customer during the calibration period.

But GBAS has not yet been certified for category three commercial operations. The original aim, announced by President Bill Clinton in 1995, was to have GBAS installed for category three approaches around the world by 2015. Now, the technology's champions, including the FAA, are aiming for the first installations to be operational by 2018. But some experts predict this deadline will be missed, too.

"I don't think you are going to see cat-

Airports International

In 2012, Atlantic Airways and Airbus developed automated precision approaches to aid in landing at Vágar Airport in the Faroe Islands between Iceland and Norway.

egory three GBAS operations for quite a few years yet, because there are still safety standards working groups working on them and you will probably need a second constellation such as [Europe's] Galileo or [Russia's] GLONASS to be able to get to that level of performance, to ensure the integrity of service," says Philip Church, a senior consultant with U.K. air traffic management advisers Helios.

Equipment standardization officials say it will take until 2019 to develop the safety standards for a GBAS category three ground station in the United States, along with operational approval of GBAS ground and airborne systems working together. It might take until 2022, they say, to complete the minimum operating standards for the multimode receiver needed to process more than one type of GNSS signal.

That is why rather than waiting for a single new type of landing aid technology, airlines, airports and aircraft manufacturers are launching their own mix-and-match procedures. They have grown restless waiting for international certification agencies and governments to provide the ground-based systems that will allow them to fully exploit their aircraft's highly accurate on-board navigation systems to provide customized, fuel-saving approaches. A new spirit of entrepreneurship has entered the international air transportation community, which has often been criticized as bureaucratic and slow to adopt new technologies given the need for global consensus. The race to deploy new, more flexible category three automated precision approaches and landings is driven now by competition, as well as improved safety and reduced environmental impact.

"New technologies, systems and procedures are enabling agile airport and airline businesses to take more control of their activities, while at the same time increasing safety, efficiency and reducing cost," says Graham Lake, a London-based executive adviser for air transport and air traffic management. "The use of satellite-based precision approach procedures is a good example, where systems, hardware and maintenance costs are reduced compared to legacy terrestrial systems."

In Europe, a new way of working was pioneered in March 2012 when Atlantic Airways of the Faroe Islands and Airbus jointly developed a non-linear approach into Vágar Airport. The archipelago sits between the Norwegian Sea and the North

Atlantic Ocean. The weather is often stormy, the airport is surrounded by mountains and the nearest diversionary airports are located hundreds of miles away in Iceland, Norway and Scotland. The new procedures have meant the aircraft can now automatically fly precision approaches in extremely challenging weather conditions, cutting the number of diverted flights considerably — and the amount of fuel that needs to be carried in case the plane needs to divert — without introducing expensive ground equipment.

In the United States, Seattle-based Alaska Airlines has pioneered heads-up guidance systems alongside ILS at many airports where wind, snow and fog are major challenges.

"Today, some approach procedures allow for reduced visibility credit based on heads-up guidance systems, or HGS, and we take advantage of that to the maximum extent possible," says Bret Peyton, one of the airline's technical pilots, by email. "For instance, we are able to fly category one ILS approaches down to 1,400 [feet] runway visual range at certain locations based in part on having an HGS. This greatly aids operational reliability and passenger satisfaction in locations that don't have operating or installed category two or category three ILS procedures."

But the use of three different systems and procedures, as at Shanghai, is taking customized airline approaches to new levels of complexity — not merely improving the accuracy and flexibility of automated approaches but developing procedures that result in automated landings as well. It is not surprising that China should be leading the way here; China has been at the forefront of pioneering required navigation performance procedures for approaches into mountainous airports, especially in regions such as Tibet, and has more experience certifying these procedures than any country outside North America and Europe.

Several GBAS trials are underway in the U.S. and Europe to validate the safety case for the systems and procedures. In 2014 the FAA started testing Honeywell prototype GBAS software at its Atlantic City Technical Center and plans to obtain operational approval by 2018. Honeywell and Boeing have been using a Boeing 787 research aircraft to text category three GBAS approaches at Boeing's test facility in Moses Lake, Washington, since last December. In Europe the first category three GBAS automated approaches and landings were carried out in September 2013 at Frankfurt airport, with a Honeywell Dassault Falcon 900EX, as part of the Single European Sky air traffic management research program.

Meanwhile, the world's airlines are gradually becoming equipped with more GBAS-compatible aircraft. According to Honeywell's Underwood, more than 20 percent of today's airline fleet have GBAS landing system capability. And by next year, approximately 40 percent — or more than 4,000 aircraft — will have this capability.

"As more and more aircraft are equipped to use GBAS, fewer and fewer ILSs will be installed. Those ILSs already installed will likely be less frequently replaced as they become older and harder to maintain," he says.

Many airports are now looking at replacing ILS or weighing whether to buy updated ILS equipment. Many are considering GBAS as an alternative. "Providing all the safeguards are in place to allow manual overrides and the ultimate decision to land or not land is left with the pilot then that's fine, "says Landells of the British pilots' association. "But it's early days yet and this new technology will need to prove that it is as safe and reliable as the systems that we currently rely upon before pilots will be happy to see the removal of conventional, ground based systems."


Alaska Airlines' Heads-Up Guidance System projects flight information onto a glass screen as pilots approach San Diego. The Seattle-based carrier has pioneered the use of the guidance system to augment instrument landing systems to help with landings in fog and snow.

# New life for an


Lockheed Martin's P-791 hybrid airship is shown during its evaluation flight in Palmdale, California, in 2006.

***Eyebrows were raised in 2010 when Lockheed Martin's vaunted Skunk Works company was passed over to supply the Army with an intelligence and communications airship tailored for the war in Afghanistan. Henry Kenyon looks at the progeny of the P-791 airship and the new cargo and passenger market Skunk Works hopes to pry open.***

**by Henry Kenyon**
hkenyon@hotmail.com

# old hybrid

Lockheed Martin

Residents of California's aerospace-rich Mojave Desert are never surprised to see strange aircraft, but most have probably never seen one more exotic than a bulbous, 38-meter-long prototype craft with the obscure name, P-791. It flew a series of tests in 2006, and pictures from plane spotters raced across the Internet. The airship was mothballed soon afterward, but the technologies developed for the P-791 are key to a new effort at Lockheed Martin's Skunk Works factory in Palmdale to build a bigger version of the airship for commercial customers.

Skunk Works tried to sell the P-791 concept to the Army in 2010 as an unmanned intelligence, surveillance and reconnaissance aircraft and communications relay for troops in Afghanistan. Skunk Works lost this Long Endurance Multi-Intelligence Vehicle competition to Northrop Grumman, whose airship the Pentagon ultimately decided not to buy when the program was canceled in 2013.

This time, Skunk Works is convinced it has the right recipe. It's building a cargo and passenger version based on the P-791 prototype and is marketing it to oil, gas and mineral explorations firms. If Skunk Works succeeds, the odd-looking craft could begin carrying supplies to remote oil exploration and mining facilities in 2018 or 2019. This is Skunk Works' first commercial venture, although the airships will be sold through a partnership between its parent, Lockheed Martin, and the airship company Hybrid Enterprises of Atlanta.

## Special delivery

The P-791 is not alone among a new breed of airships that blend the lift of forward flight with buoyancy provided by lighter-than-air gas. Hyrbrid Air Vehicles of the U.K. is building its Airlander hybrid, having worked with Northrop Grumman on the former Long Endurance Multi-Intelligence Vehicle. While conventional airships are useful for staying over an area for extended periods of time, they are not very well suited for moving cargo. This is because their inherent buoyancy becomes a problem when a large weight such as a heavy cargo pallet is released. Without anything to counter the sudden change, the craft will leap skyward. Hybrid airships don't have that problem because they are not lighter than air.

The Skunk Works hybrid derives most of its lift from helium stored in flexible bags called ballonets, just as traditional airships do, but the craft also would generate some lift from air flowing across its surfaces. Skunk Works says the P-791 derives up to 20 percent of its lift from its forward momentum and aerodynamic shape.

Skunk Works had to solve a complication of the hybrid concept. Conventional airships are lighter than air, so they naturally hover over landing zones and can be secured by tethers to towers. The P-791 needs 12 knots to 15 knots forward airspeed for take off and landing. So engineers included four diesel engines in the blueprint. For takeoff and landing, wheels were out of the question, because Skunk Works wanted the craft to land in rough, unimproved areas and even water. An air cushion system was devised similar to a hovercraft. Four fan blades encased in rubber skirts created a cushion of air to bring the P-791 to a bounce-free landing.

These fans can also be reversed, so that the airship grips the ground and remains stationary without the need for towers, cables and ground crews to secure the aircraft. This is especially useful while loading and unloading cargo in windy conditions.

"When you put those three things together" — lifting body, air cushions and vectored thrust — "the ground crew is eliminated and the susceptibility to shifting winds is eliminated. It really solves, as we saw it, all the major limitations of an airship," says John Morehead, Lockheed Martin's chief engineer


Photo illustration showing a truck unloading from a hybrid airship.

for the hybrid program in Palmdale.

Skunk Works also wanted the ability to steer the craft for precise landings, and for that a thrust vectoring mechanism was incorporated into the design. Electric servo motors allow the airship's engines to move in different directions, up to 130 degrees for direct forward, reverse and downward thrust. This arrangement provides a greater degree of control at low speeds for landing and taxiing to a parking location.

## High expectations

Skunk Works has worked on a variety of airship designs for 25 years, from tethered aerostats to one called Aerocraft, a huge cargo-lifting hybrid capable of hauling 500 tons. The company began working on the hybrid lifting body concept 10 to 12 years ago with the Aerocraft program. The current three-lobe envelope design, as demonstrated on the P-791, was the lightest and simplest engineering solution.


**Northrop Grumman's Long Endurance Multi-Intelligence Vehicle program was canceled in 2013 when the Pentagon decided not to buy the airships.**

"We did quite a bit of work on aspect ratios, and the relationship between that and how much internal complexity and weight had to go into an airship hull," Morehead says.

The P-791 does not have any rigid internal structures to support its envelope. This is done with gas pressure and two composite fabric internal curtains that run the length of the ship to form the three lobes. The outer envelope covering consists of a Vectran-based material woven with layers of film to retain helium. Morehead describes this approach as melding three airship hulls together. "In that region where they're merged, you need to have an internal structure, but it's non-rigid," he explains.

The airship's gondola is suspended from the bottom of the curtains. The engines are also attached to a non-rigid structure – the outer skin – through a combination of bonding and lacing directly to the fabric.

"That, I believe, is the first time anybody [has] really done that, at least in large scale," says Bob Boyd, the hybrid airship program manager at Skunk Works.

## Hugging the ground

The cushions can transition from a retracted soft mode to a landing mode to a parking mode or to the grip mode.

"We knew that was a critical operational aspect that we had to have because when you get out in these remote areas you just can't legislate that you've got to have mast trucks or tie-downs or anything. It defeats the whole purpose," Boyd says.

But getting the air cushions to operate properly in an airship was tricky and required a long development process. One of the most challenging aspects to designing the air cushions was to properly model and characterize the landing dynamics. "What happens when you come down at a certain sink rate and you touch the ground? Are you going to bounce and continue to bounce because it's a system that has energy added into it as you're dissipating landing energy, or is it the type of thing that is easy to manage through blow-out valves and regulating the system?" Morehead asks.

To test the landing physics, Skunk Works built a subscale test pad that spun around in a circle attached to a central arm. The pad could descend at different speeds and angles to simulate a variety of descent patterns. Weights could be added at the end of the central arm to counterbalance the mass of the air cushion pad and simulate the airship's buoyancy. The test rig was subscale but still large, with the air cushion pads measuring about two meters across. They were suspended on a 9-meter I beam.

Skunk Works has pursued several lighter-that-air designs over the past quarter century, including tethered aerostat.

Aeros

Engineers used the rig to model the physics for landings and to ensure that the air cushion system was safe, serving as "landing gear" and holding the airship to the ground under windy conditions. This ability to navigate and stay in one place is important for its future role as a cargo carrier working out of remote Arctic areas, which are prone to high winds. To handle these conditions, Skunk Works engineers say the P-791 and its larger successor can land in 28-mile-per-hour winds blowing from many direction, and nose first in gale-force 46-mile-per-hour winds.

## Airborne freight hauler

The airship is controlled with computer-assisted, fly-by-wire technology. Its four diesel-powered piston engines are mounted on external pods that can vector plus or minus 130 degrees, permitting pure vertical, pure forward and pure downward thrust. An algorithm automatically blends the right amount of elevator and rudder control into maneuvering the airship. Boyd notes that Lockheed Martin's pilot simulator for the airship has been operational for 15 years. "It's actually really simple to fly from a pilot perspective," he says.

The P-791 prototype achieved an air speed of 30 knots, while the cargo hauler under construction will have a speed around 60 knots. The new aircraft will be 91 meters long, about twice the length of the P-791. The airship will have a range of 2,700 kilometers for operations in remote areas. But Boyd expects most customers to fly between 160 and 965 kilometers. Up to 20 metric tons of cargo will fit in a bay measuring 18 meters long, 3 meters high and 3 meters wide. In addition to a crew, the airship will be able to transport up to 19 passengers and cargo.

Because the P-791 was the original prototype, the next aircraft built will be a first-of-type that will require type certification from the FAA, Boyd says.

"We're not making a different airship. What we're doing is making a different transportation device," he says.

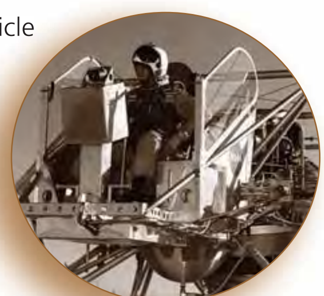
## 25 Years Ago, October 1990

**Oct. 6** Space Shuttle Discovery is launched on the 36th shuttle flight and deploys the Ulysses spacecraft toward a heliocentric orbit around the sun. A joint European Space Agency/NASA project, Ulysses will go on to encounter Jupiter in February 1992 and receive a gravity-assist to speed it up to reach the south solar latitude in June 1994. Over the next years, Ulysses investigates the solar wind, solar radio bursts, x-rays, galactic cosmic rays, space dust, and related solar phenomena until its decommissioning in 2009. NASA, Astronautics and Aeronautics, 1989-90, p. 334; Flight International, February 12-18, p. 16.

## 50 Years Ago, October 1965

**Oct. 4** Lunik 7, or Lunar 7, the USSR's 3,313-pound moon probe, is launched but crashes into the lunar surface at high speed instead of negotiating a soft landing. The mishap is blamed on a premature retrofire and cutoff of the retrorockets. The crash site is located in the Oceanus Procellarum, west of Kepler Crater, near the intended target, on October 7. Washington Evening Star, October 4, p. 1 and October 8, p. A4.

**Oct. 8** A test model of the Lunar Landing Research Vehicle is flown by former NASA X-15 pilot Joseph Walker to an altitude of 300-feet altitude and landed. The research craft, developed by Bell Aerosystems Co. to simulate soft lunar landings, is propelled by a jet engine to support 5/6th of its weight while the pilot manipulates solid-propellant rockets to support the remaining 1/6th. The craft's attitude is controlled by jets of hydrogen peroxide. Washington Post, October 9, p. A-4.



**Oct. 14** The Orbiting Geophysical Observatory 2 (OGO 2) is launched by a thrust-augmented Thor-Agena booster from Vandenberg Air Force Base in California, but the spacecraft exhausts its attitude-control gases 10 days later, hampering most of its science collections. The 1,150-pound spacecraft is furnished with some 20 onboard experiments and its overall mission was to concentrate on obtaining data on near-Earth space phenomena, with an emphasis on the global mapping of the geomagnetic field, using measurements of neutral, ionic, and electronic composition of the Earth's atmosphere. Washington Post, October 15, p. A4; NASA Release 65-368.

**Oct. 14** The USSR launches its second Molniya-1 communications satellite to further the country's two-way long-distance TV and telephone-telegraph radio communications. Early in its mission, this spacecraft is used for telephone calls and TV transmissions between Moscow and Vladivostok in what is now Russia. Washington Post, October 15, p. A4.

**Oct. 15** North American Aviation's XB-70A supersonic bomber reaches 2,000 mph and climbs to 70,000 feet in one hour, 47 minutes in an experimental flight from Edwards Air Force Base across California, Nevada, Utah and Arizona. The aircraft is powered by six turbojet engines, each with more than 30,000 pounds of thrust. The XB-70A flights are used to obtain data valuable for the design of the Supersonic Transport then in its design study phase and later called the Concord. New York Times, October 15, p. 45.

**Oct. 17-18** A sensor-equipped Convair 990 jet named Galileo takes off from Hickam Air Force Base in Hawaii and races with the sun to keep comet Ikeya-Seki in view for as long as possible. The 30 scientists on board undertake spectral and other scientific observations of Comet Ikeya-Seki and its tail in the ultraviolet and infrared. New York Times, October 18, p. 10.

**Oct. 19** NASA launches an Aerobee 150A sounding rocket from Wallops Station, Virginia, to investigate characteristics of Comet Ikeya-Seki. The rocket reaches a peak altitude of 111 miles, with its 245-pound scientific payload, designed by scientists of the University of Colorado and the Jet

Propulsion Laboratory. This payload consists of a scanning spectrometer, a filter wheel photometer, and related equipment to obtain spectra of the head and tail of the comet and to measure radiation. The data are coordinated with observations conducted by other scientists. On October 21, a second Aerobee 150 is flown from Wallops to obtain further measurements of the comet. Wallops Release 65-67 and Wallops Release 65-69.

**Oct. 25** NASA's two-man Gemini 6 spacecraft mission is canceled when the Gemini Agena target vehicle experiences a catastrophic failure soon after separating from its Atlas launch vehicle. The mission would have been the first U.S. space rendezvous and docking. It is later determined that the Agena's propulsion system failed and the unmanned target vehicle broke up before it reached orbit. NASA decides to have Gemini 6 rendezvous with the manned Gemini 7 instead. On October 28, the re-named 7/6-A rendezvous mission is announced, and on December 15, this mission is carried out. James M. Grimwood, et. al., Project Gemini — Technology and Operations: A Chronology, pp. 216-217, 227-229; David Baker, Spaceflight and Rocketry, p. 185; Aviation Week, November 15, 1965, p. 33.

SBD Dauntless

## 75 Years Ago, October 1940

**Oct. 11** Erich Klockner of Germany attains a record glider altitude of 37,598 feet, near Salzburg, Austria. A. van Hoorebeeck, La Conquete de L'Air, Vol. 2, p. 13.

**Oct. 12** The Soviet Union's Ilyushin Il-2, third prototype, makes its first flight. The plane is equipped with the new, more-powerful AN-38 engine and has significant wing modifications. This version subsequently goes into production as the first and most famous of the Shturmovik ground-attack fighters. More than 35,000 are built throughout the war and the plane is the most widely produced aircraft in history. Yefin Gordon, Dmitriy Kommisarov, and Sergey Kommisarov, OKB Ilyushin: A History of the Design Bureau and Its Aircraft, pp. 17-18.

**Oct. 26** North American Aviation's NA-73 fighter, later known as P-51 Mustang, makes its first flight. Designed to a British requirement as a replacement for the venerable Curtiss P-40, more than 15,000 are produced for the war, some 8,000 of them as the P-51D/K model — arguably the best fighter of World War II. William Green, Warplanes of the Second World War, Volume 4, pp. 136-152.

## And During October 1940

— Douglas Aircraft starts delivery to the U.S. Navy of new two-seater dive bombers designated SBD Dauntless, which were developed from the Northrop BT-1 dive bomber. The Dauntless will later achieve fame in the Battle of the Midway in June 1942 by destroying four Japanese aircraft carriers and a heavy cruiser, breaking the back of the Japanese fleet. Interavia, November 5, p. 7; Gordon Swanborough and Peter M. Bowers, United States Military Aircraft Since 1911, pp. 167-168.

## 100 Years Ago, October 1915

**Oct. 2** The French dirigible Alsace is shot down during a low altitude bombardment mission and its crew is captured. The failed attack dissuades the French from further night attacks except on moonless nights. David Baker, Flight and Flying: A Chronology, p. 81.

**Oct. 7** American pilot Raoul Lufbery, who will become an ace of France's Lafayette Escadrille squadron, is assigned to Valiant Navy Bombing Squadron 106 (VB-106). Of French descent, Lufbery joined Escadrille N.23 a year earlier as a mechanic before training as a combat pilot. David Baker, Flight and Flying: A Chronology, p. 81.

**THE OHIO STATE UNIVERSITY**
COLLEGE OF ENGINEERING

## Faculty Position in Space
## Mechanical and Aerospace Engineering

The Department of Mechanical and Aerospace Engineering at The Ohio State University invites applications from outstanding individuals for an open rank, tenured or tenure track, faculty position in space. Specific areas of interest include, but are not limited to: (a) Energy management and control of heterogeneous energy sources for prolonged space missions; (b) In-space propulsion technologies, including solar electric propulsion and deep-space cryogenic storage of fuel; (c) Thermal management in spacecraft and space structures; (d) Space System Integration; and (e) Spacecraft dynamics and control systems including navigation, guidance and pointing systems.

The department presently has 65 full-time faculty members, 20 focused on aerospace specifically, with nationally ranked undergraduate and graduate programs. Research interests cover broad ranges of aerospace, mechanical, nuclear, and materials science and engineering topics. The Ohio State University offers a vibrant research environment with one of the largest, best equipped, and best connected academic research platforms in North America. Proximity of OSU to NASA Glenn Research Center (120 miles) and Air Force Research Laboratory at WP Air Force Base (75 miles) offers great opportunities for collaborations. This position is aligned with the College of Engineering's strategic plan for crosscutting, interdisciplinary research efforts in energy and environmental monitoring. More information can be found at https://mae.osu.edu/ and http://engineering.osu.edu/.

Qualifications:
Competitive candidates should have a doctorate in Aerospace or Mechanical Engineering, or a related discipline; a demonstrated ability to conduct independent research; obtain research funding; work collaboratively within the department, college, university and with aerospace research organizations across the state and country; as well as a strong interest in teaching graduate and undergraduate classes. Rank offered will be based on the qualifications of the successful candidate. The anticipated start date is Fall 2016. Screening of applicants will begin immediately and continue until the position is filled. Interested candidates should upload a single PDF file containing a complete curriculum vitae, 2-3 page (each) statements of research and teaching goals, and contact information for four references to: https://mae.osu.edu/jobs/faculty-position-space. In addition, please email a copy of the PDF containing the application materials to: MAE_Space_Search@osu.edu. Questions regarding the position could also be asked via this email address.

*The Ohio State University is an equal opportunity employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation or identity, national origin, disability status, or protected veteran status. Columbus is a thriving metropolitan community, and the University is responsive to the needs of dual career couples.*
*The Ohio State University is an equal opportunity employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation or identity, national origin, disability status, or protected veteran status. Columbus is a thriving metropolitan community, and the University is responsive to the needs of dual career couples.*

## THE AIAA SUGGESTION PROGRAM

AIAA welcomes suggestions from members on how we can better serve you. All comments will be acknowledged. We will do our best to address issues that are important to our membership. Please send your comments to:

***Annalisa Weigel***
*VP Member Services*
*1801 Alexander Bell Drive, Suite 500*
*Reston, VA 20191-4344*

# PRINCETON

**School of Engineering and Applied Science**

The Department of Mechanical and Aerospace Engineering (MAE) at Princeton University is conducting a broad search for two (2) tenure-track assistant professors. We welcome applications from all areas in mechanical and aerospace engineering, including but not limited to the fields of particular interest, namely, (1) robotics and (2) aerospace-related sciences and engineering. Applicants must hold a Ph.D. in Engineering, Materials Science, Physics, or a related subject, and have a demonstrated record of excellence in research with the potential to establish an independent research program. We seek faculty members who will create a climate that embraces excellence and diversity, with a strong commitment to teaching and mentoring.

Princeton's MAE department has a long history of leadership in its core areas of Applied Physics, Dynamics and Controls, Fluid Mechanics, Materials Science, and Propulsion and Energy Sciences, with additional strength in cross-disciplinary efforts impacting areas such as biology, bio-inspired design, the environment, security, and astronautics. We seek creative and enthusiastic candidates with the background and skills to build upon and complement our existing departmental strengths and those who can lead the department into new and exciting research areas in the future.

To ensure full consideration, applications should be received by November 15, 2015. Applicants should submit a curriculum vitae, including a list of publications and presentations, a 3-5 page summary of research accomplishments and future plans, a 1-2 page teaching statement, and contact information for at least three references online at http://jobs.princeton.edu, reference number 1500603. Personal statements that summarize leadership experience and contributions to diversity are encouraged.

*Princeton University is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability status, protected veteran status, or any other characteristic protected by law. We welcome applications from members of all underrepresented groups. This position is subject to the University's background check policy.*

# BAYLOR UNIVERSITY

**Assistant Professor
Department of Mechanical Engineering**

The Department of Mechanical Engineering in the School of Engineering and Computer Science seeks a dynamic scholar to fill a tenure-track faculty position in computational or experimental thermofluid sciences. The position will begin in August 2016 at the Assistant Professor level. Applicants seeking a higher rank will be considered.

Requirements include an earned doctorate in Mechanical Engineering or a closely related field, outstanding English communication skills, a commitment to teaching excellence, demonstrated research achievement, and a commitment to professional activities. **In light of Baylor's strong Christian mission, the successful applicant must have an active Christian faith.** For complete information, please visit: **www.ecs.baylor.edu/mechanicalengineering/**

*Baylor is a Baptist university affiliated with the Baptist General Convention of Texas. As an Affirmative Action/Equal Employment Opportunity employer, Baylor encourages minorities, women, veterans, and persons with disabilities to apply.*

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13–17 June 2016, Washington, D.C.

**AIAA Propulsion and Energy 2016**
25–27 July 2016, Salt Lake City, Utah

**AIAA SPACE 2016**
12–15 September 2016, Long Beach, California

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*—Lt. Gen. Larry D. James, USAF (Ret.),*
*NASA Jet Propulsion Laboratory*

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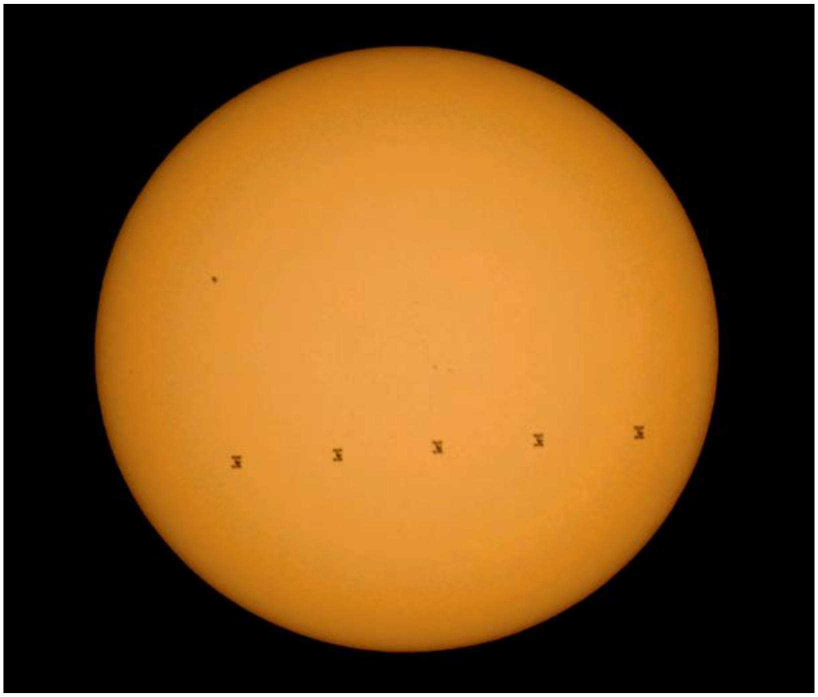
15-827

# AIAA Bulletin



This composite image made from five frames shows the International Space Station in silhouette as it transits the sun at roughly 5 miles per second on 6 September 2015, from Shenandoah National Park, Front Royal, VA. (*Image Credit: NASA/Bill Ingalls*)

## OCTOBER 2015



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

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

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 |
|---|---|---|---|
| **2015** | | | |
| 12–14 Oct† | **24th International Meshing Roundtable** | Austin, TX (Contact: Kathy Loeppky, 505.844.2376, kloeppk@sandia.gov, www.sandia.gov/imr) | |
| 12–16 Oct† | **66th International Astronautical Congress** | Jerusalem, Israel (Contact: www.iac2015.org) | |
| 26–29 Oct† | **International Telemetering Conference USA** | Las Vegas, NV (Contact: Lena Moran, 951.219.4817, info@telemetry.org, www.telemetry.org) | |
| 27–29 Oct† | **Flight Software Workshop** | Laurel, MD (Contact: http://www.flightsoftware.org) | |
| 11–14 Nov† | **31st Annual Meeting of the American Society for Gravitational and Space Research (ASGSR)** | Alexandria, VA (Contact: Cindy Martin-Brennan, 703.392.0272, executive_director@asgsr.org, www.asgsr.org) | |
| **2016** | | | |
| 2–3 Jan | **2nd AIAA CFD Aeroelastic Prediction Workshop** | San Diego, CA | |
| 2–3 Jan | **Guidance of Unmanned Aerial Vehicles** | San Diego, CA | |
| 2–3 Jan | **Systems Requirements Engineering** | San Diego, CA | |
| 4–8 Jan | **AIAA SciTech 2016 (AIAA Science and Technology Forum and Exposition)**<br>**Featuring:**<br>**24th AIAA/AHS Adaptive Structures Conference**<br>**54th AIAA Aerospace Sciences Meeting**<br>**AIAA Atmospheric Flight Mechanics Conference**<br>**15th Dynamics Specialists Conference**<br>**AIAA Guidance, Navigation, and Control Conference**<br>**AIAA Information Systems—Infotech@Aerospace Conference**<br>**AIAA Modeling and Simulation Technologies Conference**<br>**18th AIAA Non-Deterministic Approaches Conference**<br>**57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference**<br>**9th Symposium on Space Resource Utilization**<br>**3rd AIAA Spacecraft Structures Conference**<br>**34th Wind Energy Symposium** | San Diego, CA | **2 Jun 15** |
| 25-28 Jan† | **Annual Reliability and Maintainability Symposium (RAMS)** | Tucson, AZ (Contact: Sean Carter, seancarter67@gmail.com, www.rams.org) | |
| 14–18 Feb† | **26th AAS/AIAA Space Flight Mechanics Meeting** | Napa, CA (Contact: Ryan Russell, 512.471.4190, ryan.russell@utexas.edu, www.space-flight.org/docs/2016_winter/2016_winter.html) | |
| 8–10 Mar | **AIAA DEFENSE 2016 (AIAA Defense and Security Forum)**<br>**Featuring:**<br>**AIAA Missile Sciences Conference**<br>**AIAA National Forum on Weapon System Effectivenss**<br>**AIAA Strategic and Tactical Missile Systems Conference** | Laurel, MD | **8 Oct 15** |
| 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) | |
| 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** |
| 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)**<br>**Featuring:**<br>**32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference**<br>**34th AIAA Applied Aerodynamics Conference**<br>**AIAA Atmospheric Flight Mechanics Conference** | Washington, DC | **5 Nov 15** |

| DATE | MEETING (Issue of *AIAA Bulletin* in which program appears) | LOCATION | ABSTRACT DEADLINE |
|---|---|---|---|
| | **8th AIAA Atmospheric and Space Environments Conference**<br>**16th AIAA Aviation Technology, Integration, and Operations Conference**<br>**AIAA Flight Testing Conference**<br>**8th AIAA Flow Control Conference**<br>**46th AIAA Fluid Dynamics Conference**<br>**17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference**<br>**AIAA Modeling and Simulation Technologies Conference**<br>**47th AIAA Plasmadynamics and Lasers Conference**<br>**46th AIAA Thermophysics Conference** | | |
| 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) | |
| 25–27 Jul | **AIAA Propulsion and Energy 2016 (AIAA Propulsion and Energy Forum and Exposition)**<br>**Featuring:**<br>**52nd AIAA/SAE/ASEE Joint Propulsion Conference**<br>**14th International Energy Conversion Engineering Conference** | Salt Lake City, UT | |
| 12–15 Sep | **AIAA SPACE 2016 (AIAA Space and Astronautics Forum and Exposition)**<br>**Featuring:**<br>**AIAA SPACE Conference**<br>**AIAA/AAS Astrodynamics Specialist Conference**<br>**AIAA Complex Aerospace Systems Exchange** | Long Beach, CA | |
| 25–30 Sept† | **30th Congress of the International Council of the Aeronautical Sciences (ICAS 2016)** | Daejeon, South Korea (Contact: www.icas.org) | **15 Jul 15** |
| 25–30 Sept† | **35th Digital Avionics Systems Conference** | Sacramento, CA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org) | |
| 26–30 Sept† | **67th International Astronautical Congress** | Guadalajara, Mexico (Contact: http://www.iafastro.org/guadalajara-to-host-iac-2016) | |

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

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

AIAA Continuing Education courses.

## GOVERNANCE CHANGES AHEAD

*Jim Albaugh, AIAA President*

AIAA was formed more than 50 years ago when two organizations, the American Rocket Society and the Institute of the Aerospace Sciences merged. The governance model that AIAA uses today is a legacy of that time. Since then many changes have occurred. Not only have the aerospace industry and its technologies evolved but so have the ways in which people communicate and share information. Organizations such as AIAA must work more strategically and proactively to maintain relevance as these changes continue.

A year ago in the Annual Report my predecessor Mike Griffin described some of the tough choices made to address the environment the Institute faces, including government travel restrictions, sequestration, and the continuing cyclical nature of the aerospace industry to name a few. While many of the challenges of the last several years have been overcome, other issues remain. As Mike, Sandy, and I have mentioned, one of the projects underway to ensure that AIAA is positioned for the future is an examination of our five-decade-old governance system.

To support this examination a Governance Working Group (GWG) was formed and has been meeting twice weekly since August 2014. This working group, the Board of Directors, and the Institute Development Committee (IDC) have been holding periodic retreats to discuss the progress of the working group.

In January 2015, the GWG, the Board, and IDC established a list of 21 performance requirements targeting the desired outcome of a new governance system. The GWG then met to conduct a gap analysis on each of those 21 requirements to identify where current performance did not meet the desired performance requirements. In early February, the completed gap analysis was presented to the Board for consideration. In May 2015, the GWG, the Board, and IDC discussed concepts for a governance system to address those gaps. The GWG was given the go-ahead to develop those concepts further and present a new governance approach to the Board and IDC.

As a result, at the recent September Board meeting the AIAA Board of Directors passed two motions that formally began the process of reforming the governance structure of the Institute. The first motion outlines a top-level governance change for the Institute. The goal of the effort has been to identify how to create strategic guidance and still maintain a strong member voice in Institute activities. The Board believes that an evolution to a smaller, competency-based strategic Board and the creation of a House of Delegates concerned with the operation and tactical implementation of Institute activities (much like our current Board oversees) will meet this goal. The GWG has more work ahead of it to define the next level of detail needed to implement these changes. You will see more information on these concepts as they mature.

The second motion approves an action to put the constitutional changes necessary to implement this new governance model up for a vote on the ballot during the 2016 election cycle. To approve constitutional changes such as these requires a vote by 15% of eligible members with at least two-thirds of those members voting in favor of the proposed changes.

These governance reforms are the result of more than two years of discussion, consideration, and reflection. They are the culmination of the efforts of the GWG, composed of Board and IDC members. While more work still needs to be done, I believe that these changes are among the most important that the Board has addressed since the merger that created AIAA in 1963. Without governance reform the Institute risks future stagnation and decline.

In the coming months you will hear much more on this topic from Sandy, my fellow Board members, and me. We will be reaching out to the whole membership on the proposed changes, providing materials for you to read, and answering any questions you might have. A webpage will be established as a “go-to” source for details and answers. We look forward to discussing this with all of you.

## AIAA ANNOUNCES CANDIDATES FOR 2016 BOARD OF DIRECTORS ELECTION

AIAA is pleased to announce that its Nominating Committee has selected candidates for next year’s openings on the AIAA Board of Directors. The Committee’s Chairman, **Michael Griffin**, confirmed the names of the officer and director candidates who will appear on the 2016 ballot. The nominees are:

**Vice President-Elect, Member Services**
Ashwani Gupta, University of Maryland
Laura Richard, United Launch Alliance, LLC

**Vice President-Elect, Technical Activities**
James Keenan, U.S. Army, Aviation and Missile Research, Development, and Engineering Center
Thomas Duerr, The Aerospace Corporation

**Director–Technical, Information Systems Group**
James Rankin, University of Arkansas

**Director–Technical, Propulsion and Energy Group**
Jeffrey Hamstra, Lockheed Martin Aeronautics
Je-Chin Han, Texas A&M University

**Director–Region IV**
Jayant Ramakrishnan, Bastion Technologies
Terry Burress, Lockheed Martin Corporation

**Director–Region V**
Darin Haudrich, Boeing Defense, Space & Security
John Eiler, Stellar Solutions LTD

**Director–Region VII**
Abid Kahn, Institute of Space Technology
Luisella Giulicchi, European Space Agency

**Director–At-Large**
Mary Snitch, Lockheed Martin Corporation
Woodrow Whitlow, Cleveland State University
James Horkovich, Schafer Corporation Military Aerospace

**Director–International**
Kostantinos Kontis, University of Glasgow

The AIAA Constitution also allows board nominations to be made via petition. Members intending to follow this process are asked to contact the AIAA Secretary, Bill Seymore, at 703.264.7540 or bills@aiaa.org, as soon as possible before the **4 December 2015** deadline for more specific instructions and coordination. The petition must be supported by at least 300 voting members of the Institute.

All eligible voting members of AIAA will be able to cast their ballot beginning in January 2016.

## CALL FOR NOMINATIONS

Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 February 2016**. Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines to view nominee eligibility, page limits, letters of endorsement, etc. Please note that the nomination form, related materials and the three required AIAA member letters of endorsement must be submitted 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 **http://www.aiaa.org/OpenNominations.**

**Aerospace Power Systems Award** is presented for a significant contribution in the broad field of aerospace power systems, specifically as related to the application of engineering sciences and systems engineering to the production, storage, distribution, and processing of aerospace power.

**Air Breathing Propulsion Award** is presented for meritorious accomplishment in the science of air breathing propulsion, including turbomachinery or any other technical approach dependent on atmospheric air to develop thrust, or other aerodynamic forces for propulsion, or other purposes for aircraft or other vehicles in the atmosphere or on land or sea.

**Daniel Guggenheim Medal** was established to honor persons who make notable achievements in the advancement of aeronautics. AIAA, ASME, SAE, and AHS sponsor the award.

**Durand Lectureship for Public Service** is presented for notable achievements by a scientific or technical leader whose contributions have led directly to the understanding and application of the science and technology of aeronautics and astronautics for the betterment of mankind.

**Energy Systems Award** recognizes a significant contribution in the broad field of energy systems, specifically as related to the application of engineering sciences and systems engineering to the production, storage, distribution, and conservation of energy.

**George M. Low Space Transportation Award** is presented for a timely outstanding contribution to the field of space transportation. (Presented even years)

**Haley Space Flight Award** is presented for outstanding contributions by an astronaut or flight test personnel to the advancement of the art, science, or technology of astronautics. (Presented even years)

**J. Leland Atwood Award** recognizes an aerospace engineering educator for outstanding contributions to the profession. AIAA and ASEE sponsor the award. Note: Nominations should be submitted to ASEE, www.asee.org, no later than **15 January**.

**Missile Systems Award — Technical Award** is presented for a significant accomplishment in developing or using technology that is required for missile systems.

**Missile Systems Award — Management Award** is presented for a significant accomplishment in the management of missile systems programs.

**Propellants and Combustion Award** is presented for outstanding technical contributions to aeronautical or astronautical combustion engineering.

**Space Automation and Robotics Award** recognizes leadership and technical contributions by individuals and teams in the field of space automation and robotics. (Presented odd years)

**Space Science Award** is presented to an individual for demonstrated leadership of innovative scientific investigations associated with space science missions. (Presented even years)

**Space Operations and Support Award** is presented for outstanding efforts in overcoming space operations problems and assuring success, and recognizes those teams or individuals whose exceptional contributions were critical to an anomaly recovery, crew rescue, or space failure. (Presented odd years)

**Space Processing Award** is presented for significant contributions in space processing or in furthering the use of microgravity for space processing. (Presented odd years)

**Space Systems Award** recognizes outstanding achievements in the architecture, analysis, design, and implementation of space systems.

**von Braun Award for Excellence in Space Program Management** recognizes outstanding contributions in the management of a significant space or space-related program or project.

**William Littlewood Memorial Lecture**, sponsored by AIAA and SAE, focuses on a broad phase of civil air transportation considered of current interest and major importance. Nominations should be submitted by **1 February** to SAE at http://www.sae.org/news/awards/list/littlewood.

**Wright Brothers Lectureship in Aeronautics** commemorates the first powered flights made by Orville and Wilbur Wright at Kitty Hawk in 1903. The lectureship emphasizes significant advances in aeronautics by recognizing major leaders and contributors. (Presented odd years)

**Wyld Propulsion Award** recognizes outstanding achievement in the development or application of rocket propulsion systems.

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

## CALL FOR PAPERS FOR *JOURNAL OF AIR TRANSPORTATION*—A NEW PUBLICATION FROM AIAA

The *Journal of Air Transportation* (*JAT*) is an online, peer-reviewed journal 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.

Currently being published by the Air Traffic Control Association as the *Air Traffic Control Quarterly* (*ATCQ*), the journal will have a new publisher and a new name starting in January 2016, when AIAA will assume operational responsibility. AIAA is pleased to support the ATM community with the acquisition of this journal, with special acknowledgement owed to MITRE, NASA, and the FAA for their steadfast support of *ATCQ* over the years.

Submissions are being sought now as we seek to expand the scope and size of this journal. Papers presented at AIAA conferences as well as new research will be considered for publication.

More information about this journal and guidelines for preparing your manuscript can be found here: **http://www.aiaa.org/jatform**.

**Yvonne C. Brill Lectureship in Aerospace Engineering Seeks Nominees!**

The Yvonne C. Brill Lectureship in Aerospace Engineering was established in memory of Yvonne Brill, pioneering rocket scientist, AIAA Honorary Fellow, and NAE member. Nominations are now being accepted for the 2016 lectureship.

Yvonne C. Brill often referred to herself as an "only" – the only woman in the room at a time when female scientists and engineers were exceedingly few. She is best known for developing a revolutionary propulsion system, the hydrazine/resistojet propulsion system that remains the industry standard for geostationary satellite station-keeping.

In the last quarter-century of her life, she dedicated a large part of her time to helping others pursue careers in engineering, science, and mathematics, and to ensuring professional women are given the recognition they deserve.

Members of NAE or AIAA are eligible to place a nomination. The ideal nominee should have a distinguished career involving significant contributions in aerospace research and/or engineering and will be selected based on technical expertise, originality, and influence on other important aerospace issues such as ensuring a diverse and robust engineering community.

The nomination form and additional information can be downloaded at **http://www.aiaa.org/BrillLectureship**. The complete nomination package, including letters of endorsement, is due to AIAA on or before **1 November 2015.**

If you have any questions, contact Carol Stewart, AIAA Manager, Honors and Awards, carols@aiaa.org or 703.264.7538.

## OBITUARIES

### *AIAA Senior Member Witteveen Died*

**Dr. Jeroen A. S. Witteveen**, researcher at Centrum Wiskunde & Informatica (CWI) in Amsterdam, has passed away. He was 34 years old.

Dr. Witteveen studied Aerospace Engineering at TU Delft and obtained both his Bachelor's and Master's degrees with honours. He also obtained his doctorate from TU Delft with honours, with a dissertation entitled "Efficient and Robust Uncertainty Quantification for Computational Fluid Dynamics and Fluid-Structure Interaction." Subsequent to the conferral of his doctorate, Dr. Witteveen held two prestigious postdoctoral positions at TU Delft and Stanford University.

He began his promising career at CWI in 2013, taking a position as a tenure track researcher in the Scientific Computing group. His research was characterized by a blend of modern, pioneering mathematics inspired by important social issues. Dr. Witteveen was an extremely talented, passionate researcher with a strong commitment to his field. He was always open to cooperation and realized a range of successful collaborations, both within CWI and with external partners. He was actively involved in two recently acquired research projects into offshore wind and uncertainty quantification in energy-related concerns.

Dr. Witteveen was an AIAA Senior Member and a member of the AIAA Non-Deterministic Approaches Technical Committee. He was a regular attendee at AIAA conferences.

### *AIAA Associate Fellow Klein Died in July*

**Dr. Vladislav Klein**, a pioneer in the field of Aircraft System Identification, died on 15 July 2015. He was 86 years old.

Dr. Klein spent much of his career at NASA Langley Research Center in Hampton, VA, where he led research in the field of Aircraft System Identification. He was one of the founders of modern Aircraft System Identification, and made many significant technical contributions in that field. He authored many influential papers and NASA technical reports; his seminal 1978 paper entitled "Aircraft Parameter Estimation in Frequency Domain" detailed the theoretical and practical basis for nearly all frequency-domain methods currently used today. His series of papers and reports on unsteady aerodynamic modeling explained the theoretical connections among various approaches, and provided practical experimental and analytical methods for identifying accurate models for this complex and important problem.

His modeling research has been of significant importance to both military aircraft maneuverability and civilian aircraft safety. Dr. Klein successfully advocated the idea of the remotely-augmented vehicle on the highly-augmented, highly-unstable X-29 forward-swept wing aircraft. The concept was also applied to create the On-Board Excitation System (OBES) for the F-18 High-Alpha Research Vehicle (HARV). This capability allowed automatic and optimal inputs to be applied to the aircraft, producing significantly more informative data for modeling aircraft with high-gain feedback control.

Dr. Klein addressed the problem of data collinearity during X-29 flight tests, providing clearer methods to address the problem in flight test and data analysis. These developments were crucial to identifying good dynamic models for highly-augmented fighter aircraft, based on flight data. Dr. Klein also co-authored a textbook, with Dr. Gene Morelli, entitled *Aircraft System Identification: Theory and Practice*, which provides a comprehensive discussion of aircraft system identification theory and practice and a well-developed software package called SIDPAC that is in use at more than 90 organizations throughout the world.

Dr. Klein began his career as an engineer in Czechoslovakia in the 1950s. In 1969, he left for England where he served on the aeronautical engineering faculty at Cranfield Institute of Technology. In 1975, he joined the faculty of George Washington University, and spent the remainder of his professional career conducting aeronautical research and teaching Aircraft Flight Mechanics and Aircraft System Identification to graduate students at NASA Langley Research Center.

Dr. Klein received many awards for his work on NASA flight test projects, such as the X-29 forward-swept wing aircraft, X-31 high-maneuverability demonstrator, F-18 HARV, F-16XL delta wing, and many others. He received the NASA Medal for Exceptional Engineering Achievement in 1992 for his innovative development of advanced techniques in the field of aircraft system identification.

Dr. Klein was an AIAA Associate Fellow and a U.S. representative to the International Program Committee of the International Federation of Automatic Control (IFAC). He was a key organizer and chairman of special sessions for the IFAC 7th–11th Symposia on Identification and Parameter Estimation in York (UK), Beijing (China), Budapest (Hungary), Copenhagen (Denmark), and Kitakyushu (Japan). He gave invited lectures in the People's Republic of China, the Soviet Union, Oxford University, UK, and other places around the world. In 1992, he was a technical consultant to Great Britain and Germany at the request of the NATO Advisory Group for Aerospace Research and Development (AGARD).

Perhaps most important of all, Dr. Klein was a teacher, mentor, and thesis advisor to numerous graduate students in aerospace engineering, many of whom now hold positions of technical leadership at NASA and elsewhere in government, industry, and academia. Many techniques that Dr. Klein developed and advocated are common practice in the field today.

## AIAA RECOGNIZES 2015 SECTION AWARD WINNERS

### What are Section Awards?

The AIAA Section Awards honor particularly notable performances made by an Institute section working as a unit, and are intended to formally underscore the AIAA conviction that intellectually stimulating section activity is fundamental to the health of the Institute. All awards are bestowed annually in five section member categories, based on the number of members in the Section: Very Small, Small, Medium, Large, and Very Large. A certificate and cash award ($500 for first place, $200 for second, and $100 for third) are presented to the winning sections in all size categories. The award period covered is 1 June–31 May. Section award winners were recognized at the AIAA Regional Leadership Conference on 2 September in Pasadena, CA.

### Outstanding Section Award

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

• *Very Small*: First Place: Delaware, Breanne Sutton, section chair; Second Place: China Lake, Randy Drobny, section chair.

• *Small*: First Place: Sydney, Michael West, section chair; Second Place: Savannah, Charles Harrison, section chair; Third Place: Twin Cities, Kristen Gerzina, section chair.

• *Medium*: First Place (tie): Tucson Section, Elishka Jepson, section chair; First Place (tie): Long Island, David Paris, section chair; Second Place: Wichita, Minisa Childers, section chair.

• *Large*: First Place: Orange County, Dino Roman, section chair; Second Place: San Diego, Cesar Martin, section chair; Third Place: Cape Canaveral, Matthew Zuk, section chair.

• *Very Large*: First Place: Greater Huntsville, Kenneth Philippart, section chair; Second Place: National Capital, Supriya Banerjee, section chair; Third Place: Los Angeles/Las Vegas, Nicola Sarzi Amade, section chair.




### Career and Workforce Development Award

The Career and Workforce Development Award recognizes section activities focusing on career development, such as time management workshops, career transition workshops, job benefits workshops, and technical vs management career path workshops.

• *Very Small*: Third Place: Delaware, Timothy McCardell, Career and Workforce Development Committee officer.

• *Very Large*: Second Place (tie): Huntsville Section, Ken Philippart and Cody Crofford, Career and Workforce Development Committee officers; Second Place (tie): National Capital, Supriya Banerjee, Career and Workforce Development Committee officer

### Communications Award

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

• *Very Small*: First Place: Delaware, Joseph Scroggins and Daniel Nice, communication officers; Second Place: China Lake, Jeff Scott, communication officer.

• *Small*: First Place: Sydney, Rounak Manoharan and Amelia Greig, secretary and membership officers; Second Place: Twin Cities, Andrew Carlson, webmaster.

• *Medium*: First Place, Tucson, Elishka Jepson, section chair; Second Place: Long Island, David Paris, section chair and newsletter editor; Third Place: Central Florida, Josh Giffin, secretary, membership and communications officer.


• *Large*: First Place: Northern Ohio, Edmond Wong, communications officer; Second Place: San Diego, Martin Miller, secretary; Third Place: Orange County, Jody Hart, communications officer and webmaster.

• *Very Large*: First Place: Greater Huntsville, Ken Philippart, Arloe Mayne, and Gabe Xu, section chair, webmaster and newsletter editor; Second Place (tie): National Capital, Bruce Cranford and Nils Jespersen, communication co-chairs; Second Place (tie): Hampton Roads, John Lin, newsletter editor.

### Membership Award

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

• *Very Small*: First Place: Delaware, Di Ena Davis, membership officer.

• *Small*: First Place: Sydney, Amelia Greig, membership officer; Second Place: Savannah, Charles Harrison, section chair; Third Place: Twin Cities, Kristen Gerzina, section chair.

• *Medium*: First Place: Central Florida, Josh Giffin, membership officer; Second Place: Tucson, Elishka Jepson, section chair.

• *Large*: First Place: Orange County, Bob Welge, vice chair membership; Second Place, San Fernando Pacific, Carl Ehrlich, membership officer; Third Place: Cape Canaveral, Anthony Mansk, membership officer.

• *Very Large*: Hampton Roads, Marlyn Andino, membership officer; Second Place (tie): Dayton – Cincinnati, Timothy Cleaver, membership officer; Second Place (tie): Greater Huntsville, Joseph Herdy, membership officer; Second Place (tie): Los Angeles/Las Vegas, Nicola Sarzi Amade, section chair.

### STEM K–12 Award

The Harry Staubs Precollege Outreach Award is given to sections that have developed and implemented an outstanding STEM K–12 outreach program that provides quality educational resources for K–12 teachers in the STEM subject areas of science, technology, engineering, and mathematics. The winners are:

• *Very Small*: First Place: Delaware, Elishabet Lato, STEM K-12 officer.

• *Small*: First Place: Sydney, Andrew Neely, STEM K-12 officer; Second Place (tie), Savannah, Jason Riopelle and James

Fowlkes, STEM K-12 officers; Second Place (tie): Vandenberg, Tom Stevens, STEM K-12 officer; Third Place: Twin Cities, Kristen Gerzina, section chair.

• *Medium*: First Place: Tucson, Elishka Jepson, section chair; Michelle Rouch, aerospace and societies officer; Second Place: Southwest Texas, Joan Labay-Marquez, STEM K-12 officer; Third Place: Long Island, David Paris, section chair.

• *Large*: First Place: Orange County, Jann Koepke, vice chair, education; Second Place: Northern Ohio, Julie Kleinhenz, STEM K-12 officer; Third Place (tie): Cape Canaveral, Matthew Zuk, section chair; Third Place (tie): San Diego, Chris McEachin, student activities chair.

• *Very Large*: Dayton-Cincinnati, Carl Tilmann, STEM K-12 officer; Second Place: Pacific Northwest, Elana Slagle, vice chair; Third Place: Greater Huntsville, Meagan Beattie, STEM K-12 officer and Ken Philippart, section chair

### Public Policy Award

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

• *Very Small*: First Place: Delaware, Timothy Dominick, public policy officer.

• *Small*: First Place: Sydney, Michael West, public policy officer; Second Place: Savannah, Charles Harrison, section chair.

• *Medium*: First Place: Central Florida, Jason Hopkins, public policy officer; Second Place: Tucson, Michelle Rouch, aerospace and societies officer; Matt Angiulo, section member; Jeff Jepson, Regional Activities Council representative.

• *Large*: First Place: Orange County, John Rose, director at large; Second Place: Northern Ohio, Amber Abbott-Hearn, public policy officer; Third Place: San Diego, John Kucharski, public policy officer.

• *Very Large*: First Place: National Capital, Supriya Banerjee, section chair; David Brandt, programs vice chair; Second Place: Los Angeles/Las Vegas, Jeff Puschell & Michael Todaro, public policy officers; Third Place: Huntsville, Ken Philippart, section chair.

### Young Professional Award

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

• *Very Small*: Delaware, Daniel Nice, young professional officer.

• *Small*: First Place: Sydney, Arnab Dasgupta, young professional officer; Second Place: Savannah, Ryan Stanford, young professional officer.

• *Large*: First Place: San Diego, Iona Broome, young professional officer; Second Place: Phoenix, Garrick Williams, young professional officer; Third Place: Cape Canaveral, Taylor Dacko, young professional officer.

• *Very Large*: First Place: Dayton-Cincinnati, Robert Mitchell, young professional officer; Second Place: Greater Huntsville, Cody Crofford, young professional officer; Third Place: National Capital, Scott Fry, young professional officer.

### Outstanding Activity Award

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

• *Very Small*: China Lake, Randy Drobny, section chair. **Ridgecrest Autism Awareness Aviation Day**. This event was organized around an aviation theme to expose participants to STEM education and opportunities in the aerospace field. The China Lake Section provided educational activities for children and young adults, including setting up and operating a homemade wind tunnel; manning a table with a space flight simulator game called the Kerbal Space Program; and helping kids operate simulators of radio-controlled planes, cars, and helicopters.

• *Small* (tie): Sydney, Michael West, section chair. P**erspectives from Space: 2015 AIAA National Lecture Tour**. Dr Sandra Magnus toured Australia in May 2015 to meet with members and promote AIAA. The section coordinated a five-day city national tour that featured public lectures in Canberra, Sydney, Brisbane, and Melbourne. Dr. Magnus' visit included talking to school assemblies and groups of underrepresented university students. Visits to AIAA student branches around the country and STEM K–12 outreach events were a particular focus. Over 3,000 people attended the events ranging from aerospace professionals, university to school students and the general public.

• *Small* (tie): Northwest Florida, Benjamin Dickinson, section chair. **Eglin Flight Line Tour**. 7th and 8th math students from Paxton High School requested to tour the Eglin Air Force Base flight line (fighters). The AIAA Northwest Florida section organized the trip, providing a fighter jet pilot as the flight line tour guide and funds for the bus transportation for the students. The students were impressed with the aircraft and night vision goggles. This event encouraged students to pursue aerospace careers.

• *Medium*: Tucson, Elishka Jepson, section chair. **"Planes of the Future Past: Dan Raymer's Advanced Aircraft Designs at Rockwell, Lockheed, RAND, and CRC."** The AIAA Tucson Section hosted a lecture by Daniel Raymer at the Pima Air and Space Museum. This talk covered Raymer's involvement in the projects that became the X-31, B-2, F-22, T-45, F-35, and more. Raymer also showed his original baseline design concepts and explained how they were created.

• *Medium*: Southwest Texas (Honorable Mention). Joan Labay-Marquez, section chair. **University of Texas Introduce a Girl to Engineering Day**. During Engineers Week at the University of


Texas at Austin, more than 300 girls in grades 4 and 5 designed, built, and tested a balloon car racer made from water bottles and arts and crafts items. Student branch members and professional members from the AIAA Southwest Texas Section volunteered.

• *Large*: Cape Canaveral (tie), Matthew Zuk, section chair. **AIAA Fall Gala**. The Cape Canaveral Section hosted a Fall Gala in November 2014. Over 39 AIAA professional members, 20 student members, and 19 guests were in attendance, including the Kennedy Space Center director and several corporate senior leaders. To increase meeting participation, the event was held at the Exploration Tower facility, which has seven floors of museum exhibits, interactive play stations, and an observation tower overlooking Port Canaveral and KSC.

• *Large*: Orange County (tie), Dino Roman, section chair. **Student Payload and Rocketry Challenge (SPARC), Team America Rocketry Challenge, and AIAA OC Rocketry Club**. The AIAA Orange County Section created a STEM education through rocketry program that included the first annual SPARC, which is open to 7th–12th graders and runs through the summer months. It places the emphasis on electronic scientific and engineering payload as well as the rocket. SPARC further inspires kids in STEM as well as AIAA members and others to get involved and give back to their profession, community and the next generation.

• *Very Large*: Los Angeles/Las Vegas (tie), Nicola Sarzi Amade, section chair and Ninh Le, Career and Workforce Development Chair. **Aerospace Career Mentoring Event – Journey to Success**. The Los Angeles/Las Vegas Section hosted a career mentoring event with five high-profile individuals in the aerospace industry. The program consisted of general networking, mentoring discussions from the featured speakers, and additional individual mentoring sessions and a speed networking event.



• *Very Large*: National Capital (tie), Supriya Banerjee, section chair. **AIAA NCS Patuxent River Chapter Inaugural Event**. The event, organized by Major Tucker Hamilton and held at the Patuxent River Naval Air Station in Patuxent River, MD, focused on a revitalization effort of the Southern MD Chapter of the AIAA NCS. It focused on two discussions led by NCS members: “Introduction to AIAA” by Major Hamilton, U.S. Air Force and Brendan Andrus, NCS Membership Chair and “F-35C Carrier Suitability & Ship Trials” by Commander Michael Wilson, U.S. Navy. The event attracted people interested in joining AIAA and becoming involved in running a local chapter. The event was hugely successful with about 100 people attending.

• *Very Large*: Greater Huntsville (tie), Kenneth Philippart, section chair. **Engineers Week**. The Greater Huntsville Section scheduled a full program to commemorate Engineers Week (E Week). They organized, conducted and/or participated in nine events, more than double the number they had held during E Week in 2014. At least one event was scheduled for each day in E Week. They ensured that each of their membership demographics had at least one event tailored for them and that every AIAA mission area was covered during the week.

# AIAA Science and Technology Forum and Exposition

## The Largest Event for Aerospace Research, Development, and Technology

4–8 January 2016
Manchester Grand Hyatt
San Diego, California

**Featuring:**

**AIAA/AHS Adaptive Structures Conference**
**AIAA Aerospace Sciences Meeting**
**AIAA Atmospheric Flight Mechanics Conference**
**Dynamics Specialists Conference**
**AIAA Information Systems — Infotech@Aerospace Conference**
**AIAA Guidance, Navigation, and Control Conference**
**AIAA Modeling and Simulation Technologies Conference**
**AIAA Non-Deterministic Approaches Conference**
**AIAA Spacecraft Structures Conference**
**AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference**
**Symposium on Space Resource Utilization**
**Wind Energy Symposium**

### Organizing Committee

Mason Peck, Cornell University, SciTech 2015 Forum General Chair
Ann Zulkosky, Lockheed Martin Space Systems Company, Forum 360 Chair
Benjamin Marchionna, Lockheed Martin, Young Professional Chair
Sam Alberts, Purdue University, Young Professional Chair

***Forum Technical Chairs***
Brad Burchett, Rose-Hulman Institute of Technology
Misty Davies, NASA Ames Research Center
Jeanette Domber, Ball Aerospace & Technologies Corporation

***Forum Deputy Technical Chairs***
Terry Morris, NASA Langley Research Center
Richard Ruff, MathWorks
Ben Thacker, Southwest Research Institute
Michael White, Ohio Aerospace Institute

*Complete list of organizers at* ***aiaa-scitech.org/Organizers***

Join more than 3,000 participants at the AIAA Science and Technology Forum and Exposition (AIAA SciTech 2016) when we discuss the science, technologies, policies, and regulations that are shaping the future of aerospace. Walk away with innovative solutions that will create new opportunities and help to overcome challenges.

### Plenary Program

Industry, academia, and government leaders share their perspectives on the new challenges, future opportunities, and emerging trends in the global aerospace industry. Plenary sessions examine some of the most critical issues in aerospace today. Scheduled plenary topics include:

- Aerospace Science and Technology Policy in the 2016 Political Arena
- Lessons Learned from a Half Century of Innovation in Aerospace Technology
- The Future of Design
- Aerospace Frontiers – Academia, Government, Industry, AIAA Collaboration
- Unmanned Aerial Vehicles

# AIAA Programs

### Forum 360 Program
The Forum 360 panel discussions build on the themes and discussions of each day's opening plenary session, adding a layer of content and context that enhances the value of your forum experience. These discussions also give you time to interact with industry leaders in more intimate settings, enabling meaningful communication, and stimulating greater insight into the critical issues of the day.

### Technical Program
An extensive technical program provides the latest in innovative research and developments that will drive advancements in aerospace. More than **2,500 technical abstracts** from about **800 institutions in 39 countries** offering the latest research results on 44 high-impact topics have been accepted for presentation at AIAA SciTech 2016. Bringing together 12 individual technical events at a single location and drawing more than 3,000 participants from around the world, this forum is the place to engage with colleagues within your discipline and to interact with experts in other disciplines. Check the website for program developments (**www.aiaa-scitech.org**).

### Rising Leaders in Aerospace Program
Young aerospace leaders, age 35 and under, participate with others in a multidimensional program featuring a leadership exchange/speed mentoring, panel session, Q&A with top industry leaders, and multiple opportunities for networking. These exciting and energetic activities provide access to top aerospace leaders and their perspectives, with subject matter relevant to your career stage. Check the website for program developments.

### Student Activities
Kick off the week at the Student Reception on Sunday night, and then engage with students from around the world during the following student paper competitions:

- AIAA Foundation International Student Conference
- Atmospheric Flight Mechanics
- Guidance, Navigation, and Control
- Structures, Structural Dynamics, and Materials
- Intelligent Systems
- Software
- Thermophysics

### Continuing Education
Stay at the top of your game with AIAA's continuing education offerings. You will leave with invaluable improvements and solutions that you can put to immediate use. Scheduled:

- 2nd AIAA Aeroelastic Prediction Workshop
- Guidance of Unmanned Aerial Vehicles
- Systems Requirements Engineering

Check the website for additional offerings.

### Recognition Awards
Celebrate outstanding contributions in aerospace! The following award activities are planned:

- Durand Lecture for Public Service and Luncheon
- 2016 Associate Fellows Recognition Ceremony and Dinner (ticketed event)
- Dryden Lecture in Research
- Recognition Luncheon: Celebrating Achievements in Aerospace Sciences and Information Systems
- Recognition Luncheon: Celebrating Achievements in Aerospace Design/Structures and Literary Excellence

### Special Events and Networking
Understanding the importance of networking with colleagues new and old, a series of activities have been planned that will help you connect with current colleagues and new acquaintances.

- Women at SciTech Happy Hour and Keynote with Ann Zulkosky, Lockheed Martin Space Systems Company
- AIAA Governance Update
- Welcome Reception
- Coffee Breaks

### Exposition
The Exposition Hall is the hub of activity during this event—from seeing exhibitor displays to enjoying networking breaks and other functions. Networking events are held in the Exposition Hall to give attendees and exhibitors an opportunity to connect with partners, industry thought leaders, and collaborators. The Exposition is free to attend.

### Plan Your Trip
AIAA has made arrangements for a block of rooms at the Manchester Grand Hyatt San Diego, One Market Place, San Diego, California 92101. Room rates for single/double occupancy are $199/night + 10.7% tax. Current Government: Rate is $147/night + 10.7% tax. Make reservations online: **https://aws.passkey.com/event/12135515/owner/414/home**.

### Registration
Registration is open! The early-bird registration deadline is **14 December 2015**. Save $470 when you register early as an AIAA member! Visit the website at **www.aiaa-scitech.org** to register.

# 26th AAS/AIAA Space Flight Mechanics Meeting

14–18 February 2016
Embassy Suites Napa Valley
Napa, California

**AAS Technical Chair**
Renato Zanetti
NASA Johnson Space Center
281.483.7435 • Email: renato.zanetti@nasa.gov

**AIAA Technical Chair**
Ryan Russell
University of Texas at Austin
W. R. Woolrich Laboratories, 210 E. 24th St., Austin, TX 78712
512.471.4190 • Email: ryan.russell@utexas.edu

**AAS General Chair**
Martin T. Ozimek
John Hopkins University Applied Physics Lab
11100 Johns Hopkins Rd, Laurel, MD 20723
443.778.1569 • Email: martin.ozimek@jhuapl.edu

**AIAA General Chair**
Angela Bowes
NASA Langley Research Center
Bldg 1209, MS 489, Hampton, VA 23681
757.864.2364 • Email: angela.bowes@nasa.gov

## Abstract Deadline: 19 October 2015

The 26th Space Flight Mechanics Meeting will be held 14–18 February 2016, in Napa, CA. The conference is organized by the American Astronautical Society (AAS) Space Flight Mechanics Committee and cosponsored by the AIAA Astrodynamics Technical Committee. Manuscripts are solicited on topics related to space-flight mechanics and astrodynamics, including but not limited to:

- Asteroid and non-Earth orbiting missions
- Atmospheric re-entry guidance and control
- Attitude dynamics, determination and control
- Attitude-sensor and payload-sensor calibration
- Dynamical systems theory applied to space-flight problems
- Dynamics and control of large space structures and tethers
- Earth orbital and planetary mission studies
- Flight dynamics operations and spacecraft autonomy
- Orbit determination and space-surveillance tracking
- Orbital debris and space environment
- Orbital dynamics, perturbations, and stability
- Rendezvous, relative motion, proximity missions, and formation flying
- Reusable launch vehicle design, dynamics, guidance, and control
- Satellite constellations
- Spacecraft guidance, navigation, and control (GNC)
- Space Situational Awareness (SSA), Conjunction Analysis (CA), and collision avoidance
- Trajectory / mission / maneuver design and optimization

Manuscripts will be accepted based on the quality of the extended abstract, the originality of the work and/or ideas, and the anticipated interest in the proposed subject. Submissions based on experimental results or current data, or that report on ongoing missions, are especially encouraged. Complete manuscripts are required before the conference. English is the working language for the conference. Additional up-to-date information can be found at the conference website: **http://space-flight.org/docs/2016_winter/2016_winter.html**.

### Special Sessions

Proposals are being considered for suitable special sessions, such as topical panel discussions, invited sessions, workshops, mini-symposia, and technology demonstrations. Prospective special-session organizers should submit their proposals to the Technical Chairs.

### Breakwell Student Travel Award

The AAS Space Flight Mechanics Committee announces the John V. Breakwell Student Travel Award. This award provides travel expenses for up to four students (from U.S. and Canadian universities) presenting at this conference. Students wishing to apply for this award are strongly advised to submit their completed manuscript by the abstract submittal deadline. The maximum coverage per student is limited to $1000. Details and applications may be obtained via **http://www.space-flight.org**.

### Information for Authors

The submission deadline of 19 October 2015 will not be extended due to the constraints of the conference planning schedule. Notification of acceptance will be sent via email by 19 November 2015. Detailed author instructions will be sent by email following acceptance. By submitting an abstract, the author affirms that the manuscript's majority content has not been previously presented or published elsewhere.

Authors may access the web-based abstract submittal system using the link available via the official website http://www.space-flight.org. During the online submission process, authors are expected to provide the paper title and contact information for all authors; a PDF of the extended abstract (at least 500 words); and a condensed abstract of 100 words. See the website for more detailed instructions.

Foreign contributors requiring an official letter of acceptance for a visa application should contact the Technical Chairs by email at their earliest opportunity.

*Technology Transfer Notice*—To preclude late submissions and withdrawals, it is the responsibility of the author(s) to determine the extent of necessary approvals prior to submitting an abstract.

*No-Paper/No-Podium Policy*—A complete manuscript must be electronically uploaded to the web site prior to the conference in PDF format, be no more than 20 pages in length, and conform to the AAS manuscript format. If a complete manuscript is not received on time, then its presentation at the conference shall be forfeited; and if a presentation is not made by an author at the conference, then the manuscript shall be omitted from published proceedings.

Questions concerning the submission of manuscripts should be addressed to the technical chairs.

# Technical Committee Nominations

Membership nominations are now open for AIAA Technical Committees (TC) for 2016/2017. Our TCs have between 30 and 35 members each. Nearly one-third of the members rotate off the committees each year, leaving six to ten openings per TC.

The TC chairs and the Technical Activities Committee (TAC) work diligently to maintain a reasonable balance in (1) appropriate representation to the field from industry, research, education, and government; (2) the specialties covered in the specific TC scopes; and (3) geographical distribution relative to the area's technical activity. TAC encourages the nomination of young professionals, and has instituted a TC associate member category (see associate membership guidelines). Associate members, with identified restrictions, are included on TCs in addition to the 35 regular member limit.

If you currently serve on a TC, do not nominate yourself. You will automatically be considered for the 2016/2017 TC year.

Enclosed are instructions for nominations. Nominations are submitted online. The TC nomination form can be found on the AIAA Web site at **www.aiaa.org**, under My AIAA, Nominations and Voting, Technical Committee Online Nomination. We look forward to receiving your nominations. If you have any questions, please call Betty Guillie at 703.264.7573.

Nominations are due by **1 November 2015**.

## Current AIAA Technical Committees

**Adaptive Structures**
**Aeroacoustics**
**Aerodynamic Decelerator Systems**
**Aerodynamic Measurement Technology**
**Aerospace Power Systems**
**Air Breathing Propulsion Systems Integration**
**Air Transportation Systems**
**Aircraft Design**
**Aircraft Operations**
**Applied Aerodynamics**
**Astrodynamics**
**Atmospheric and Space Environments**
**Atmospheric Flight Mechanics**
**Balloon Systems**
**Communications Systems**
**Computer Systems**
**Design Engineering**
**Digital Avionics**
**Economics**
**Electric Propulsion**
**Energetic Components and Systems**
**Flight Testing**
**Fluid Dynamics**
**Gas Turbine Engines**
**General Aviation**
**Ground Testing**
**Guidance, Navigation and Control**
**High Speed Air Breathing Propulsion**
**History**
**Hybrid Rockets**
**Information and Command and Control Systems**
**Intelligent Systems**
**Legal Aspects of Aeronautics and Astonautics**
**Life Sciences and Systems**
**Lighter-Than-Air Systems**
**Liquid Propulsion**
**Management**
**Materials**
**Meshing, Visualization and Computational Environments**
**Microgravity and Space Processes**
**Missile Systems**
**Modeling and Simulation**
**Multidisciplinary Design Optimization**
**Non-Deterministic Approaches**
**Nuclear and Future Flight Propulsion**
**Plasmadynamics and Lasers**
**Product Support**
**Propellants and Combustion**
**Sensor Systems and Information Fusion**
**Small Satellite**
**Society and Aerospace Technology**
**Software**
**Solid Rockets**
**Space Architecture**
**Space Automation and Robotics**
**Space Colonization**
**Space Logistics**
**Space Operations and Support**
**Space Resources**
**Space Systems**
**Space Tethers**
**Space Transportation**
**Spacecraft Structures**
**Structural Dynamics**
**Structures**
**Survivability**
**Systems Engineering**
**Terrestrial Energy Systems**
**Thermophysics**
**V/STOL Aircraft Systems**
**Weapon System Effectiveness**

Instructions for completing the Technical Committee (TC) nomination forms and information about TC associate membership guidelines are available at https://www.aiaa.org/Secondary.aspx?id=14297. The TC organization chart is found on page B16.

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# AIAA TECHNICAL ACTIVITIES COMMITTEE 2015-2016

DAVID RILEY – Vice President, Technical Activities
Thomas E. Duerr – Deputy VP
Betty Guillie – Staff Liaison – Technical Activities
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HyTASP – Timothy O'Brien
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Space Exploration – Chris Moore/Surendra Sharma
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Unmanned Systems – Richard Christiansen
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Air Breathing Propulsion Systems Integration – Chen Chuck
Electric Propulsion – Rostislav Spektor
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Gas Turbine Engines – John Sordyl
High Speed Air Breathing Propulsion – Dora Musielak
Hybrid Rockets – Joseph Majdalani
Liquid Propulsion – Ivett Leyva
Nuclear and Future Flight Propulsion – George Williams
Propellants and Combustion – Robert Pitz
Solid Rockets – Barbara Leary
Terrestrial Energy Systems – Ryoichi Amano

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Aircraft Design – Hernando Jimenez
Balloon Systems – Henry Cathey
General Aviation – Troy Downen
Lighter-Than-Air Systems – Rajkumar Pant
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Missile Systems – Darren Hayashi
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Space Automation and Robotics – David Spangler
Space Colonization – Ron Kohl
Space Logistics – Eric Jackson
Space Operations and Support – John Hughes
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Space Transportation – Randy Kendall
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Updated on 8/25/2015

# 22nd AIAA/CEAS Aeroacoustics Conference

**30 MAY – 1 JUNE 2016** **LYON, FRANCE**

# CALL FOR PAPERS

**AIAA Technical Co-Chair**
William J. Devenport

**CEAS Technical Co-Chair**
Denis Gely

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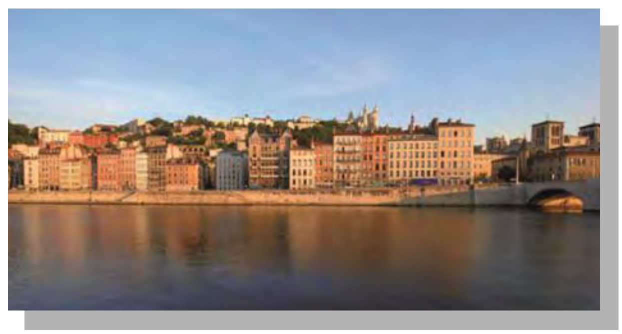
Daniel Juvé

The AIAA/CEAS Aeroacoustics Conference has established itself as the premier international forum for the field of aeroacoustics. It offers scientists and engineers from industry, government, and universities an exceptional opportunity to exchange knowledge and results of current studies and to discuss directions for future research. Students: Submit your papers in order to be considered for the Student Paper Award!



## Topics:

Acoustic/Fluid Dynamics Interactions
Active Control of Noise, Vibration and Flows
Advanced Testing Techniques
Airframe/High-Lift Noise
Community Noise and Metrics
Computational Aeroacoustics
Duct Acoustics
General Acoustics
Integration Effects and Flight Acoustics
Interior Noise/Structural Acoustics
Jet Aeroacoustics
Loads/Sonic Fatigue
Propeller, Rotorcraft and V/STOL Noise
Sonic Boom
Turbomachinery and Core Noise

**Submit your abstracts no later than 2000 hrs U.S. Eastern Time on 9 November 2015**

**www.aiaa.org/aeroacoustics2016CFP**

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