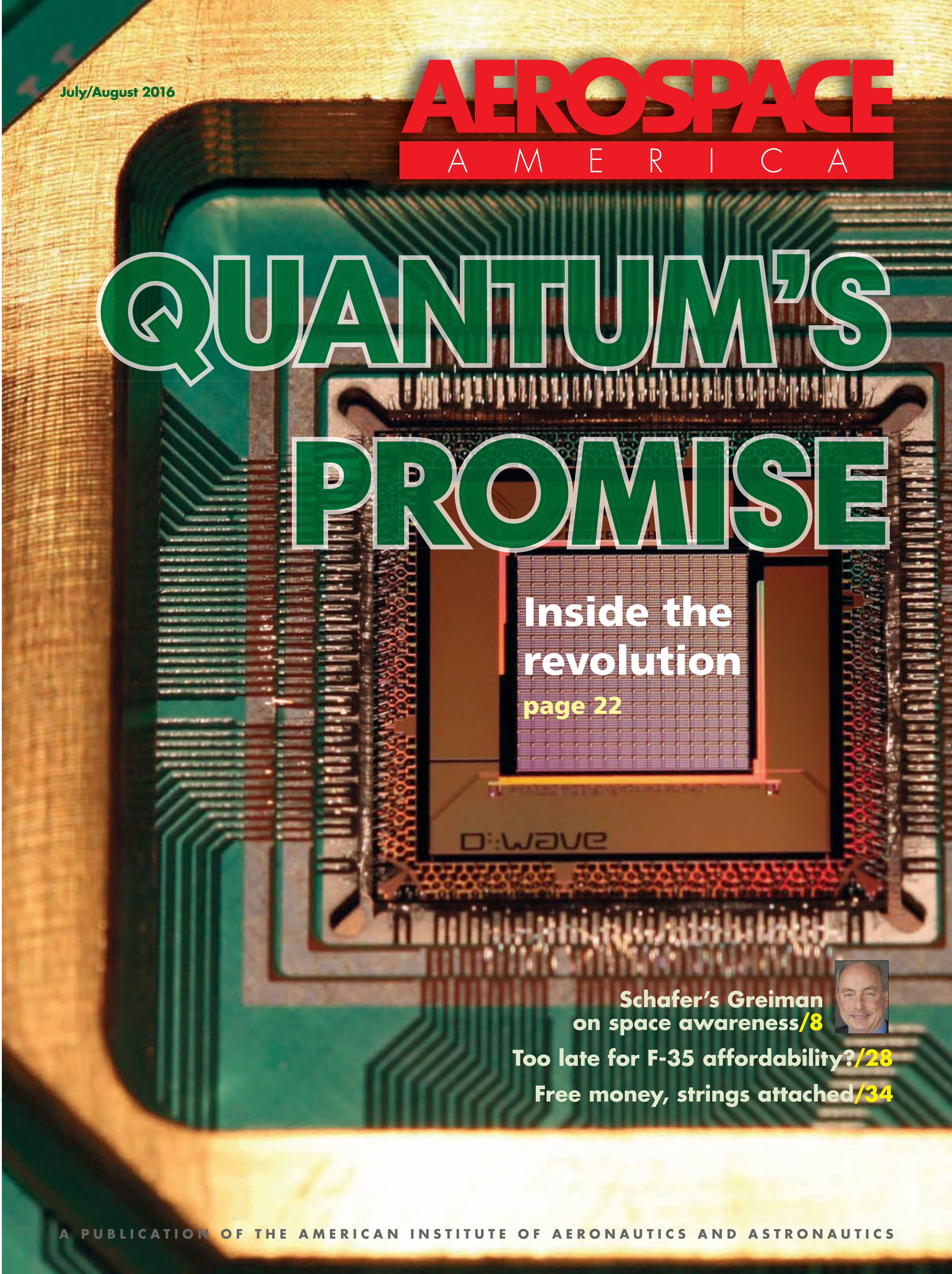
July/August 2016

AEROSPACE AMERICA



QUANTUM'S PROMISE

Inside the revolution

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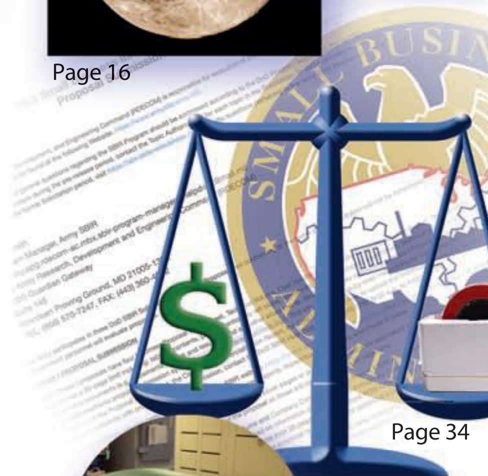

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The D-Wave quantum processor
Credit: D-Wave Systems

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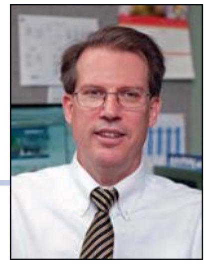
AIAA
Shaping the Future of Aerospace

Editor's Notebook



Learning from cybersecurity

The exploding interest in commercial space situational awareness strikes me as similar in some respects to the emergence of cybersecurity as a technology and policy issue over the last decade. Hopefully, some of the pitfalls of managing cybersecurity can be averted in space situational awareness. For sure, awareness of objects in space will be crucial for start-up companies and long-established satellite operators, given the expected proliferation of small satellites and cubesats in the coming years. Collisions and radio-frequency interference will need to be avoided, and some companies will want competitive intelligence, too.

Looking at the cyber realm, two interrelated similarities to space awareness come to mind. One has to do with information sharing. When U.S. corporations are hacked or phished, they've historically been hesitant to share details of the penetration with the government, for fear that the information could be leaked or publicized, putting them at a competitive disadvantage. Likewise, for reasons of classification, the U.S. government sometimes finds it hard to tell the industry what it knows about cyberthreats. The other key similarity is privatization. Corporations today rely on private companies to scan networks for malware and investigate the origins of cyberattacks and snooping. It's basically private spying, but without it, companies would be much less secure.

Equivalents of these trends are underway in space situational awareness. For this edition, I spoke to the Schafer Corp.'s Don Greiman ["Competing for space awareness," page 8] about the new business unit he heads that will scan space with privately operated, ground-based telescopes and radars and then analyze the data for customers.

These days, it seems hard to imagine the U.S. or any government trying to conduct space situational awareness alone, provided all the private satellites in planning are eventually launched. That would be like a government trying to alert every corporation to every conceivable cyberthreat against it. In the space realm, the U.S. government's Joint Space Operations Center in California would be overwhelmed if it tried to do track and analyze the vast constellations of private cubesats and other small satellites as a service to the private sector.

Two separate space-situational-awarness systems are emerging: one operated by the U.S. government and the other by private companies. By looking at the history of cybersecurity, those in the space industry and government may be able to find shortcuts toward effective information sharing. Satellite operators have a legitimate interest in guarding certain secrets for the sake of proprietary business advantages, but just as in cybersecurity, it's likely that some space-situational-awareness data will need to be shared among all for the sake of security and a smoothly functioning marketplace.

Ben Iannotta
Editor-in-Chief

Revitalizing general aviation

The general aviation industry has been hampered by an outdated FAA certification rule that has driven up the costs of aircraft and discouraged innovation, but a solution may be near.

The FAA and industry experts have been working to update the section of the federal regulation covering the airworthiness certification of planes capable of carrying up to 19 passengers, called Part 23. The new Part 23 will be in place by the end of the year, predicted Greg Bowles of the General Aviation Manufacturers Association, and moderator of the panel, "General aviation: Restoring the foundation."

The draft rule makes a "fundamental philosophical" move away from strict prescriptions, added panelist Rick Peri, head of government and industry affairs at AES, the Aircraft Electronics Association. Instead of specifying how to conduct tests on burnable materials, Peri said, the new rule simply bans such material aboard aircraft. Several panelists suggested that the FAA's new regulatory approach also will benefit safety. General aviation fatality rates have not changed much in recent years. "The bottom line is: New technology enhances safety," said Andy Supinie of Textron Aviation, a merger of Cessna and Beechcraft.

FAA flight test engineer Lowell Foster said he sees reason for optimism about restoration of the industry, which is currently dominated by decades-old aircraft. "I think we're in a transition to a new growth phase, and one that could be even neater than what we've done in the past," Foster said.

The panelists were hopeful that the shift in philosophy will usher in innovations that could reduce the costs of general aviation planes and lead to bold, new aircraft designs. Until now, certifying new technologies has often been "cost prohibitive," said Peri.

Specifically, several panelists said the new Part 23 could open the door to applying entirely new approaches, such as the distributed electric propulsion technology to be tested by NASA's piloted SCEPTOR plane, short for Scalable Convergent Electric Propulsion Technology and Operations Research.

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Greg Bowles

AIAA

Managing explosive growth, congestion in aviation

From the first flight in 1903, the commercial aviation industry has grown swiftly, and so have its challenges.

"The time that lapsed between Orville Wright's first flight and Neil Armstrong's giant leap was just a mere 65 years," said Boeing Commercial Airplanes executive Michael Delaney in the opening address of the Aviation Forum.

"The Second World War served as a greater industrial stimulus that gave rise to the jet engine, rocket-powered propulsion, radar and long-distance airplanes," said Delaney, vice president for airplane development. "The peacetime dividend was a masterful supersonic flight less than 45 years after Kitty Hawk and the birth of the commercial jet transport, ultimately, with man leaving the planet Earth in 1969."

The global industry built on those successes, he said, has brought infrastructure, security, and energy and environmental challenges.

With 65 billion passenger trips expected between now and 2030, air congestion is a looming crisis. Also worrisome are the long security lines at airports, outdated and inadequate infrastructure, increasing demand for energy and the challenges of reining in aviation's environmental footprint. Cyberattacks also are an ever-present danger, with more electronic systems and more sophisticated hackers seeking to exploit them, Delaney said.

On the bright side, he said, current projects show promise in making the future of aviation leaner and greener. Delaney compared the Solar Impulse 2 to the Wright Flyer, which was also very small and very slow but "shows us what's possible."

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Filling the workforce gap

With a tidal wave of retirements likely to hit the aerospace community by 2025, it will be up to the next generation to carry on the community's legacy, according to panelists in The Future of Education session.

The panelists grappled with two questions: What programs exist for inspiring students to pursue an aerospace career? What is the best way to go about preparing the workforce?

Darryll Pines, aerospace engineering professor and dean of the A. James Clark School of Engineering at the University of Maryland, noted that 4 percent of students in grades K-12 go on to study science, technology, engineering or math in college. Of those, just 2 percent graduate with a STEM degree.

Norman Fortenberry, executive director of the American Society for Engineering Education, said children who are scared off by science and math should be encouraged with the explanation that an engineer is simply "someone who solves problems."

The panelists also stressed the importance of cooperative learning experiences and internships with corporations. Melissa Musgrave, head of employment at Airbus and Airbus Group North America, said that international coop programs are also important since they "expose kids to other cultures and other ways of thinking."

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Cyberattacks getting more sophisticated

Richard Clarke, a former U.S. counterterrorism chief, returned to AIAA's AVIATION Forum to speak on the same topic he discussed three years earlier: cybersecurity.

He held up a copy of The Wall Street Journal to suggest that the dangers have not eased since then, reading off fresh headlines about the Russian government allegedly breaching the computer network of the Democratic National Committee and North Korean hackers reportedly stealing wing designs for U.S. F-15 fighters from Korean Air Lines.

In fact, the threats are mutating and growing more intractable, warned Clarke, chairman and CEO of Good Harbor Security Risk Management of Washington, D.C. Identity thieves don't stop at bogus credit-card purchases or pulling cash from ATMs. They file tax returns in victims' names and collect refunds.

The perpetrators, as well as their motives and methods, are changing as well. Attacks once orchestrated mainly by governments or large organizations now are deployed by criminal cartels or individual blackmailers. Instead of relying on an underwear bomber to blow up a jetliner, Clarke said, al-Qaida in the Arabian Peninsula could "hire a hacker who could disrupt an entire country's aviation system."

Cyberattacks are no longer limited to inflicting chaos and disruption. They can cause physical damage, Clarke said, much the same way the Obama administration unleashed the Stuxnet computer worm to disable Iranian centrifuges making enriched uranium.

Clarke said virtually no one is immune from attacks. The targets could be anyone, from the Pentagon to hospitals to banks to airlines and other private corporations. Potentially one of the most crippling, Clarke said, would be an attack on the nation's electrical power grid, an event his book, "Cyber War," terms "an electronic Pearl Harbor."

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Notable:

"Capabilities that we have come to depend on for our own military edge are now proliferating widely across the world."

Shawn Brimley, Center for a New American Security, referring to stealth, satellites, networking and GPS

"Since 9/11, we have had to live with heightened level of security. I see this only getting harder."

Michael Delaney, Boeing Commercial Airplanes, on growth and crowding in aviation

"The biggest causes of flight delays [are baggage drivers who] drive into the airplanes. An autonomous vehicle would not do that."

John-Paul Clarke, Georgia Tech, at the inaugural Demand for Unmanned Symposium

"Planes are much better flown on sensors than humans."

Mary Louise "Missy" Cummings, Duke University, on aircraft autonomous technology

"We are not the only country that can design and produce aircraft or engines anymore."

Jaiwon Shin, NASA Aeronautics Research Mission Directorate

"I saw some opportunity to design, build and sell."

Michimasa Fujino, Honda Aircraft Co., on how he helped bring HondaJet to market

Six revelations from a young professional

Life after college comes with its share of challenges (goodbye midday naps). Samantha Walters, who was an intern at AIAA last year, muses about her first months as an aerospace engineer at the NASA Jet Propulsion Laboratory in Pasadena, California.

1. New way to learn

When I started working, I quickly realized that I'd be using almost nothing of what I'd learned in the classroom. With no professors or textbooks, writing software command sequences for Mars spacecraft or understanding the Curiosity rover's flight software demanded a new way to learn. This has required lots of independent research and poring through countless technical documents. It also meant discovering the value of knowing when to ask for help. There may not be teachers in a literal sense, but the workplace is full of veteran engineers who are eager to share their knowledge. I just have to ask.

One of the biggest challenges Samantha Walters tackled on the job was outlining all the fault-protection steps that NASA's Curiosity rover might take after entering "safe mode." No professors were standing by to help.

2. Daily grind

During my senior year, when I was subsisting on boxed mac and cheese, a nine-to-five job sounded great. Regular schedules! No homework! But what I did not consider was that I would need to devote all my energies to my job for nine hours a day, five days a week. No Netflix breaks when I get frustrated. Definitely no skipping meetings just because I felt like it. Now when I get home, I'm lucky to have the energy to make a box of mac and cheese.

3. Staying motivated

I have wanted to work for NASA since I was 12. I've moved toward that goal in orderly increments: get into college, finish the semester, graduate, find a job. At 23, with my dream achieved, I find myself without new, concrete goals. That can make it difficult to stay motivated. For now, I'm focusing on the present and savoring my small successes.

4. Real impacts

At the University of Maryland, I was often frustrated with the abstractness of textbooks, which devoted pages to the world of perfect insulators but ignored such real-world matters as wind resistance. As a professional engineer, I know every problem I solve is a step toward real innovation. Seeing the results of my work, such as ground software I wrote to help operate the InSight Mars lander, is much more rewarding than any grade I've ever received.

5. Personal freedom

The combination of financial independence and totally free weekends that come with being a young professional makes any stress on the job feel worthwhile. Instead of taking out tuition loans and hitting my parents up for grocery money, I'm supporting myself, paying down debt and still have enough leftover to afford a few of life's luxuries, including a vacation that doesn't involve sleeping on a friend's couch.

6. Inspiring others

Every year, JPL holds an open house for people in the Pasadena community. A girl who appeared to be about age 10 asked if she could interview me for a school project. She said she wanted to grow up to be an aerospace engineer. I realized how privileged I was to be able to inspire the next generation of innovators. This is one deeply rewarding aspect of my career I never dreamed of in the lecture halls.

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Competing for space

With startups planning to launch vast constellations of small satellites in the months and years ahead, a fierce competition is underway to provide satellite operators with knowledge about where other objects are in space, where those objects will be in the future and what the intentions of other satellite operators might be. In the U.S., space situational awareness, or SSA, has largely been the purview of the military and intelligence communities, but that is changing. Ben Iannotta spoke by phone with Don Greiman, a leading expert in the emerging industry of commercial SSA and a retired Air Force colonel. Schafer Corp. announced his selection in May to lead the company's new Commercial Space Situational Awareness business unit.

Why is this a good time to set up a business unit devoted specifically to commercial space situational awareness?

Interest in space envisioned so many years ago is here and now. Space situational awareness is not for the faint of heart in terms of the technical challenges; the math models; the propagation theory; the ability to improve on very complex things to make them fast, better and easier to understand. There's a whole list of things you could talk about: The ability to take position information today and do some additional analysis, and figure out where things are going to be in three months, six months or even a year.

Could the trend toward maneuvering satellites complicate things?

It makes it difficult. If you require an indication, or a warning, or a notice that something might be happening, and then you go look at it, that's a good way to assure that you're going to miss the most important things. It drives us toward an affordable and persistent collection enterprise. Affordable and persistent are very difficult for government systems. Our [corporate] partners have pretty much built their capabilities on relatively small budgets. They've done more work with algorithms as opposed to exquisite technology. One of our companies that supports us, XO Analytics, has a suite of astronomy club-quality telescopes. They're very cost effective. By scattering those telescopes around the world, we can get an affordable look into space.

Some of our [team's] other capabilities are like that as well. SRI International does radar stations. SRI can use them for commercial purposes, as well as supporting the government and academic purposes for which they were originally intended.

Those are on the ground, right?

Yes, all of our enterprise is ground based, presently. We would love to have assets in space doing commercial space situational awareness, and we talked to a couple additional companies about putting telescopes in space, sensors in space, or leveraging capabilities that they already have. That's what sets us apart. We start with what's possible and what's affordable. Not with what's extravagant or expensive.

Doesn't the government already have this kind of data?

The government has ground systems and space systems as well, but from my own experience inside the government, I never met an intelligence analyst that didn't want more data. Exquisite capabilities are tied to missile defense, or other [requirements]. When you say, "Could you turn that telescope and that camera over to look at this particular thing?" national priorities get in the way, and they're the right priorities. There just simply isn't enough exquisite national capability to answer all the questions. One of the things from a commercial perspective that we can offer is a lower cost alternative way to see something.

To those folks who say, "Why would I want to look at something with an astronomy club quality telescope?" my response is: When that national asset can be made available to you, you should use it. In the meantime, we'd be happy to show you things that you may be missing.

What do you see as the role of private companies like Schafer compared to the military's Joint Space Operations Center?

awareness

Interview by Ben Iannotta
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Don Greiman, general manager of Schafer Corp.'s Commercial Space Situational Awareness unit

They're complementary. The thing that we can do is persistence. There's such an increase in commercial demand for space situational awareness, and it's growing significantly. We talked to an FAA [expert] not long ago, and he said, "We're thinking its something like a fivefold increase in the amount of objects in space in the next two to five years." JSpOC [Joint Space Operations Center] has to protect sensitive sources and methods. They have to review information before they release it to anyone for embedded classifications, or implied classifications. That affects the timeliness.

I would like to see a relationship with JSpOC whereby we say "Here are the things that we can do at a relatively low cost." Find out how accurate we are, and where we can provide service to commercial customers, to the State Department, to spaceports. The insurance industry, heretofore, has used their actuarial tables as a basis for claim, [but] for the first time, you can have technical information that shows where that object came from that caused you to have to maneuver, which spent some of your fuel for that satellite.

Would the government, also have access to your data?

I would love to make our data available to the government, if we're able to put together the kind of capability that the Federal Aviation Administration will need in order to become the space cops of the future — that's a little hyperbole. The cornerstone starts with commercial information that is not classified, and is immediately available, timely, and technical. Then put a mechanism in place whereby that information is vetted for inclusion into the JSpOC catalogs, and their common operational pictures.


Schafer Corporation

So U.S. government agencies could be a customer for the CSSA unit?

Absolutely. I can see if I can tell the U.S. government things about [their] own satellites as accurately as anything that a national system can do. Maybe a cloaking mechanism isn't working exactly as designed or [there's] an underestimation of what you could do with commercial technology. While that's uncomfortable for our defense and intelligence community, it's my responsibility to help them know what others can discover.

Think about other nations' capabilities. If I can tell you technically accurate [information] in a timely way for less money, why wouldn't you allow me to do that for you? You can focus your exquisite systems on exquisite problems. Then, you get to the "Oh my God" box, which is discoveries about adversaries that you didn't already know.

Might a government customer say, "OMG, that needs to be classified"? Now you can't sell it to your commercial customers, right?

We're American citizens, we're a U.S. company. Absolutely, when a government organization tells us "Yesterday, you saw it, and today you don't," we're fine with that. One of the reasons the U.S. government classifies information is because its revelation could cause grave damage to the future of the United States. That is not a foreign concept in industry. We have sensitive and proprietary information. The future of my company and my ability to continue to work, and make a livelihood is gravely at stake, as well.

One of our [commercial] customers says, "I really want to know what my competition is doing," we say "Okay, let's put that in place."

Meaning look at satellites from orbit, or from the ground?

From the ground. Radars, telescopes, laser-pointing capabilities, LIDAR, short wave, midwave, long wave: We have those capabilities today. If somebody said "My competition is the Black Pencil Company. Where are their assets deployed?" there's nothing today that prevents me from saying here's the Black Pencil Company's constellation. You can do a competitive analysis on other commercial assets that are flying in space.

What's driving this interest in SSA — the planned numbers of cubesats and smallsats?

That's certainly part of it. It's just an exciting time to be alive. Colleges and universities, even high school teams can build a cubesat, a nanosat for thousands of dollars, [and] see if somebody will put that object in space for them.

Don Greiman

Title: *General manager, Schafer Corp.'s Commercial Space Situational Awareness unit*

Age: *61*

Birthplace: *Minneapolis, Minnesota*

Education: *Bachelor's degree, music education; master's degree, public administration*

Experience: *30-year career in U.S. Air Force; former vice commander and former director of advanced programs at National Air and Space Intelligence Center*

Residence: *Springboro, Ohio*

Family: *Wife, Noel Greiman*

Interests: *Bass trombone in the Ohio Valley British Brass Band, golf, reading*

Favorite quote: *"We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time."* — T. S. Eliot

They're not being effectively tracked [because] it's too small of a problem for exquisite national systems to be worrying about. Those are exactly the kinds of things that we formed our team to be able to do. We have a capability to fingerprint cubesats and smallsats of different varieties. We can tell you where they are, probably within a meter.

The companies you've teamed with, are those exclusive arrangements or could they also be working for, say, Analytical Graphics, Inc.?

Oh, they are. Several of the data providers, especially XO Analytics, Vision Engineering Solutions, and SRI are providing information to AGI for use in the Systems Toolkit. Would I like them to be exclusive to the Schafer team? Well, yes I would. That's not the reality of things. That's not how the marketplace works. I stay in business by creating a value proposition to my customers that they can't get other places.

Do you have to beat AGI on price?

I do, absolutely. We've actually put together a catalog of capabilities: prelaunch, launch, orbit insertion, onboard activity, and beyond mission life or deorbiting or retirement of an asset. We've organized our engineering services in that catalog around each of those particular areas. I can build a tailored common operational picture that does not require them to buy a shrink wrapped box of software that has a lot of things in it that they'll never use. Our model is to use the catalog as a starting point for a discussion, understand what problems the customer has.

Would you track or surveil government satellites, meaning U.S., Chinese, Russian, for a customer?

A telescope doesn't know whether it's looking at a U.S., a Chinese or an Antarctic satellite. One of the strengths of our enterprise is our ability to persistently see everything that's up there. We're going to see some things that people would not like us to.

Then what do you do?

Well again, depending on what we are told, we cannot and should not share; we do not share.

De-icing with nanotubes

U.S. military drones were rushed into service during the wars in Iraq and Afghanistan, sometimes with known technical compromises, one of them being a lack of in-flight de-icing equipment. Michael Peck spoke to scientists who say they have an "elegant" solution.

Battelle

In Battelle's HeatCoat system, a thin layer of carbon nanotubes thaws ice on the wings of unmanned aircraft, as shown in this rendering.

The U.S. Air Force's MQ-9 Reapers, the terror of the Taliban, are vulnerable to an unlikely foe: Frozen water. In fact, the Air Force advises Reaper pilots in ground control stations to avoid steering the planes into icing conditions "to the maximum extent possible." The service's RQ-4 Global Hawks, which eavesdrop and take images from high altitudes, also cannot shed ice. It's not just an Air Force problem. The Army's RQ-7 Shadow tactical intelligence drones aren't equipped for de-icing, either.

Among those vying to potentially retrofit these and other military drones with de-icing technology are the materials scientists at Battelle, a private, nonprofit research organization in Columbus, Ohio. Battelle wants to coat the most vulnerable areas of airframes with carbon-nanotube molecules and heat them to melt ice. Lots of lab and wind tunnel work lies ahead toward flight tests planned for 2018. If all goes as Battelle hopes, a frustrating constraint for commanders and drone operators could be lifted.

Innovating with nanotubes

Weight is the first enemy for any technologist working on drones. As the Air Force told the industry in December, the Reaper "is operated with zero excess power and weight for stores. Whenever anything is added to the platform, something must be removed (i.e., fuel, sensors, stores)." The Air Force is open to ideas, but it's safe to say that proposals to sacrifice cameras, computers, missiles or fuel would not go over well.

Nanotubes are lightweight, but their possible role as a de-icing solution for drones wasn't immediately obvious.

"This story starts in the way that it is often not recommended to do product development," jokes Amy Heintz, the Battelle materials scientist who conceived HeatCoat and in May received an award as Battelle's 2015 Inventor of the Year.

Rather than waiting for a requirement from the Pentagon, as is often done, Battelle developed HeatCoat on its own about 11 years ago, after the organization began delving into the emerging technology of carbon nanotubes. While looking for potential applications, it occurred to Heintz that nanotubes, which have a diameter 10,000 times narrower than a human hair, could be used to de-ice aircraft.

These carbon molecules can form corrosion-resistant materials stronger than steel, but most important for Heintz was their remarkable thermal conductivity, which meant they could convey heat to surfaces vulnerable to icing.

Heintz originally envisioned HeatCoat as a de-icer for commuter aircraft, but in 2006 she concluded that there was more of a demand for de-icing unmanned aircraft, and there would be fewer regulatory hurdles to fielding the technology. Indeed, Battelle started receiving research dollars in 2010 from several Air Force unmanned aircraft program offices.

No moving parts

Engineers and scientists refer to an efficient design as elegant, and the de-icing systems that Battelle saw on the market were anything but.

"We knew a lot of the systems being used had a lot of moving parts, had poor reliability, and people didn't want to use them," Heintz explains.

She and her colleagues got to work designing a system that would eliminate moving parts.

Placing de-icing gear on the surface of an aircraft, especially the wings, is usually a nonstarter, because anything protruding into the air flow could rob lift and create drag. Heintz reasoned that lightweight connectors could feed power to heating wires (similar to those in a toaster or baseboard heater) that could be installed under the skin of a drone. These would radiate heat to nanotubes applied as a layer of paint or film. The nanotube layer would have to be thin enough that aerodynamic effects would be minimal and light enough that nothing would have to be removed to compensate.

The next question was how to suspend nanotubes in a paint so that they would conduct heat effectively. It would not be easy. "Nanotubes are just like carbon soot," Heintz says. "Imagine taking carbon soot and putting it in water."

The soot wants to clump up, but the microscopic tubes must be evenly dispersed and they must be close to each other. "We knew that the junctions between the CNTs [carbon nanotubes] and the spacing between the junctions were the limiting factor for the conductivity, so we sought to minimize these junctions and achieve tight connections," Heintz says.

The solution was to mix the nanotubes with a dispersing agent to maintain the right concentration.

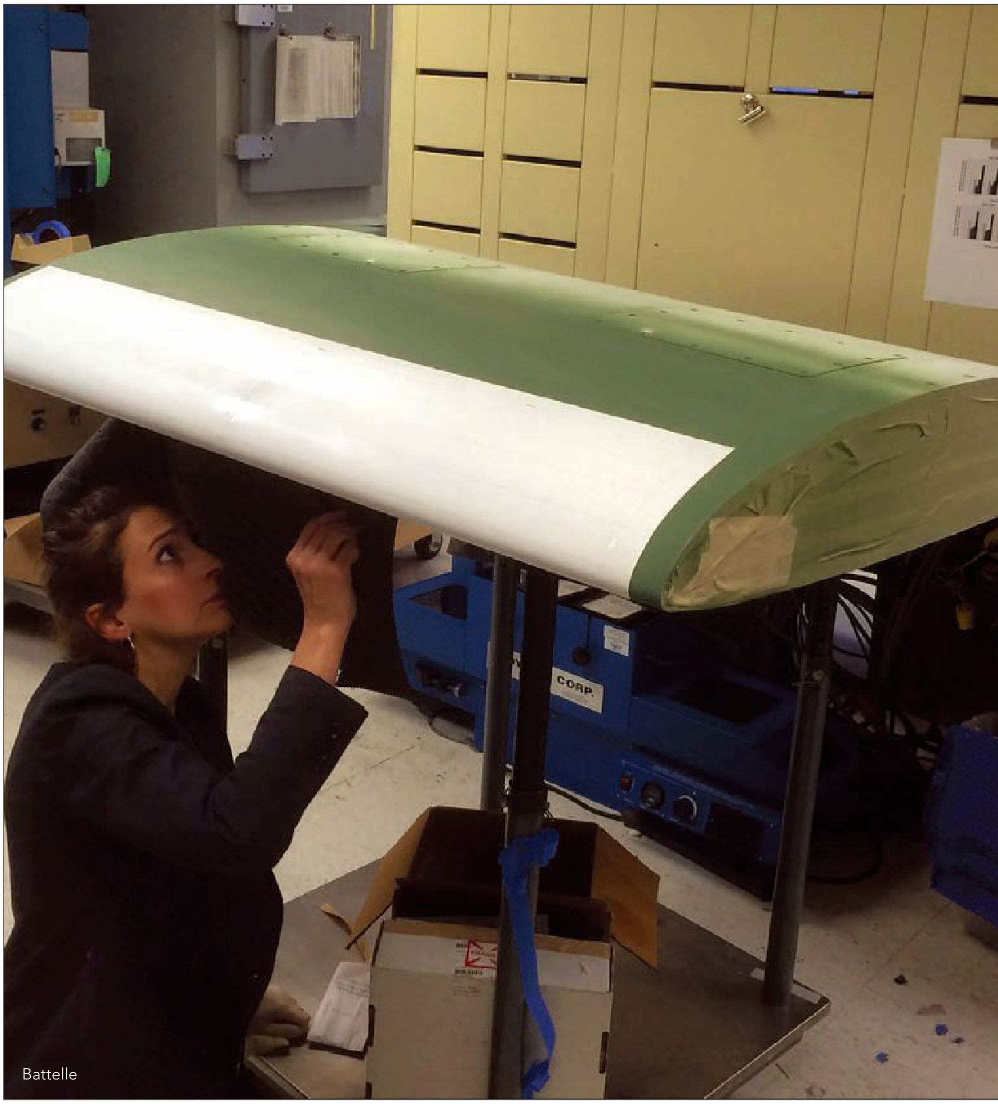
"The total thickness of the coating stackup applied to the aircraft surface is less than 0.51 millimeters, including the original paint layers," says HeatCoat Program Manager Brett Burton, who co-developed the technology with Heintz.

Battelle's HeatCoat brochure shows a plane retrofitted with a five-layer surface. At the bottom is the aircraft's skin, then the regular primer. On top of the primer is the layer of nanotubes, and then a barrier coating of commercial paint is applied to keep moisture out, and a top coating of regular paint is applied. Small electrical leads affixed to the surface of the aircraft are hooked through pass-through connectors to the aircraft's existing wiring system.

Another hurdle was power consumption.

"If you were to take that watts per square inch and multiply it over the whole aircraft surface, you would find that you need way too much power," Heintz says.

Materials scientist Amy Heintz examines a layer of conductive coating applied on a wing for de-icing.



Battelle

The team conceived of a solution. The nanotube material would be applied only on locations that are vulnerable to icing, and they would not conduct heat all the time.

A control and sensor system on board the aircraft would detect weather conditions that could create icing. Nanotube heating elements on the wings, engine inlet and tail would be cycled on and off as a preventive measure (HeatCoat will eventually include ice sensors for even more precise heating).

"The heaters are applied as an array, with multiple individual heaters situated along the leading edges of the wings, engine inlets, and tails as required," Burton says.

Enough heat would need to be conducted to melt the ice, but not so much as to cause wear or damage the surface. HeatCoat applies just the appropriate amount of power depending on the weather.

Battelle employees attach an alignment drill jig to a wing section in an engineering lab in Columbus, Ohio. Holes were drilled to run wires to carry current to melt ice.

Real-world considerations

HeatCoat's designers needed to keep in mind that the technology would have to be retrofitted to existing aircraft and serviced by military personnel.

"Have we affected how they do routine maintenance? People don't want to have to do anything differently," Heintz says. Rather than stripping the aircraft and removing the primer, HeatCoat will be applied by removing the top coat of paint, putting down the nanotube paint and barrier layer, and then reapplying the top coat.

Mindful that other de-icing products are on the market, Heintz's team resolved to show "as fast as we could" that the HeatCoat concept worked.

"It was a challenge to think a little bit differently; to not solve every problem and risk we thought might be there, but to push it through as a beta test, so to speak," Heintz recalls.

The gamble paid off. In 2009, Battelle tested a small HeatCoat-equipped airfoil in United Technologies Corp.'s Goodrich icing tunnel. The team met its goal of showing that the air foil could be de-iced to FAA standards for light and moderate icing and within the power budget of the Army's Shadow. After that, Battelle received HeatCoat funding from several Air Force program offices.

Heintz's team is still refining HeatCoat, including how to efficiently manufacture the nanotube components. There are also discussions with manufacturers about applying the technology to manned aircraft, though there is not yet any experimentation along those lines.

Battelle declines to say which Air Force offices are funding HeatCoat, but the company's HeatCoat brochure is printed with a drawing of a drone firing a missile. The drone looks remarkably like an MQ-9 Reaper.

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The moon still beckons

The Obama White House shifted NASA away from returning astronauts to the moon, but a new presidential administration may see matters differently next year. Tom Jones explains the lunar allure and why it makes sense to go back.

Stanley Kubrick's 1968 film, "2001: A Space Odyssey," opens its space sequences with a journey to the moon, where the U.S. operates an expansive base beneath the floor of the crater Clavius in the southern hemisphere. Astronauts skim over the stark lunar terrain in a rocket-driven bus, heading to an excavation where geologists have unearthed an ancient, mysterious sentinel.

The vision of this groundbreaking sci-fi film outpaced reality. After Apollo, the U.S. dropped plans for more extensive human exploration, and today the first party of colonists has yet to arrive on the moon. Although no human voyage is on anyone's current launch schedule, space agencies around the globe are planning a new wave of robotic exploration of our nearest celestial neighbor, driven by its proximity, scientific potential and the promise of useful natural resources. If only some of these missions find what they're looking for, the results may spur humans to follow.

A "supermoon" photographed from Earth in 2014.

The dynamic moon

Scientific exploration of the moon took a pause after Apollo and the Soviet Union's Luna robotic missions four decades ago. Those efforts barely scratched the surface of the moon's scientific potential, but a flurry of robotic missions in the last decade reminds us that the moon tells a complex, 4.5-billion-year story that's still being written.

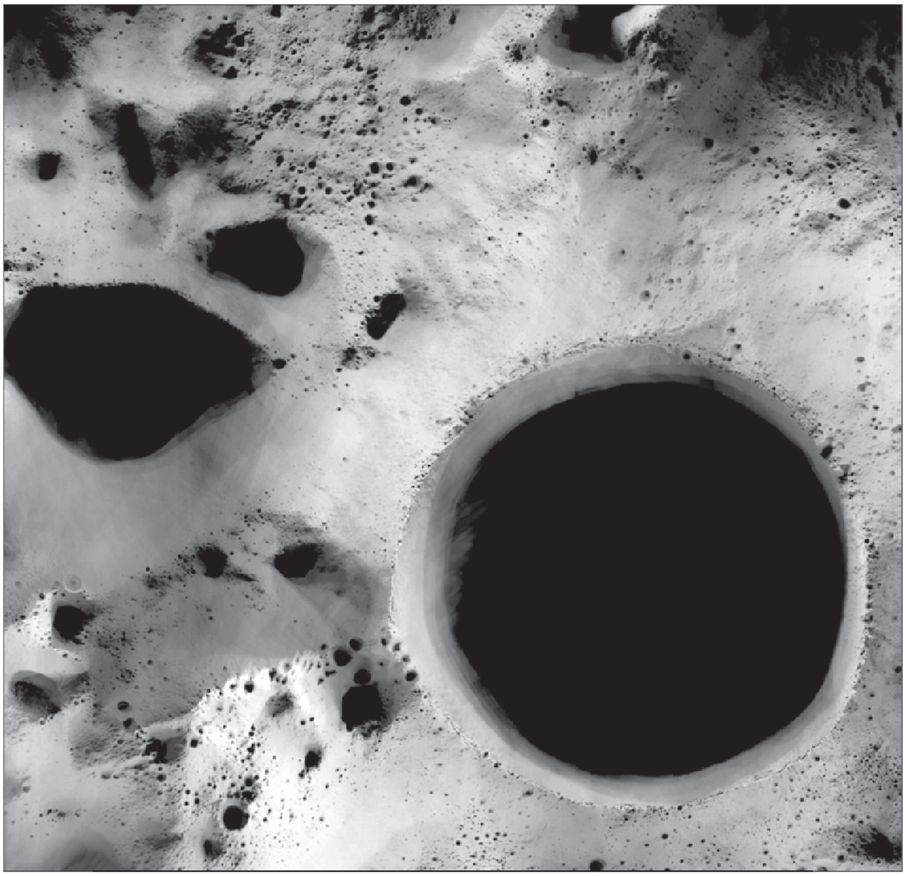
An exhibit at the National Air and Space Museum, "A New Moon Rises," in Washington, D.C., showcases some of the most recent and revealing photos taken by the Lunar Reconnaissance Orbiter Camera, LROC, which continues to circle the moon. Images on the museum's website show a variety of perspectives and suggest a surprising level of geological activity in the recent past. These are the scenes that will greet human explorers when we finally return.

The images demonstrate that the moon is still changing. Slowly cooling over billions of years, the lunar interior has steadily contracted, buckling the overlying crust into scallop-edged faults, called lobate scarps. Some of these scarps are relatively free of impact craters, so they must have formed fairly recently. New examples may still be forming today.

The lunar seas, or maria, created by giant asteroid impacts, quickly filled with vast ponds of fluid basalt lava, with a thin rock crust overlying the still-scalding reservoir of liquid rock. As this basalt cooled and contracted, surface faults called "wrinkle ridges" formed. Along these ridges, the LROC has images of boulders shaken loose by moonquakes triggered by the recent buckling of these lava plains.

The moon's surface was long thought to be static, changing only when pummeled by asteroids and comets. But lava flows lacking the usual carpet of impact craters point to volcanic activity within the last 10 million to 100 million years in the moon's history. The LROC team has discovered more than 60 such examples. Some recent flows have erupted onto crater floors; these "puddled" lavas suggest that radioactive heat within the moon may still be producing subsurface pockets of liquid rock. The existence of these radioactive element concentrations may revise geochemists' estimates of the moon's internal composition. Some of the most intriguing volcanic features are "skylights," pits formed when the crust on top of underground channels of flowing lava collapsed after the eruption ended, emptying the cave beneath. Peering into these cavities reveals collapsed rubble and layers of basalt lava flows; these lava caves could serve as natural radiation shelters for future astronaut habitats.

The most surprising lunar discovery in the last 20 years is that it is not a bone-dry, ancient relic, but a geologically changing world with accessible water in its polar regions. Scientists have also detected trace amounts of hydroxyl, molecules consisting of an oxygen and hydrogen atom, possibly formed by solar wind action. But polar water ice deposits will be of most value to explorers.



NASA/Goddard Space Flight Center/Arizona State University

Lunar explorers might someday sustain themselves with water ice harvested from the darkness of the Shackleton crater and other impact sites on the moon. This image was created from thousands of photos taken by NASA's Lunar Reconnaissance Orbiter Camera. Black represents areas that never receive sunlight.

Moon moisture

When the Pentagon's Clementine probe bounced S-band radio signals off the lunar surface in 1994, the data suggested the presence of water ice on the shady side of craters near its south pole. Lunar probes since then have repeatedly suggested the same. Because the sun's rays slant obliquely across the poles, some deep crater floors are entirely hidden from the sun. Lunar Prospector in 1998 found evidence for about 1 to 3 cubic kilometers of water ice, but this neutron-spectrometer data couldn't rule out hydroxyl as the hydrogen source.

After India's Chandrayaan-1 orbiter reflected radar signals off the surface in 2009, scientists concluded that the north polar region indeed harbors some 600 billion kilograms of water ice (over half a cubic kilometer of water), likely in the form of small, pebble-sized chunks mixed with the lunar soil, called regolith.

NASA's Lunar Crater Observation and Sensing Satellite, LCROSS, was intentionally crashed into the south polar region of the moon in 2009, creating a debris plume that LRO examined for traces of water. The data showed that regolith in the crater Cabeus contains about 6 percent water ice by mass.

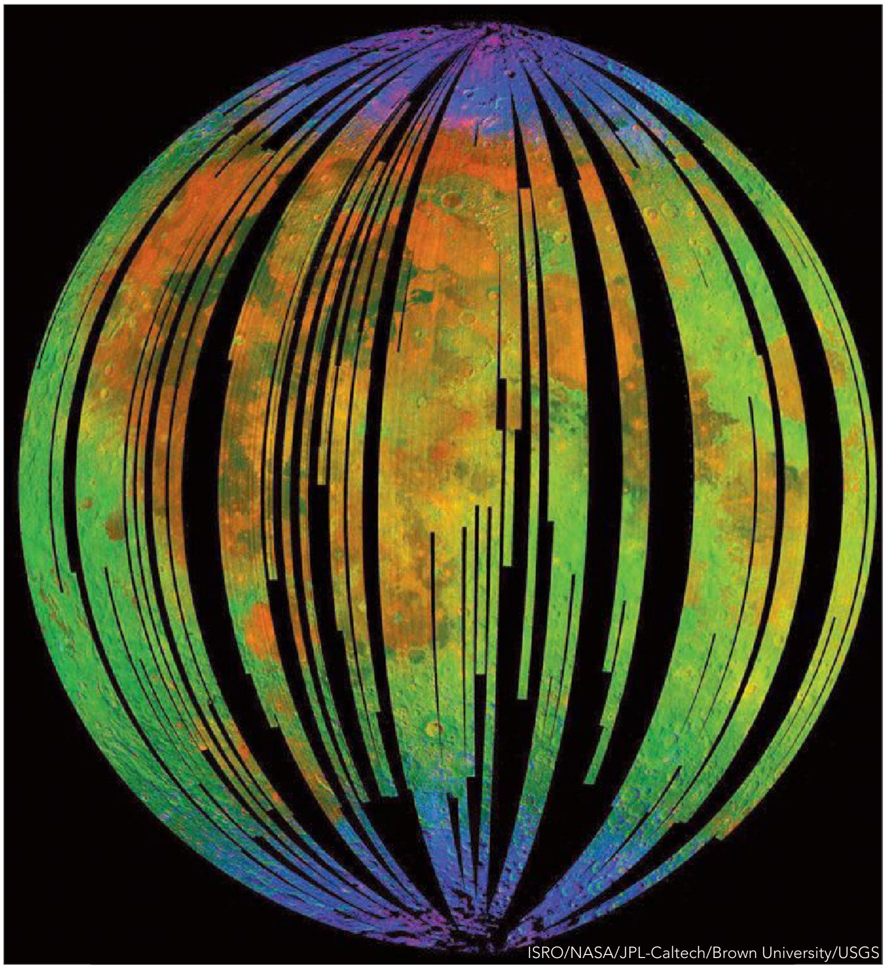
When NASA's Lunar Reconnaissance Orbiter examined the sun-shadowed Shackleton crater near the south pole with its laser altimeter, it found evidence that at least 20 percent of the crater floor is covered in ice. LRO's Mini-RF radar frequency experiment also indicated that polar ice is probably mixed as small particles in the lunar regolith.

Although we know lunar water ice is there, we don't yet know its spatial extent, overall concentration and whether it exists in the regolith as small chunks, crystals or massive slabs. The only way to determine all that would be to send robots to the surface near the polar regions.

A robotic return

Chemical rockets can get a craft to the moon in just three days or so, and traffic around the moon is starting to increase. In the last decade, China, Europe, Japan and the U.S. each have sent spacecraft to scrutinize it from orbit. In 2013, China also landed the Chang'e 3 probe, which deployed a short-lived rover, the first surface visit to the moon since 1976.

The surface is also the target of the next generation of lunar probes. India is readying a 2018 lander mission, and China is preparing its Chang'e 5 sample return mission for a launch sometime next year. The European and Russian space agencies are proposing a Luna-Resurs craft that would be launched in about 2025 to place a drilling and analysis package at a polar crater. The craft would drill 1 to 2 meters into the icy regolith to determine the water content.



Water was mapped on the moon in 2009 by NASA's Moon Mineralogy Mapper, an instrument on the Indian Space Research Organization's Chandrayaan-1 spacecraft. The blue indicates the presence of water ice in the polar-region regolith, as lunar soil is known.

The next U.S. craft to bid for the moon will be the NASA Resource Prospector, which is currently in the formulation phase. It will land in a shadowed crater and extend a drill that will retrieve a soil sample from a depth of about a meter to look for water ice. An onboard laboratory will then heat the sample and analyze any water and volatile compounds released. Funded by NASA's Human Exploration and Operations Mission Directorate, the $250 million mission could fly in the early 2020s.

The moon's value to the U.S.

Since the cancellation of NASA's Constellation lunar-return program in 2010, the agency has rarely mentioned "astronauts" and "moon" in the same sentence. Although current NASA policy is to let other nations lead a human return to the moon, critics hope that congressional direction and a new administration will put American explorers back on track for the lunar surface.

One such advocate is planetary scientist Paul Spudis, who argues in his latest book, "The Value of the Moon," that its proximity to Earth, its abundant solar energy and emerging natural resources make the moon simply too important for the U.S. and NASA to overlook for long.

"The big, new revolutionary discovery of the last 20 years is that the moon is not just interesting from a scientific point of view, but that it has utilitarian value," Spudis says. "We can use what it has to offer to create new opportunities in spaceflight."

Spudis was principal investigator for the radar instrument on Chandrayaan-1 and deputy leader of the Clementine science team. In addition to being reachable by today's rockets, the moon's proximity means that Earth-bound engineers can control robots on the moon's surface in near-real time, directing them to explore, build infrastructure, and erect outposts in advance of a human expedition.

The moon is also blessed with abundant energy, essential for any long-term human presence. Elevated crater rims near the poles are bathed in near-constant sunlight, as seen in precise maps drawn from Lunar Reconnaissance Orbiter data. Photovoltaic systems, erected telerobotically on this illuminated high ground, could supply reliable energy for excavation and processing of water ice. This sunny situation means that initial human outposts near the lunar poles need not require massive battery systems or a nuclear reactor that would be expensive to design, test and qualify.

Most importantly, the moon's resources are known to be plentiful enough for practical use in future exploration.

"We've learned there's a water cycle on the moon, with significant deposits of water, in different forms and locations. We don't know how old, how massive, or how concentrated this water is, but there are tantalizing hints that the stuff is present in massive quantities—at least hundreds of millions of tons, to well over a billion," Spudis says. "We need to get down on the surface and make in situ measurements. We need ground truth, in multiple places, preferably, to resolve the ambiguities."

Spudis thinks the Resource Prospector mission is an essential first step toward those answers.

The moon can't wait

Spudis argues in his book that it is important to America's future economic and national security. The U.S. can't afford to neglect such useful resources in nearby space, ones eyed by China and Russia as well. Rocket propellants produced from that water could enable affordable exploration missions, not only on the moon, but out to nearby asteroids and Mars.

"The next step for human spaceflight is a permanent lunar return, because the Moon has so much to offer us in building capability."

China has discussed oblique plans for a piloted lunar landing sometime in the late 2020s. When could U.S. astronauts return to the moon? That answer lies cloaked in the bone-cracking cold of its permanently shadowed polar craters. The more accessible the ice, the greater the rewards of an accelerated return. But Spudis believes that a U.S. return, this time with international partners, could proceed quickly and affordably, contributing invaluable experience and resources toward our efforts to reach Mars.

"That's the advantage of the moon. Because it's so close, you can do these human-controlled robots on a fairly inexpensive basis. You can't do that on Mars or the asteroids because of the distances, but you can do it on the moon."

To me, a lunar return seems an affordable, practical way to gain experience and access to resources, even as we plan for journeys to nearby asteroids and the Mars system, using much of the same hardware. The Obama administration's decision to forgo the moon was based on politics, not a candid evaluation of the moon's potential. The moon is simply too close and too valuable today to ignore. If the robots find "the right stuff" there, astronauts should follow in their footsteps well before 2030.

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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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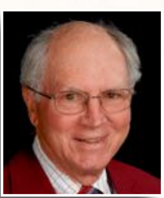
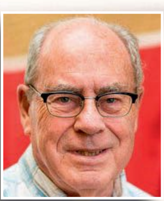
Russell M. Cummings
Department of Aeronautics
U.S. Air Force Academy
Colorado Springs, Colorado

AIAA Aircraft Design Award
Darold B. Cummings
Aerospace Consultant
Boeing Technical Fellow (retired)
Huntington Beach, California



AIAA Distinguished Service Award
Roy V. Harris Jr.
Director of Aeronautics (retired)
NASA Langley Research Center
Williamsburg, Virginia



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Professor, Department of Aerospace Engineering
University of Michigan
Ann Arbor, Michigan

AIAA Foundation Award for Excellence
X-37B Orbital Test Vehicle Team
Award accepted by
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Cambridge, Massachusetts
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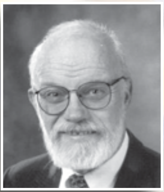
Christopher J. Scolese
Director
NASA Goddard Space Flight Center
Greenbelt, Maryland



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Philip E. Cassady
Senior Technical Fellow (retired)
The Boeing Company
Seattle, Washington

AIAA Public Service Award

Ralph M. Hall
Congressman (1981–2015), 4th District Texas
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Michael Sinnett, Vice President, Product Development and the Boeing 787-8 Development Team

Thank You, Nominators!

AIAA appreciates your time and effort in preparing the nomination package!

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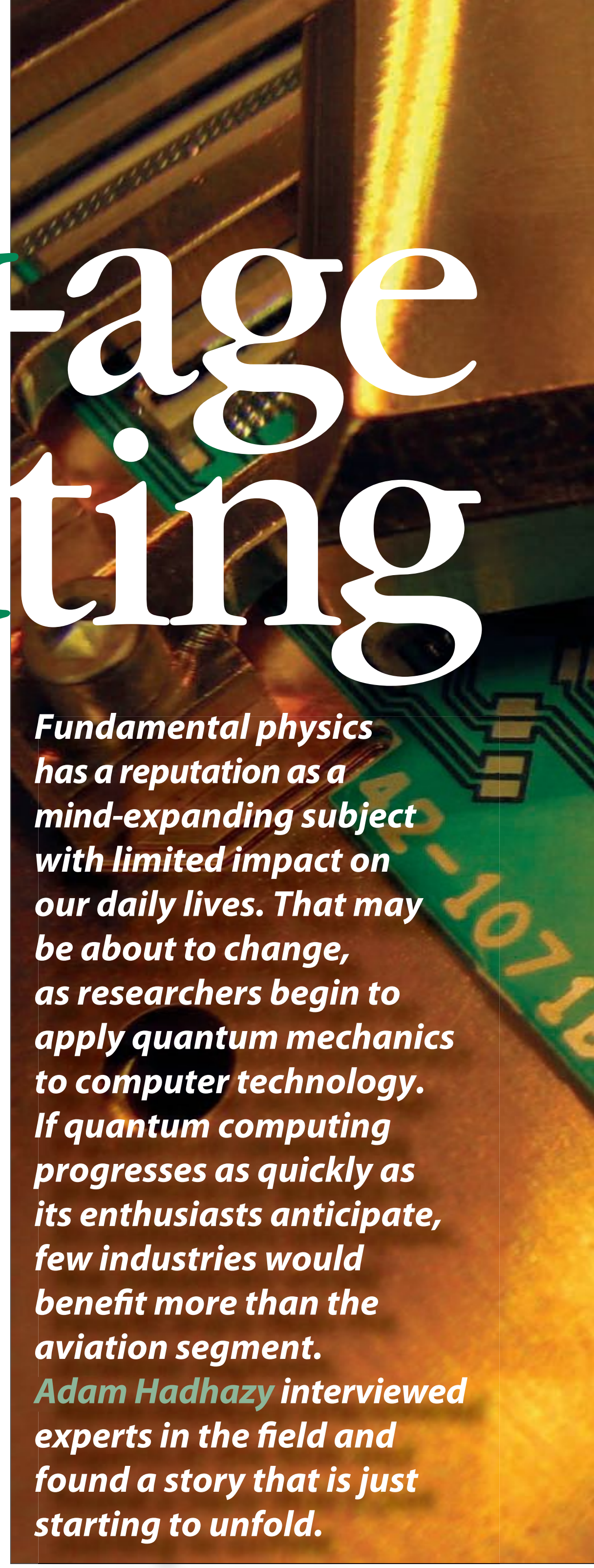


New-age computing

Fundamental physics has a reputation as a mind-expanding subject with limited impact on our daily lives. That may be about to change, as researchers begin to apply quantum mechanics to computer technology. If quantum computing progresses as quickly as its enthusiasts anticipate, few industries would benefit more than the aviation segment. Adam Hadhazy interviewed experts in the field and found a story that is just starting to unfold.

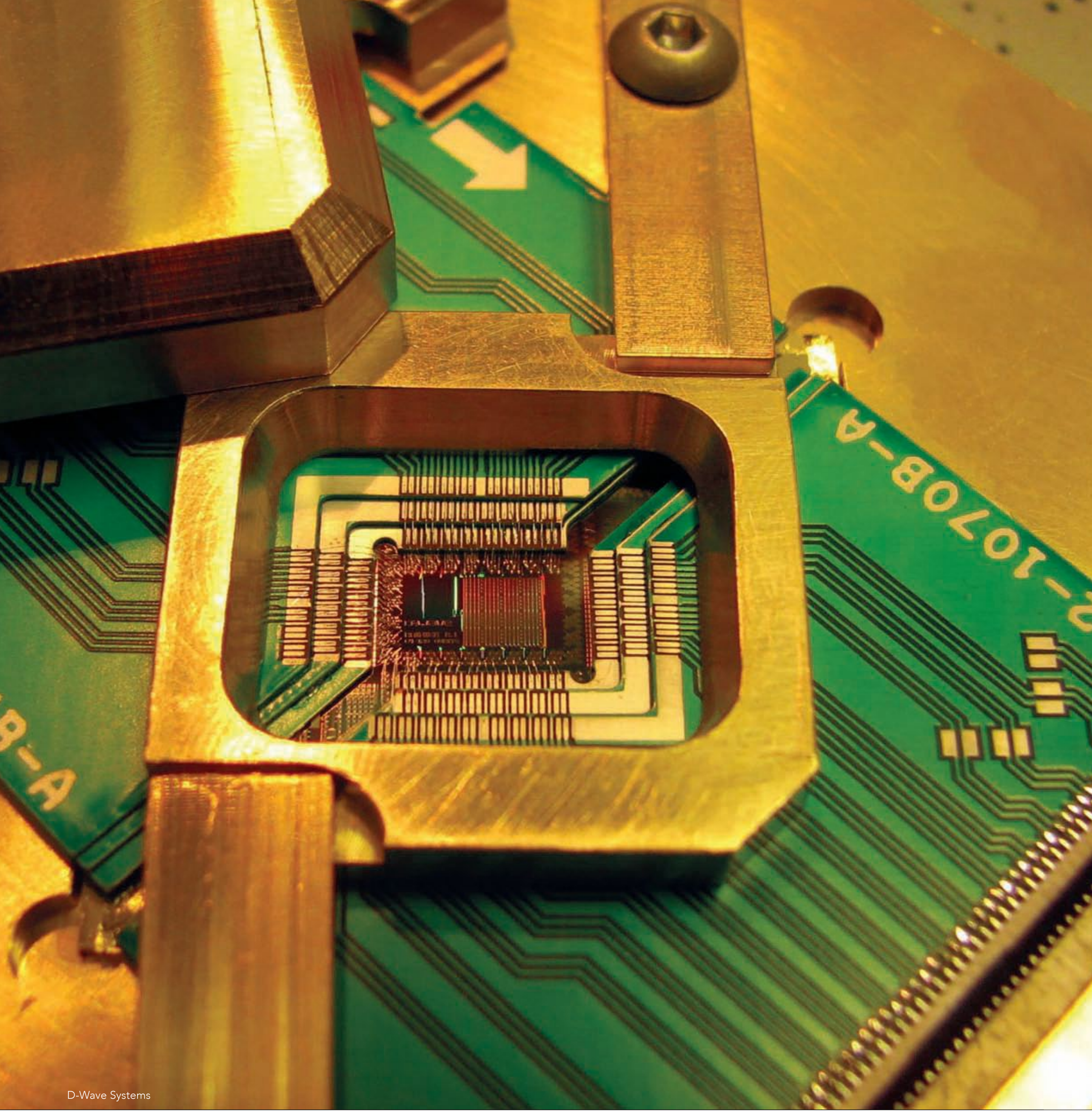
by Adam Hadhazy
adamhadhazy@gmail.com

The era of quantum computing — if there is to be one — has almost arrived. Scientists around the world have made tremendous progress in the almost 40 years since American physicist Richard Feynman and others conceived of harnessing the strange, quantum mechanical behaviors of atoms and subatomic particles for computational purposes. Should the pace of advancement continue, the fiendishly difficult, yet potentially revolutionary, method of number-crunching could emerge from the lab and do real world problem-solving within a decade or two.

Few industries seem more willing to bet on quantum computers than aviation. Case in point: In 2010, the very first commercial sale of a quantum computer, a $10 million early version made by D-Wave Systems of Burnaby, Canada, went to Lockheed Martin, which has been experimenting with the technology. That machine and its more recent incarnations resemble giant server racks, but inside, niobium atoms are chilled to near absolute zero to make their electrons act in odd ways. These quantum states do not last long enough, as yet, to unleash anywhere near quantum computing's full potential.

That said, lots of research is underway from D-Wave's laboratory in Canada to the research arms of IBM, Microsoft and Hewlett-Packard to universities and government labs. The sense of potential has spread beyond Lockheed Martin, with Boeing now confirming it is highly interested in the technology. In December, its arch rival, Airbus, announced the opening of a quantum computing unit at its Wales facility.

Why all the interest among the avia-



D-Wave Systems

A quantum processor known as a Rainier chip appeared in D-Wave Systems' first quantum computer, the D-Wave One. The 128 quantum-bit chip is being wirebonded.

tion community? If scientists can figure out how to control the quantum states and crunch data effectively, lots of thorny problems could be tackled more quickly than with today's binary calculations. In conventional computers, data is represented as ones and zeros inside circuitry, but quantum bits, or qubits, would have many more options for representing data. Complex calculations that would take hundreds of years to perform if attempted today would take just days. Computational fluid dynamics simulations could be enriched with unprecedented details; errors could be quickly pinpointed in aircraft software code; recovery from airline flight disruptions could be accelerated; weather forecasting could be revolutionized.

"In the big picture, I suspect quantum computers will affect us in ways we don't even know yet," says Jeffrey Hunt, a principal scientist and technical fellow at Boeing.

Quantum leap

This would not be the first information revolution for the aviation industry. Over the span of six decades, computers have transformed the commercial aviation enterprise. The first Sabre computers began automating airline reservations in the 1960s, and aerospace engineers began simulating the airflow in engines via computer, which led to today's computational fluid dynamics modeling. The FAA followed in the 1970s by introducing computer-assisted air traffic control.

Inside a classical computer, voltage levels are set at high or low in integrated circuits to represent ones or zeros. Billions of calculations are made per second one step at a time, which sounds impressive until one considers what happens inside a quantum computer like D-Wave. Individual quanta exist in a range of energy states, called superposition. The upshot: qubits can mind-bogglingly be both on and off at the same time. Qubits can also become "entangled," meaning that an action executed on one qubit happens to its entangled partners as well. Quantum computers can work through all possibilities simultaneously, rather than sequentially.

An employee interfaces with a D-Wave quantum computer using a conventional computer at a workstation.

"It's all very weird," admits computer scientist Murray Thom, the director of professional services at D-Wave, whose clients in addition to Lockheed Martin include Los Alamos National Laboratory and NASA's QuAIL, the Quantum Artificial Intelligence Lab, a collaboration with Google and the Universities Space Research Association.

In the machines Thom's company sells, a liquid helium refrigeration system takes the quantum processor down to 15 millikelvin — that's a whisker above absolute zero and, about 21 degrees Celsius (70 Fahrenheit) cooler than the region of interplanetary space where the James Webb Space telescope will operate after its launch in 2018. The D-Wave computer's metal loops are also shielded from external perturbations, such as electromagnetic fields, that can introduce energy and throw off delicate quantum states. In these extremely cold and isolated conditions, the electrons of the niobium atoms start to exhibit usefully exploitable quantum mechanical behavior. The electrons enter a state of superposition, with their current flowing clockwise and counterclockwise at the same time.

Researchers funded by the Department of Energy and the Intelligence Advanced Research Projects Activity, among others are exploring many kinds of quantum architectures that can likewise produce two opposing quantum states. Photons, particles of light, might do the trick, as well as ions, or even the pure, crystal structures of diamonds doped with other atoms.

As gnarly as these innards of quantum computers sound, interfacing with a device such as D-Wave is surprisingly straightforward. A programmer sits at a traditional computer terminal connected via a standard network to the quantum computer, which could be housed onsite or offsite in the cloud. A basic user interface program, like those employed at a national lab to link to a supercomputer, lets users send over input in classical computer language. A server in the quantum computer translates this input into code appropriate for running on its components. As with a conventional computer, the quantum system is initialized to a starting point for a calculation and then an algorithm is run. To stick with the example of D-Wave machines, these tasks are accomplished by applying electromagnetic fields to the qubits. Components built into the quantum processor then translate the qubits into 1s or 0s as they collapse out of their many-state superpositions.

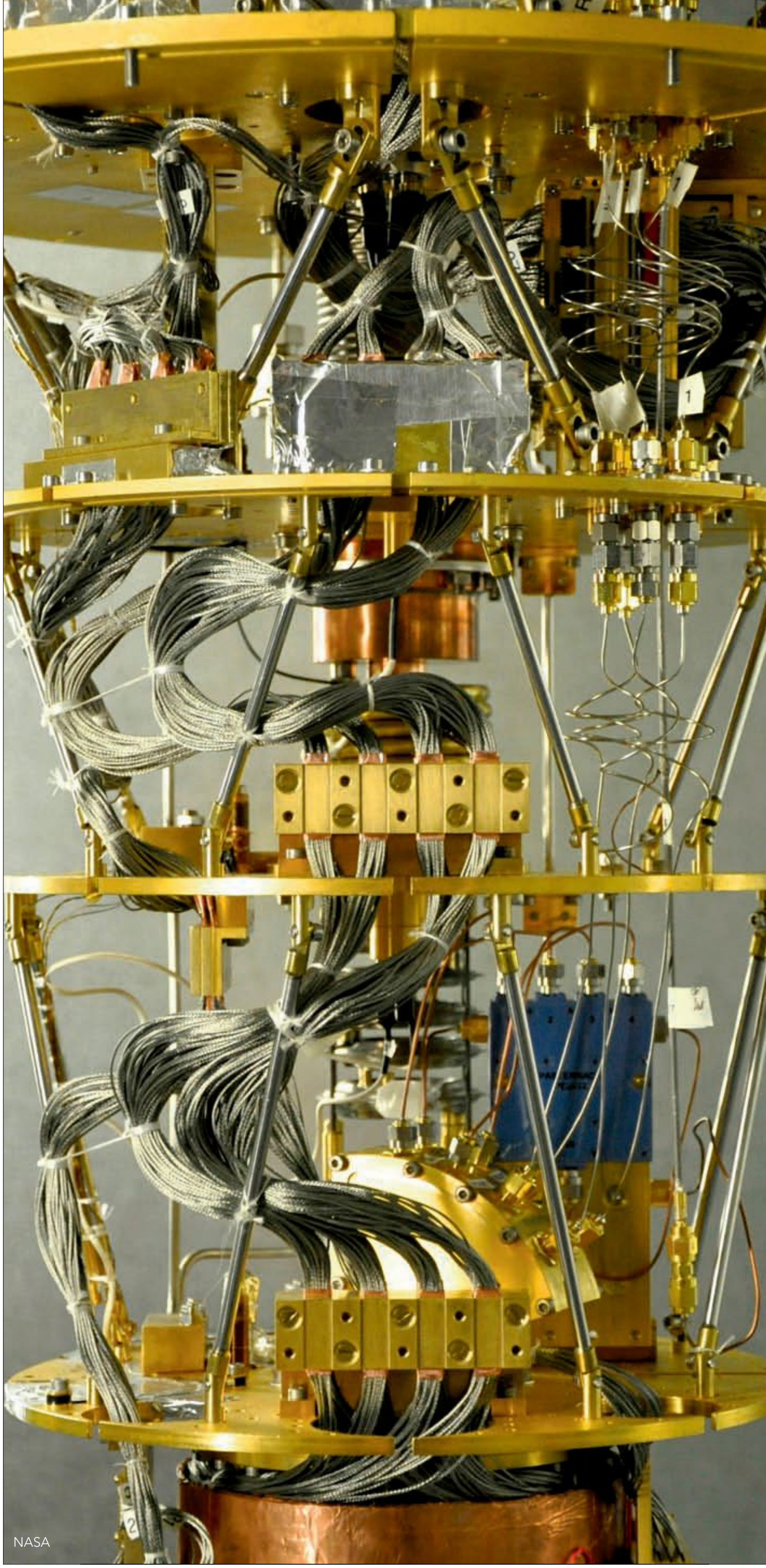
The tougher part of programming is instead the conceptual conversion of a problem from conventional computing's do-this-then-that algorithms into the do-this-altogether style of quantum processing. Interpreting the answers one gets from quantum machines can be tricky, too, because they deliver probabilistic rather than deterministic answers arrived at in classical computing. If telling a classical computer to show the quickest way to the airport from your home, we get a clearcut solution. A quantum computer would provide a richer range of answers by considering all of the variables and possibilities in conjunction with each other. Some of the answers might work out to be better and more efficient than the deduction made by a classical computer. On the other hand, some answers will be spectacularly unlikely and might even be perceived as wrong. Building up statistical robustness might require multiple runs, eating into gains over classical computers, or some form of oversight.

"The quantum computation approach is a fundamentally different way of thinking about problems," says Michael Brett, CEO of QxBranch, a quantum computing software and services startup based in Washington, D.C. "It can involve quite a leap in creativity and problem-solving."

New take on old problems

Given how they operate, an obvious application for quantum computers in the aviation industry would be optimization — meaning defining the best way to get from point A to point B, literally and figuratively.

D-Wave offers a helpful analogy for how its machines handle optimization compared to classical computers. Picture a landscape of mountains and valleys and imagine the goal is to travel along the lowest points in the valleys to save time and money. The analogy comes from navigation, but it figuratively represents any complex problem. Like a weary traveler, a classical computer must ascend and descend



NASA

This is the support structure for D-Wave Systems' second-generation quantum processor, codenamed Vesuvius. It is the heart of the D-Wave Two machine, one of which is housed at NASA's Quantum Artificial Intelligence Laboratory. The structure cools the chip, located at its bottom, to just 20 millikelvin degrees, near absolute zero, a temperature realm where quantum mechanical behavior emerges in the quantum processor's niobium atoms.

Lockheed Martin test drove its D-Wave quantum computer before buying it. The quantum computer took just six weeks to find an error in an old flight control code for an F-16, compared to several months for a conventional computer.

every rise and drop before it can find the coordinates of the lowest, optimal points. A quantum computer, in contrast, is akin to a tunnel boring machine that can burrow right through mountainsides and valley walls, seeking ever lower terrain.

Efficiently solving these sorts of optimization problems could in turn lead to the design of more efficient aircraft. Tweaking the airframe's shape in new ways revealed by quantum computing could reduce drag, upping fuel efficiency and addressing the biggest cost to an airline's bottom line.

"Optimization of design parameters such as fuselage and wing shapes, engine location and layout — all of these would be heavily impacted by a powerful quantum computer," says Rupak Biswas, director of exploration technology at NASA's QuAIL, who also offers the reminder that in the acronym NASA, "the first 'A' is for 'aeronautics.'"

Advanced quantum computers could go even further. Unlike classical computers, quantum computers might accurately simulate the quirky quantum nature of reality on small scales — one of the rationales that got scientists excited about developing them in the first place. Airbus has accordingly suggested that quantum computers could model the interaction of each and every atom of air with the exterior atoms of an aircraft, opening up unprecedented design specificities.

From a materials science perspective, accurately modeling substances' complex behavior on atomic levels could usher in lighter, stronger substances for constructing airframes.

"Every big jump in aviation has happened because of advancement in materials," says Boeing's Hunt.

The Wright brothers' wood and fabric gave way to all-metal planes of lightweight aluminum, then to modern planes, like the 787 Dreamliner, made with even lighter and stronger composites such as carbon fiber infused with epoxy resin. There are even wilder possibilities. Airbus' quantum computing group offers the example of creating transparent metals for breathtaking views from passenger cabins.

A decidedly less sexy, but integral problem in aircraft production that quantum computers have already been tasked with is dubbed "V and V," for verification and validation. At Lockheed Martin, this particular application convinced the firm to buy a D-Wave machine, housed at the University of Southern California-Lockheed Martin Quantum Computation Center. About half the cost of designing the elaborate software control systems in fighter jets goes toward making sure the lengthy codes do not contain bugs. "We purchased the D-Wave machine to address the issue of software complexity by using the D-Wave to rapidly evaluate all possible conditions in the code," says Ray Johnson, who was chief technology officer at Lockheed Martin at the time and is now executive director at QxBranch.

Lockheed has not publicly indicated the extent to which it uses quantum computing in its current V and V or other operations, but the evidence suggests the company sees lots of merit in quantum computing. The firm upgraded the D-Wave One system it bought in 2010, once in 2013 and again last year with the latest, most powerful components from its maker.

Before Lockheed bought its first D-Wave, it was permitted to run a test. Employees fed 30-year-old flight control code from the F-16 program into the D-Wave machine to see if it could find an error that had taken engineers several months to find. D-Wave spotted the bug in six weeks. Even so, the D-Wavers are careful not to over promise:

"It's important to stress this wasn't an example of our hardware beating a classical computer," says D-Wave's Thom. "This was a proof-of-principle test."

Applying quantum computing

Not just airplane manufacturers stand to benefit from eventually going quantum, but airlines as well.

According to the International Air Transport Association, around 100,000 commercial flights take off every day around the world. In U.S. airspace alone, several thousand planes ply the skies at any moment. Airlines must diligently manage the arrivals and departures at their hub-and-spoke airports, tweaking schedules to fill flights with paying passengers. On top of that, airlines must allocate pilots, attendants, maintenance crews and their equipment in sufficient levels. "It's the traveling salesman problem on steroids," says QxBranch's Johnson, referring to a famous mathematical optimization problem.

By harnessing quantum computers, airlines could strive to maximize efficiencies in their flight scheduling and turnaround times at gates by better apportioning aircrews and ground crews. Airlines and air traffic controllers could also better deal with disruptions caused by common weather nuisances, such as fog, thunderstorms and snowstorms, as well as rare accidents or acts of terrorism. "We will get to situational awareness about the state of the airplanes, where they are, what can be done if there are perturbations and how to handle those perturbations," says Johnson.

Besides dealing with the crush of airline scheduling and its frequent hiccups, quantum computers might boost weather prediction accuracy, allowing for more proactive rather than reactive changes on the fly. Numerous other realms relevant to aviation could see progress, too, including machine learning, wherein computers teach themselves, as it were, through trial-and-error and experience. Quantum computing should let machines consider probabilistic, rather than deterministic outcomes, better accounting for uncertainty, hidden variables, and randomness — much like how we humans cope with the messiness and unpredictability of life.

If all of these rewards from quantum computing sound too good to be true, well, for now they are. Broadly useful quantum computers are years away, most researchers agree. And despite D-Wave's status as the first company out the gate, critics say its machines serve mainly as objects of research and that its system architecture cannot be scaled up to outpace classical computers.

"There's now been some useful science that's come out of the D-Wave machine," says Scott Aaronson, an associate professor of electrical engineering and computer science at MIT. "However, in terms of practical results, there's been nothing, zero, from D-Wave machines that couldn't have been much more easily obtained using a classical computer."

Maybe so, but quantum scientists are marching on, given the immense interest they perceive.

"If and when we get scalable quantum computers, it's possible that they'll give some speedups over classical computers," Aaronson says. "We probably won't know for sure until we have real quantum computers to run tests with."

"We're early in the process," says NASA's Biswas. "So the risk is high, but the rewards can be even greater."

Affording the

Lockheed Martin projects that the Blueprint for Affordability, a set of production improvements for the F-35, will bring cost reductions of nearly $2 billion to the program as it progresses. With the blueprint funds nearly all spent, Michael Peck spoke to analysts and Pentagon officials about whether the blueprint can meet its goals.

The F-35 supersonic stealth fighter comes in three variants, including the F-35B version built for the U.S. Marine Corps, which is capable of short takeoff and vertical landing.

by Michael Peck
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Two years ago, Lockheed Martin and the Pentagon made a deal over the F-35 strike fighter. Lockheed Martin and its partners, BAE Systems and Northrop Grumman, would invest their own money into the F-35 manufacturing line.

If the price of each new F-35 dropped enough, then the production team would receive a financial reward from the Pentagon. How much lower the price would have to be, and how great the reward, have not been disclosed by the U.S. government or the manufacturers. But if the cost reductions prove to be great, the government might then have evidence and confidence to warrant spending tax dollars to introduce even more efficiency into F-35 production. Should that happen, according to Lockheed Martin, American taxpayers would pay less for a cutting-edge aircraft, and Lockheed Martin would generate more sales and ultimately more profit for shareholders.

The Blueprint for Affordability is an attempt to resolve a chicken-or-egg conundrum endemic to all manufacturing: Making a product that can be priced affordably requires expenditures in the manufacturing process, but few are will-

F-35


Lockheed Martin

ing to invest unless they are confident that they will sell enough product to recoup their money. If the blueprint works, it could potentially serve as a template for other troubled programs.

"The concept is absolutely sound in principle and practice," says analyst Andrew Hunter, director of the Defense Industrial Initiatives Group at the Center for Strategic and International Studies in Washington, D.C. He cautions that the devil will be in the details of how much money was invested and how much was saved. Other analysts say that while such arrangements are not uncommon in defense acquisitions, it's a little late to save a lot of money for the F-35, which entered limited production in 2006.

What no one disputes is that F-35 costs have soared. In March, the Government Accountability Office estimated that the F-35 program, including research and development as well as purchases, will cost $379 billion for 2,457 aircraft, or $154 million per plane. That's almost double the estimated program cost when Lockheed Martin won the F-35 contract in 2001.

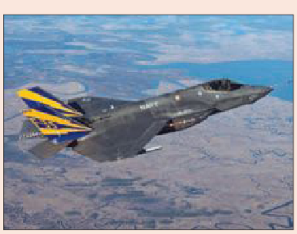
The program wasn't supposed to unfold this way. When the Joint Strike Fighter

One fighter, three variants

The F-35 comes in aircraft carrier, conventional and short-takeoff, vertical-landing versions. All are single-engine, single-seat aircraft that fly at Mach 1.6 (1,960 kph). They achieve stealth by deflecting radar energy with the aircraft's shape, by absorbing it and by internally hiding parts. The aircraft are in production, and the U.S. Air Force and the Navy are edging toward fielding their first squadrons, a milestone called initial operational capability. The Marine version was declared combat ready in 2015. The variants differ in key ways:

F-35A: *Takes off and lands conventionally. Initial operating capability for the U.S. Air Force is expected as early as August. Will be the Air Force's primary strike fighter, designed to attack ground targets. Only version with an internal cannon: a four-barrel, 25-millimeter Gatling gun. The F-35A has the highest maneuverability among the three versions, with a maximum G-force rating of 9, compared to 7 Gs for the F-35B and 7.5 Gs for the F-35C. Most prevalent F-35 variant, with 1,763 current orders for the U.S. Air Force and another 559 to 10 countries.*

F-35B: *Capable of short takeoff and vertical landing, or STOVL. Built for the U.S. Marines and the U.K.'s Royal Navy and the Royal Air Force, which want a fighter to operate from short-field runways, ships with helicopter decks, aircraft carriers and even highways. It can also fly conventionally on longer runways. World's first radar-evading supersonic fighter with STOVL. Two counter-rotating fans blow unheated air down for vertical flight, as opposed to the Harrier's direct-lift propulsion system that channels hot engine gases for lift. Has 353 orders from the U.S. Marines and 168 from the U.K. and Italy.*



F-35C: *First stealth fighter built for aircraft carriers. Heaviest and most expensive variant. The F-35C's airframe contains a lot of high-strength titanium to withstand the stress of arrested landings and catapult takeoffs. Wings fold for tight parking on carrier decks. The U.S. Navy has ordered 340 F-35Cs and the Marines have ordered another 67.*

Source: Aerospace America reporting

was conceived 20 years ago, costs were supposed to be kept in check by building variants for multiple military services from a common blueprint. This way, expenditures would be spread across the largest possible number of aircraft.

Funding the blueprint

In 2014, Lockheed Martin, Northrop Grumman and BAE Systems contributed a combined $170 million to a manufacturing investment pool. All are deeply involved in F-35 production, either directly or through subcontractors. Lockheed Martin does the assembly as well as providing the forward fuselage, wings and flight control system; Northrop Grumman adds the center fuselage and radar; U.K.'s BAE makes the fuselage and tail empennage and its U.S. subsidiary makes the flight control computer, electronic warfare and life support systems.

About half the money was to be spent on improving manufacturing processes by Lockheed Martin and its subcontractors. The F-35's main assembly line is at the Lockheed Martin plant in Fort Worth, Texas, with secondary lines in Italy and Japan. The funds were spent on a variety of improvements, such as better tools to forge more precisely-sized aluminum bulkheads. The retooling cost Lockheed Martin $652,000, but the company estimates this will save $65,000 per jet, or $204 million over the life of the F-35 program. The remaining Blueprint for Affordability funds were spent by Northrop Grumman and BAE on their own manufacturing processes and subcontractors. This corporate funding will expire in 2016.

Before spending the money, Lockheed Martin negotiated targets with the Department of Defense's F-35 Joint Program Office: If the expenditures lowered the price of each aircraft more than would be expected for any maturing production program, then the contractors would receive a reward. The parties are currently negotiating whether the Blueprint for Affordability goals were met, though it seems unlikely the plan will be judged a failure, according to the F-35 Joint Program Office.

Lockheed Martin projects that by 2019 the corporate spending will shave $10 million from the $108-million price tag (in 2012 dollars) of an F-35A model, the version to be flown by the Air Force, and that efficiencies outside of the blueprint will bring the unit cost to under $85 million. Lockheed Martin says the Pentagon will have spent $1.9 billion less by 2019 than it would have without the Blueprint for Affordability as well as other efficiencies. Lockheed Martin says it is not authorized by the F-35 Joint Program Office to disclose the cumulative savings from the initial $170 million investment across all variants and the entire procurement. This means that although F-35 production could easily run through the 2020s, there is no public estimate of how much the Blueprint for Affordability will reduce costs in total.

Complicating matters is that the F-35 is still in low-rate initial production, or LRIP, a common Pentagon contracting method in which equipment initially bought in small quantities — called lots in the case of the F-35. The idea is to work out the bugs before committing to full production, which is scheduled to commence for the F-35 in 2019. The aircraft coming off the production line are from LRIP lot 8, and Congress has approved funding for long-lead components that require extra time to prepare lots 9 and 10. Lockheed Martin says it is discussing a lot-11 order with the F-35 Joint Program Office, while Air Force Lt. Gen. Christopher Bogdan, who heads the F-35 Program Office, spoke of lots 12 through 14 during testimony before the House Armed Services Committee in March.

Lockheed Martin says the initial $170 million Blueprint for Affordability investment will save $260,000 on each of those lot-8 aircraft, $1.1 million per lot 9 and $1.7 million for lot 10.

Under Lockheed's plan, the government would next step in with an investment of $300 million, with $100 million allocated per year for three years. Savings would kick in at $1.7 million per plane for lot 11, lot 12 and lot 13. Again, cumulative program savings were not specified. The government is still considering the option.

Dreaming big

The blueprint is based on a fundamental assumption: That enough aircraft will be ordered to recoup investment in lowering

Lockheed Martin

Lockheed Martin builds the F-35 at its assembly plant in Fort Worth, Texas. In 2014, the company and its partners invested $170 million to reduce manufacturing costs, with hopes of recouping even more money through higher sales.

$pending **to save**

The Blueprint for Affordability consists of hundreds of small expenditures that are meant to add up to big savings. Maintenance costs will be reduced for the canopy assembly, radar, landing gear, and doors and panels. Improved manufacturing procedures will lead to savings in field and depot maintenance throughout the life of the F-35 program, says Don Kinard a Lockheed Martin engineer and senior fellow. Here are other examples:

- *Tools to forge more precisely sized aluminum bulkheads. This reduces the amount of aluminum in each plane by 2,132 kilograms, as well as time needed to machine the metal into a bulkhead. Lockheed spent $652,000 for the tools, but estimates this will save $65,000 per jet, or $204 million over the life of the F-35 program.*

- *Lasers to remove excess paint and prepare component surfaces for bonding, beginning with lot 9. The lasers cost the company $800,000, but will save an estimated $15,000 in manufacturing costs per aircraft, or $46 million over the life of the program.*

- *Coatings that are molded in place for the inlet bumps on the air intakes, rather than using robots to spray them on. Lockheed spent $742,000 for the new process, which began with lot 8, for a savings of $6,000 per plane, or $27 million for the entire program.*

the cost of production. The poster child for how not to buy warplanes might be the F-22 Raptor. The Air Force originally wanted 750 of the air superiority fighters, which originally cost around $178 million each. By the time the last 60 jets were delivered, some $860 million in cost-reduction measures had brought the price down to $137 million each. The only problem was that production was terminated in 2012 after only 187 Raptors had been delivered, which meant that there wasn't time to reap the benefits of the cost-cutting.

What defense contractors like Lockheed Martin dream of are multiyear procurements, in which the Pentagon commits to buying items for several years in a single contract, rather than multiple annual contracts. Bogdan told Congress in March that the Pentagon might issue a block buy, or multiyear contract, beginning in lot 12 or 13. Estimates for savings under multiyear procurement range from 5 to 10 percent, according to a Congressional Research Service report, though the report also notes that verifying these savings is difficult.

Multiyear procurement made a difference — or rather should have made more of a difference — to the F-22. The price of the Raptor dropped sharply for the last 60 aircraft, which were built under a multiyear agreement, though the program was terminated afterward before reaping any more savings.

Don Kinard, a Lockheed Martin engineer and senior fellow who has worked extensively on the F-35 and other aircraft programs, says the blueprint's estimated cost reductions are not dependent on multiyear procurement contracts. They are based on the U.S. and foreign customers ordering the roughly 3,000 F-35s in the current plan. Even so, Pentagon officials told Congress in April that a multiyear procurement contract for the F-35 could save $3 billion, though analysts point out that lawmakers aren't keen about approving multiyear buys that give them less control over military acquisition.

Hunter, of the Center for Strategic and International Studies, says multiyear contracts can encourage a company to invest in lowering costs, especially if there is a prospect for additional multiyear purchases.

Lockheed Martin

The Pentagon stopped buying Lockheed Martin's F-22 Raptor long before $860 million in cost-reduction measures paid full dividends. The company hopes to avoid repeating that with its F-35 stealth fighter program.

"A company with a multi-year contract where there is a prospect of more multi-year contracts afterward will likely be more forward leaning and aggressive in cost savings than a company that says, 'I need to get all my profit out of this contract.'"

"By and large, these [arrangements] have been successful," Hunter adds. "The only risk is if you start a multiyear procurement and don't finish it, then you're on the hook for the money."

But what about the idea of the government giving taxpayer's money to industry, even if it might result in taxpayers saving money in the long run? Hunter describes the blueprint as similar to other capital expenditure investments in defense manufacturing that the government has historically made. The Navy invested in shipyard capacity, he notes.

Kinard also says the basic approach is not unique: "Every program I've worked on has had affordability investment programs," he says.

One government official sees a big distinction. "We are flipping the standard model on its head," says Amanda Gentry, science and technology lead for the F-35 Joint Program Office. "Right now the risk is on industry to generate enough savings and meet overall cost targets before they will have their investment recouped."

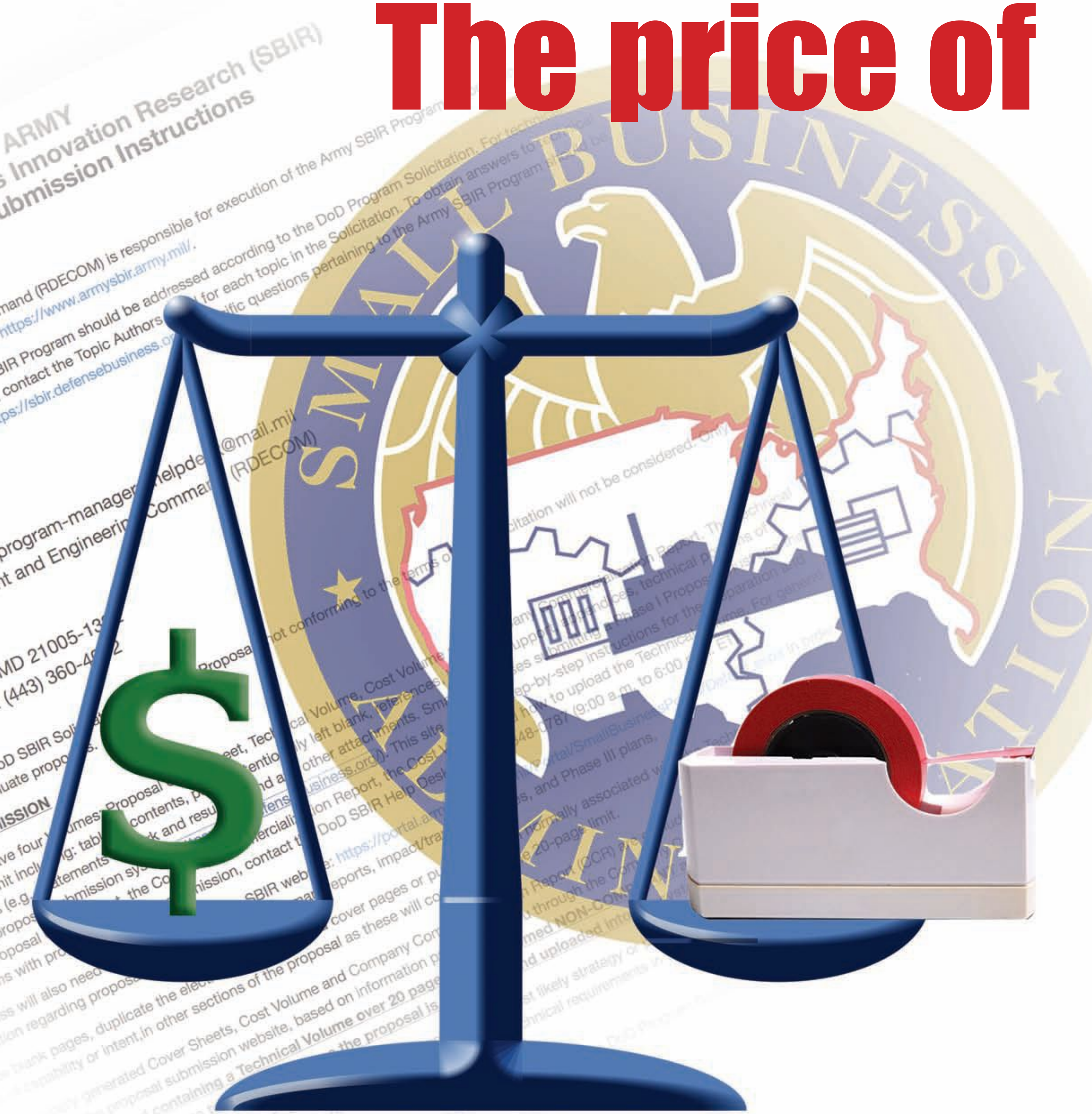
Given the almost visceral criticism of the F-35, and repeated shortfalls and missed deadlines with the aircraft's performance, opinions differ over whether there is enough time and enough F-35s in the plan to justify the government investing in production improvements beyond the industry's $170 million pool. That decision ultimately rests with Congress and the White House. Hunter is among those who think there will be enough time and enough planes. He says that "any reasonable analysis beyond liquidation of the United States government" suggests that at least 1,000 F-35s will be built. "I would say you're looking at a minimum of 10 years of additional production of this aircraft."

Others aren't so sure. Richard Aboulafia, aviation analyst for the Teal Group, wonders whether the blueprint is too little, too late. Programs like the Blueprint for Affordability work best with multiyear procurment, he explains, but "you still don't have a multiyear procurement, and you're at a fairly late stage in the game to be making cost reduction investment."

Aboulafia finds it strange that 10 years after the F-35 entered low-rate production, the program is still stuck there. "You're seeing a lot of aircraft purchased under LRIP, more than any other aircraft in history. I've never seen anything like this."

Given the history of the F-35, the notion that it might serve as a model for military procurement programs could raise a few eyebrows. That said, Gentry of the F-35 Joint Program Office says staff have received inquiries about the Blueprint for Affordability from aircraft and non-aircraft military acquisition programs. For the concept to work, the military office running the program must have budgetary control, she explains. "One example that comes up frequently, where a [Blueprint for Affordability] model does not seem to work, is trying to incentivize contractors to perform fuel saving activities. Program offices do not control fuel budgets, therefore they have no way to pay back the contractor investment," she cautions. "In our case [the F-35], we are paying the recoupment out of the savings in the production line, which will continue to pay dividends in future years," Gentry says. A

The price of



by Kari L. Barnes
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VIEWPOINT

free money

Federal grants can be the lifeblood for small aerospace companies. But complex paperwork can trip unwary applicants and jeopardize their full rights to their innovations. Intellectual-property attorney Kari L. Barnes highlights the pitfalls, and how to avoid them.

Government money permeates the aerospace industry. The proposed 2017 federal budget would allocate $152.3 billion for research and development by government agencies and outside contractors. The budget would set aside $827 million for R&D on space technology, $324 million for advanced exploration systems and $100 million for low-carbon-emission aircraft, among other projects.

Federal law mandates that 3.2 percent of any external R&D investment must go to small businesses with fewer than 500 employees. So if the Pentagon were to give Boeing $97 million to develop a fighter jet, another $3 million must be reserved for small contractors on the jet program or directed to firms through separate channels, such as the federal Small Business Innovation Research program.

SBIR grants are a major source of federal funds for small innovators, including those in the aerospace sector. Each year, the government sets aside about $2 billion for SBIR, and several thousand firms receive awards that currently average $150,000 for promising technologies and $1 million for more developed concepts.

This free money, however, can be a loaded gift for the unwary.

In exchange for taxpayer-funded grants to help recipients bring their ideas to market, the government always gets to retain a royalty-free right to use anything invented or delivered under the SBIR program. The government can also extend that right to other parties. Furthermore, subcontractors retained by the small business using SBIR money will get ownership of any part of the subcontractor's work generated under the contract.

Unless they're vigilant, small businesses risk jeopardizing the full benefit of their research, and undermining possession of their intellectual property. As a patent attorney, I work frequently with clients who learn too late that their inventions and innovations resulting from SBIR grants belong partly to subcontractors or that their trade secrets can be subject to disclosure under the Freedom of Information Act.

The good news is that businesses can protect themselves by using the federal bureaucracy to their advantage.

The key is meticulous paperwork. Paperwork to document which data, code, prototype or report remains under the company's ownership. Paperwork to designate what information is confidential. Paperwork to keep track of separate budgets to avoid comingling non-SBIR activities.

Imagine the most complicated tax return you've ever endured: the calculations, rules, exceptions and exceptions to exceptions. That's a cakewalk compared to navigating the byzantine world that is SBIR funding. But the potential payoff can be worth a lot of money, or even make a difference in your company's survival.

Let's say a fictional company we'll call Zirfram invents a long-range optical communication system in response to an SBIR solicitation for a device to relay information from upper-atmosphere stations to ground stations. With the grant, Zirfram gets to retain ownership of its invention and the right to sell it to other parties. NASA or the Pentagon or other government agencies would pay to use Zirfram's communication system in any or all government upper-atmosphere stations. The government can also permit other companies, including Zirfram's competitors, to make Zirfram's communication system for the government's use on government stations without paying any royalties.

Ownership rights also extend to any subcontractors Zirfram hires to work on the SBIR project. So if Zirfram contracts out development of an actuated mount for tracking the ground station from the upper-atmosphere station, the subcontractor will own the actuated mount outright. If Zirfram were to commercialize its communication system, it would have to negotiate separate ownership or use rights with the subcontractor.

In essence, an SBIR grant buys the government "billable time" for all work products performed for that specific project. So it's imperative that Zirfram strategically and proactively accounts for every step of its work that does or does not fall under the SBIR grant.

Zirfram could choose to spend its own money to employ a subcontractor. Or it would use SBIR funds for that, but then purchase the rights to the actuated mount with the company's money, even for a nominal sum. Another option is for Zirfram to agree at the outset that the subcontractor will give Zirfram exclusive royalty-free license [but not ownership] for the actuated mount.

Another valuable tactic is for Zirfram to protect its rights to any technical data, software and other intellectual property generated under the SBIR grant. There are different levels of data rights, but they all restrict the government's use of the data and, more importantly, restrict disclosing the data to others. Used properly, data rights could help Zirfram land additional government contracts while shutting out potential competitors.

An SBIR award can be a game changer for small businesses, enabling them to prove their concepts or build prototypes when funding from banks or venture capitalists is unavailable. But I have too often seen small businesses lose out because they didn't know — or know how — to assert control over their intellectual assets from the start.

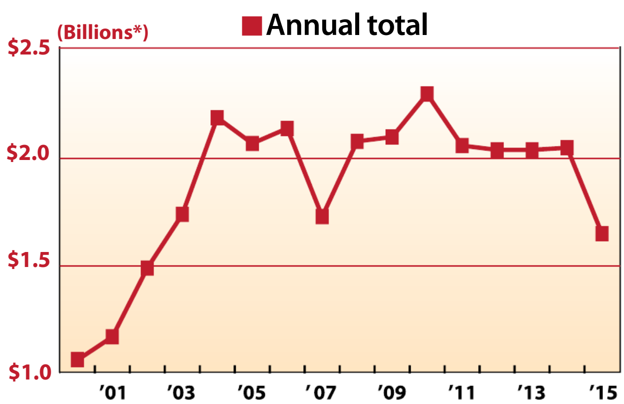
The path to protecting those rights is treacherous. Be aware. Be aggressive. Be successful.

✈✈✈

Kari Barnes is an attorney with BuchalterNemer's intellectual property practice group in Irvine, California. She advises aerospace firms seeking to patent their technology created in part with federal grants.

Money for small innovators

The U.S. has consistently allocated about $2 billion a year to encourage small businesses with fewer than 500 employees to pursue technological innovations. Small Business Innovation Research grants are awarded to several thousand firms annually and range from $150,000 for early-phase projects to $1 million for more developed concepts.



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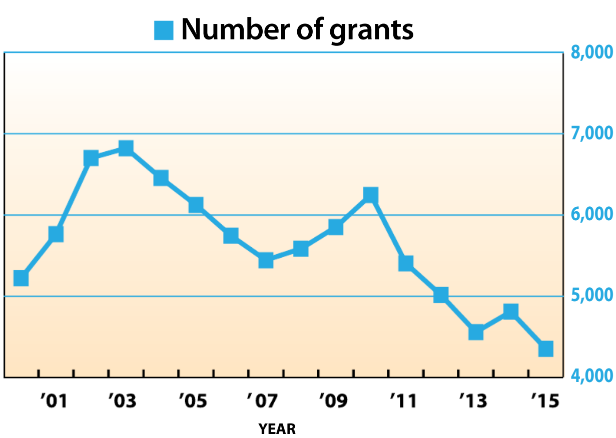

Source: U.S. Small Business Administration

NEW SPACE MECCA

Can NASA's Kennedy Space Center recapture the magic of the Apollo and space shuttle eras? Mark Williamson traveled to Florida to explore that question. He found a facility in the midst of a renaissance driven largely by commercial-space enterprises.

by Mark Williamson
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Five years ago, when NASA retired the space shuttle fleet and shipped the orbiters to museums across the nation, it seemed that the Kennedy Space Center had lost its raison d'etre. By the time Atlantis returned from the 135th and final shuttle mission in July 2011, KSC's government and contractor workforce had already shrunk to 8,000, from a high of 16,000 in the mid-1990s.

Today, it remains unclear whether the KSC workforce can ever return to that peak, but on a visit earlier this year I saw evidence of its transition to what KSC's leadership predicts will be a vibrant spaceport driven by the emerging commercial space market.

Orbital ATK is negotiating to lease parts of the former space shuttle facilities at NASA's Kennedy Space Center in Florida. The company plans to use the Vehicle Assembly Building's High Bay 2, possibly for new rockets the company might build.

Mark Williamson

NASA is busy reconfiguring the former shuttle Launch Complex 39B to an Apollo-era clean-pad design to make it usable to a wide mix of government and commercial launch vehicles. The pad has a flame trench, sound-suppression system and lightning towers, but minimal fixed-service structures such as a gantry or umbilical tower. NASA has removed shuttle-specific equipment such as the rotating service structure that gave access to the payload bay. In April, NASA announced the start of negotiations with Orbital ATK for use of the shuttle's Vehicle Assembly Building's High Bay 2, possibly for assembly of a new series of American-built rockets the company says it might build for intermediate and heavy payloads. This would mark the first time that government and commercial launchers would be assembled side-by-side in the iconic building — NASA's Space Launch System rockets in High Bay 3 and Orbital ATK's in High Bay 2.

Meanwhile, SpaceX is converting the other shuttle launch complex, 39A, for the company's Falcon Heavy rockets, whose first launch is currently expected later this year. And OneWeb, the Arlington, Virginia-based satellite-internet startup, is set to open a satellite-manufacturing plant by the end of 2017 at Exploration Park, 120 hectares (300 acres) of former wetland and scrubland adjacent to the KSC Industrial Area.

Genesis

KSC's effort to reinvigorate the center follows an earlier, unsuccessful attempt to prepare for a post-shuttle economy, as evidenced by a rusting "Spaceport Florida" sign just south of Titusville, across the lagoon from KCS's entrance gate.

According to Scott Colloredo, director of KSC's Planning and Development Directorate, the end of the shuttle program and the rise of a commercial space industry created "a unique opportunity for Kennedy to reinvent itself" as a public-private international spaceport. In fact, the rebranding efforts began even before the shuttle's final landing, with the 2010 creation of Colloredo's office to chart KSC's future.

Colloredo is optimistic. He says new ideas and new suppliers have forced new approaches to managing KSC's unique assets.

"To think that private companies would be operating at launch pads 39A and 39B, the Neil Armstrong Operations and Checkout facility, Vehicle Assembly Building, all three of the Orbiter Processing Facilities and other critical NASA assets would have been unheard of until recently," Colloredo says.

A pivotal tool in KSC's metamorphosis was the 2015 deal for Space Florida, a state aerospace economic development agency, to take over management of certain legacy shuttle facilities. Under the 30-year property agreement, Space Florida owns and operates the Shuttle Landing Facility and leases it back to NASA and commercial customers. Space Florida also spent $20 million to upgrade and modify the former Orbiter Processing Facility-3, and renamed it the Commercial Crew and Cargo Processing Facility, where Boeing is now testing its CST-100 Starliner crew capsule.

Space Florida negotiated the agreement announced in April under which OneWeb's satellite factory will be located at Exploration Park, says Dale Ketcham, chief of strategic alliances at the state agency. OneWeb Satellites, a joint venture between OneWeb and Airbus Defence and Space, will design

SpaceX is converting Launch Pad 39A, used for three decades by the space shuttle program, for the company's Falcon Heavy rocket.

Mark Williamson

the satellites and build the first 10 flight models in France. OneWeb Satellites then will manufacture 890 more satellites in Florida.

Likewise, Space Florida will be the landlord for an eight-story complex for Jeff Bezos's Blue Origin company, which broke ground on the facility in late May. Ketcham says Blue Origin's rockets will be the first to be built at the same location from which they will launch.

Transition

Frank DiBello, Space Florida's president and CEO, says NASA had difficulty rising to the challenges of a changing marketplace.

NASA is "neither chartered nor equipped to well manage commercial enterprises and operations," he says.

Space Florida, by contrast, was chartered expressly for that purpose. Much like an airport or seaport authority, Space Florida can finance major capital projects by private customers on public land. To date, Florida has invested some $1.6 billion of taxpayer money to make the state more competitive in attracting aerospace businesses.

Since the peak of the 30-year shuttle program's heyday, KSC's workforce has shrunk by about 50 percent. Current employment stands at about 7,800: 2,000 civil servants and 5,800 contract workers. That compares to 2,000 civil employees and 14,000 contractors two decades ago.

The decline reflects not only the reduction in the "standing army" required for shuttle operations and the reduced workload at the Cape, but also the lean-business ethos of commercial space operators. That change, DiBello says, will only continue "as the commercial sector becomes the more dominant economic engine within the U.S. space program nationally."

In 2015, the 10 launches of government payloads — ranging from space station supply capsules to spy satellites — outnumbered the six launches of commercially owned payloads, such as communications satellites. But data on launch management, as opposed to payload ownership, suggest a different story. According to Ketcham, KSC made the transition to commercial operation immediately after the shuttle's retirement. Since then, all launches, including those of United Launch Alliance's Atlases and SpaceX's Falcons, have been managed by commercial launch providers, not NASA. The agency's calendar for the next 10 years includes only two launches of its Space Launch System, whereas Ketcham estimates the commercial sector will oversee more than 100 launches.

Although KSC remains a government-funded NASA center, a key objective has been to repurpose selected facilities to create "a 21st century space launch complex with modernized infrastructure for more cost-effective operations, serving multiple users," as Kennedy Director Bob Cabana puts it.

His colleague Colloredo acknowledges that other NASA field centers also are transitioning to a "partnering approach" with other public agencies or with commercial firms. But "this dramatic change … is unique to KSC."

The center is valuable as a launch site because of its position in the southernmost state in the continental U.S. Earth's spin provides a greater boost to rockets headed for near-equatorial orbits, so they can launch with heavier payloads.

NASA

Atlantis lifts off from Launch Pad 39A at Kennedy Space Center in 2011, the final space shuttle flight.

Growing pains

KSC's reinvigoration will affect not just NASA but Florida's entire Space Coast region, which stretches from Titusville to Palm Bay to the south. The end of the shuttle program, which followed on the heels of the Great Recession of 2008, "was a double blow to this community," DiBello says. He says perseverance and hard work has enabled the region to bounce back.

Colloredo acknowledges that the journey has not been without "some growing pains." When the Orbiter Processing Facility-3 was left vacant after the shuttles, NASA needed time to decide whether to keep it or to demolish it. Ultimately, Colloredo says, the demand from commercial space became obvious, paving the way for Space Florida's agreement with Boeing to manufacture the CST-100 at the location.

Even if KSC never fully matches the glory years of Apollo and the shuttle program, it's easy to spot pockets of transformation throughout the sprawling launch base. Where once the NASA "meatball" was the only insignia in sight, visitors now can spot SpaceX's logo and a giant Boeing mural, testaments to KSC's metamorphosis.

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Out of the

25 Years Ago, July-August 1991

July 1 After a distinguished 40-year run, the Avro Shackleton patrol aircraft is retired by the U.K. Royal Air Force. Based on the historic Avro Lancaster heavy bomber of World War II fame, the Shackleton is to be replaced by Boeing E-3 Sentries. David Baker, Flight and Flying: A Chronology, p. 87.

50 Years Ago, July-August 1966

July 1 Astronaut Edward White, the first American to make a spacewalk, is presented the General Thomas D. White Space Trophy from U.S. Air Force Secretary Harold Brown, at the National Geographic Society in Washington, D.C. The award was established in 1961 and is given to an Air Force officer, or a unit, that makes the foremost contribution to the progress of U.S. aerospace. New York Times, July 12.

July 5 The Apollo-Saturn AS-203 mission of the Saturn 1B vehicle is launched from the Kennedy Space Center, Florida, to gather flight data on the vehicle's second stage and Instrument Unit that are to be adapted to the Saturn 5 configuration. This is the second flight of the two-stage Saturn 1B and carries the unmanned second stage, Instrument Unit and nose cone into a 188-kilometer circular orbit. The second stage first ignites in the atmosphere during the ascent, then shuts down and is restarted after coasting. This reignition of the second stage is a demonstration of what would be required for the more advanced Saturn 5. New York Times, July 6, p. 1; Flight International, July 14, p. 86.

July 12 The Northrop M2-F2 Lifting Body, designed to acquire aerodynamic and controllability data toward the development of future manned spacecraft re-entering the Earth's atmosphere, makes its first flight when it's launched from a B-52 bomber from an altitude of 13,716 meters, then is maneuvered into a landing at 322 kph. This first MS-F2 is flown by NASA test pilot Milton Thompson. Another phase of the program, which later contributes to the Space Shuttle program, explores how such a craft can survive re-entry into the Earth's atmosphere. New York Times, July 18, p. 17.

July 15 NASA opens up permanent public admission to its Cape Kennedy Space Center in Florida. Previously, only private visits were allowed. Some two million visitors are projected for 1967, and three million annually by 1970. For a fee, visitors are driven around the launching area on buses. Later, the Kennedy Space Center Visitor Complex is established with exhibits of U.S. space program artifacts. Flight International, July 21, p. 117.

July 15 Boeing celebrates its Golden Jubilee, 50 years after William Boeing incorporated the Pacific Aero Products Co., which nine months later changed its name to the Boeing Airplane Co. ("Airplane" was later dropped). Boeing's first major developments were seaplanes, but the company went on to produce bombers, fighters, commercial planes, missiles, rockets and spacecraft. Flight International, July 28, p. 123.

July 18-21 The U.S.'s Gemini 10 mission, flown by command pilot John Young and pilot Michael Collins, carries out low-orbit docking of the spacecraft with the Gemini Agena Target Vehicle booster launched 100 minutes earlier. A second rendezvous and docking is also achieved. Collins also conducts two spacewalks with the aid of a tether. During the second walk, he becomes the first person to meet another spacecraft in orbit during a spacewalk and retrieves a cosmic dust-collecting panel from the side of the Agena. Recovery is made just 5 kilometers off target in the Atlantic Ocean and 8 kilometers from the recovery ship, U.S.S. Guadalcanal. Aviation Week, July 25, pp. 26-30.

Aug. 10 The Lunar Orbiter 1 unmanned space probe is launched by an Atlas-Agena D vehicle from Kennedy Space Center, the first U.S. attempt to orbit the moon and photograph potential landing sites for Project Apollo astronauts. The 387-kilogram probe enters into a lunar orbit on August 21 with a 40 kilometer perigee and 1,817 kilometer apogee. A total of 413 photos are taken and transmitted back to Earth before Lunar Orbiter 1 crashes on the lunar surface. Washington Post, August 14, pp. A1, A6.

Past

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

Aug. 11 The X-15 hypersonic rocket research aircraft, flown by NASA test pilot John McKay, reaches a speed of 5,650 kph (Mach 5.15) and an altitude of 76,505 meters, where he carries out a micrometeorite collection study as well as an ultraviolet stellar photography experiment.

Although the X-15 primarily conducts extremely high-speed aerodynamic research flights, this is among the more unusual flights that include astronomical experiments. Dennis R. Jenkins, X-15: Extending the Frontiers of Flight, p. 650; New York Times, August 14, p. 8.

Aug. 17 The new, more powerful Aerobee 350 liquid-propellant sounding rocket, with 27,216-kilogram thrust, completes its second developmental flight and reaches a 357-kilometer altitude before landing in the Atlantic Ocean, following its launch from NASA's Wallops Island, Virginia, launch station. The Aerobee 350 is the largest and most sophisticated of a family of historical sounding rockets that consists of a dozen models and has been in operation since 1948. NASA, Astronautics and Aeronautics, 1966, p. 269.

Aug. 24 The Soviet Union launches its 3,000-kilogram Luna 11 space station toward the moon and carries scientific instruments to study gamma and X-ray emissions from the lunar surface toward the beginning of an analysis of the geochemical constituents of the lunar crust. Luna 11 also studies the Moon's magnetic environment. However, the spacecraft's cameras fail to work. On October 1, 1966, the spacecraft goes silent when its battery power runs out. David Baker, Spaceflight and Rocketry, p. 199.

75 Years Ago, July-August 1941

July 8 The Boeing B-17C Flying Fortress, known to the British as the Fortress 1, makes its combat debut. Furnished to the Royal Air Force on lend-lease, the planes conduct a daylight attack on Wilhelmshaven, Germany. P.M. Bowers, Boeing Aircraft Since 1916, p. 305.

July 18 One of Italy's best known pilots, Lt. Col. Arturo Ferrarin, is killed while testing a new aircraft. Ferrarin made the first Rome-Tokyo flight in 1920 and participated in the Schneider Trophy Races in 1927. He also established endurance and long distance records with Carlo Del Prete in 1928 in a Savoia-Marchetti 64 flying-boat, covering 7,665 kilometers in 58 hours 27 minutes and made other record flights. Interavia, July 23, p. 22.

July 19 Capt. Claire Chennault, retired U.S. Army Air Corps pilot, flies to Chungking, China, to become chief instructor of the Chinese air force controlled by Marshal Chiang Kai-shek. Subsequently, Chennault, who is called back into active service in 1942, leads the American volunteer group known as the "Flying Tigers" into combat against the Japanese. Interavia, July 23, p. 20.

Aug. 1 Grumman Aircraft's XTBF-1 Avenger prototype makes its first flight. This plane subsequently becomes the U.S. Navy's standard torpedo-bomber during World War II. Rene J. Francillon, Grumman Aircraft Since 1929, pp. 161-163.

Aug. 1 Three static tests are made with James Wyld's regeneratively cooled liquid-fuel rocket motor on the American Rocket Society's Test Stand No. 2 at Midvale, New Jersey. The average thrust of 556 newtons is considered a major U.S. breakthrough in the cooling of long-duration rockets. Eugene Emme, ed., Aeronautics and Astronautics 1915-60, p. 42; Frank Winter, Prelude to the Space Age, p. 85.

Aug. 15 At the inauguration of the new Curtiss-Wright factory in Buffalo, New York, the 2,000th Curtiss P-40 single-seat fighter rolls off the assembly line at the old plant. At the same time, the prototype of the Curtiss P-40D is demonstrated in public for the first time. Interavia, September 8, p. 13.

100 Years Ago, July-August 1916

July 30 Two months after joining N.124, the squadron soon to be known as the Escadrille de Lafayette, American Raoul Lufbery achieves the first of his eventual 16 victories during World War I. David Baker, Flight and Flying: A Chronology, p. 87.

Aug. 16 The British submarine B-10 is the first sunk by aircraft when Austrian Naval Service planes raid the port of Venice and make a direct hit on the vessel while at her moorings. Alfred Price, Aircraft versus Submarine, p. 18.

UNITED STATES AIR FORCE ACADEMY

Assistant Professor of Engineering Mechanics (#16-33DFEM)

The Department of Engineering Mechanics anticipates filling an Assistant Professor position not later than June 26, 2017. Responsibilities include teaching undergraduate core and majors' mechanical engineering courses to officer candidates, and performing research in mechanical engineering. The selected candidate will participate in academic advising, mentoring, accreditation reviews, and fulfilling departmental duties. The initial appointment will be three years; reappointments of up to four years each are possible.

By the time of application, an earned doctoral degree with demonstrated expertise is required in Engineering Mechanics, Mechanical, Aeronautical, or Astronautical Engineering focused in mechanics of materials, aerospace structures, finite element analysis, fatigue and fracture, composite materials, structural dynamics, experimental mechanics, or materials science. Essential qualities include integrity, industry, cooperation, initiative, enthusiasm, and breadth of intellectual interests. Successful candidates will have a strong commitment to undergraduate teaching.

The United States Air Force Academy is located just north of Colorado Springs, Colorado. It is an undergraduate institution that awards the Bachelor of Science degree. Its mission is to educate, train, and inspire men and women to become officers of character, motivated to lead in the United States Air Force and in service to our nation. The student body consists of approximately 4,000 men and women representing every state and several foreign countries. The curriculum includes core academic and professional courses and 26 disciplinary and interdisciplinary majors

To Apply: Applications must be received by **October 14, 2016**. Go to www.usajobs.gov. Search for #16-33DFEM in the "Keyword" box, or type in "USAF Academy" in the "Location" box. Click "Search," then scroll down until you locate this position.

U.S. citizenship is required and the selected candidate must complete a security investigation.

The U.S. Air Force Academy is an Equal Opportunity Employer.

TEXAS TECH UNIVERSITY
Department *of* Mechanical Engineering

Texas Tech University (TTU) Department of Mechanical Engineering invites applications for a tenure-track faculty position in the thermal and fluid sciences. The successful candidate will develop an independent research program and collaborate with TTU faculty. Preference will be placed on research focused on energy-generation technologies and may incorporate energetic materials towards this end. Research interests include general combustion theory, modeling and experimental work, as well as materials synthesis. Candidates who have a strong record of scholarship supported by extramural funding and have the potential to bring externally sponsored research to TTU are encouraged to apply. Teaching at both graduate and undergraduate levels is also essential. Service duties include program-building, commitment to extra-curricular activities, as well as service to the department, college, and university.

As an Equal Employment Opportunity/Affirmative Action employer, Texas Tech University is dedicated building a culturally diverse faculty committed to working in a multicultural environment. The university welcomes applications from minorities, women, veterans, persons with disabilities, and dual-career couples. Additional information can be found at http://www.depts.ttu.edu/me.

Qualifications: Applicants must hold a doctoral degree in mechanical engineering or a closely related field. The appointment will be at the associate professor level. Other rankings will be considered depending on candidate qualifications. The preferable starting date for the position is August 2016. Applicants should submit a resume, a statement of research and teaching interests, and a list of at least three references. Review of applications will continue until the positions are filled. Electronic submission of application materials via http://www.workattexastech.com is required, enter via FACULTY portal and search for requisition ID# 6889BR. If you should need assistance with the application process, please contact our HR, Talent Acquisition office at hrs.recruiting@ttu.edu or 806-742-3851.

For additional information regarding the Texas Tech University or the Department of Mechanical Engineering and this position, please contact ronda.ingle@ttu.edu.

AIAA Bulletin

On 17 June, NASA Administrator Charles Bolden spoke at AIAA AVIATION 2016 on "Concept to Reality—Our Journey to Transforming Aviation," where he announced NASA's plans for a new electric airplane called X-57 and nicknamed "Maxwell" (see the speech on Livestream: **http://bit.ly/28JnKSN**). The artist's concept shows the plane's specially designed wing and 14 electric motors. NASA Aeronautics researchers will use the Maxwell to demonstrate that electric propulsion can make planes quieter, more efficient, and more environmentally friendly. (*Credits: NASA Langley/Advanced Concepts Lab, AMA, Inc.*)

JULY–AUGUST 2016

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
2016			
5–8 Jul†	ICNPAA 2016 Mathematical Problems in Engineering, Aerospace and Sciences	University of La Rochelle, France (Contact: Prof. Seenith Sivasundaram, 386.761.9829, seenithi@gmail.com, www.icnpaa.com)	
23–24 Jul	3rd Propulsion Aerodynamics Workshop	Salt Lake City, UT	
23–24 Jul	Advanced High-Speed Air-Breathing Propulsion Technology	Salt Lake City, UT	
23–24 Jul	Electric Propulsion for Space Systems	Salt Lake City, UT	
23–24 Jul	Fundamentals of Liquid Chemical Propellants and Applications for Less-Toxic Alternatives	Salt Lake City, UT	
23–24 Jul	Hybrid Rocket Propulsion	Salt Lake City, UT	
24 Jul	Detonation-Based Combustors Tutorial	Salt Lake City, UT	
25–27 Jul	AIAA Propulsion and Energy 2016 (AIAA Propulsion and Energy Forum and Exposition) Featuring: 52nd AIAA/SAE/ASEE Joint Propulsion Conference; 14th International Energy Conversion Engineering Conference	Salt Lake City, UT	12 Jan 16
5–7 Sept†	Advanced Satellite Multimedia Systems Conference	Palma de Mallorca, Spain (Contact: www.asmsconference.org)	
7–8 Sep	2016 National Aerospace & Defense Workforce Summit	Washington, DC	
7–8 Sept†	20th Workshop of the Aeroacoustics Specialists Committee of the Council of European Aerospace Societies (CEAS): Measurement Techniques and Analysis Methods for Aircraft Noise	University of Southampton, United Kingdom (Contact: www.southampton.ac.uk/engineering/research/groups/acoustics-group/ceas-asc-workshop-2016)	
11 Sep	Space Standards and Architecture Workshop	Long Beach, CA	
11–12 Sep	Introduction to Space Systems	Long Beach, CA	
11–12 Sep	Systems Engineering Fundamentals	Long Beach, CA	
13–16 Sep	AIAA SPACE 2016 (AIAA Space and Astronautics Forum and Exposition) Featuring: AIAA SPACE Conference; AIAA/AAS Astrodynamics Specialist Conference; AIAA Complex Aerospace Systems Exchange	Long Beach, CA	25 Feb 16
25–30 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: www.iac2016.org)	
27–29 Sept†	SAE/AIAA/RAeS/AHS International Powered Lift Conference	Hartford, CT	26 Feb 16
12–13 Oct†	12th Annual International Symposium for Personal and Commercial Spaceflight (ISPCS 2016)	Las Cruces, NM (Contact: http://www.ispcs.com/)	3 May 16
17–20 Oct†	22nd KA and Broadband Communications Conference and the 34th AIAA International Communications Satellite Systems Conference	Cleveland, OH (Contact: Chuck Cynamon, 301.820.0002, chuck.cynamon@gmail.com)	
7–10 Nov†	International Telemetering Conference	Glendale, AZ (Contact: www.telemetry.org)	
2017			
7–8 Jan	2nd Sonic Boom Prediction Workshop		
9–13 Jan	AIAA SciTech 2017 (AIAA Science and Technology Forum and Exposition) Featuring: 25th AIAA/AHS Adaptive Structures Conference; 55th AIAA Aerospace Sciences Meeting; AIAA Atmospheric Flight Mechanics Conference	Grapevine, TX	6 Jun 16

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
	AIAA Information Systems — Infotech@Aerospace Conference AIAA Guidance, Navigation, and Control Conference AIAA Modeling and Simulation Technologies Conference 19th AIAA Non-Deterministic Approaches Conference 58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference 10th Symposium on Space Resource Utilization 4th AIAA Spacecraft Structures Conference 35th Wind Energy Symposium		
5–9 Feb†	**27th AAS/AIAA Space Flight Mechanics Meeting**	San Antonio, TX (Contact: www.space-flight.org/docs/2017_winter/2017_winter.html)	**7 Oct 16**
4–11 Mar†	**IEEE Aerospace Conference**	Big Sky, MT (Contact: www.aeroconf.org)	
6–9 Mar†	**21st AIAA International Space Planes and Hypersonic Systems and Technology Conference (Hypersonics 2017)**	Xiamen, China	**4 Oct 16**
18–20 Apr†	**17th Integrated Communications and Surveillance (ICNS) Conference**	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, http://i-cns.org)	
25–27 Apr	**AIAA DEFENSE 2017 Forum** **(AIAA Defense and Security Forum)** **Featuring:** AIAA Missile Sciences Conference AIAA National Forum on Weapon System Effectivenss AIAA Strategic and Tactical Missile Systems Conference	Laurel, MD	**1 Nov 16**
25–27 Apr†	**EuroGNC 2017, 4th CEAS Specialist Conference on Guidance, Navigation, and Control**	Warsaw, Poland (Contact: robert.glebocki@mel.pw.edu.pl; http://www.ceas-gnc.eu/)	
3 May	**Aerospace Spotlight Awards Gala**	Washington, DC	
29–31 May†	**24th Saint Petersburg International Conference on Integrated Navigation Systems**	Saint Petersburg, Russia (Contact: Ms. M. V. Grishina, icins@eprib.ru, www.elektropribor.spb.ru)	
3–4 Jun	**3rd AIAA CFD High Lift Prediction Workshop**		
3–4 Jun	**1st AIAA Geometry and Mesh Generation Workshop**		
5–9 Jun	**AIAA AVIATION 2017 Forum** **(AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** 24th AIAA Aerodynamic Decelerator Systems Technology Conference 33rd AIAA Aerodynamic Measurement Technology and Ground Testing Conference 35th AIAA Applied Aerodynamics Conference AIAA Atmospheric Flight Mechanics Conference 9th AIAA Atmospheric and Space Environments Conference 17th AIAA Aviation Technology, Integration, and Operations Conference AIAA Flight Testing Conference 47th AIAA Fluid Dynamics Conference 18th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference AIAA Modeling and Simulation Technologies Conference 48th Plasmadynamics and Lasers Conference AIAA Balloon Systems Conference 23rd AIAA Lighter-Than-Air Systems Technology Conference 23rd AIAA/CEAS Aeroacoustics Conference 8th AIAA Theoretical Fluid Mechanics Conference AIAA Complex Aerospace Systems Exchange 23rd AIAA Computational Fluid Dynamics Conference 47th Thermophysics Conference	Denver, CO	
10–12 Jul	**AIAA Propulsion and Energy 2017 Forum** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** 53rd AIAA/SAE/ASEE Joint Propulsion Conference 15th International Energy Conversion Engineering Conference	Atlanta, GA	

continued on page **B4**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
12–14 Sep	**AIAA SPACE 2017 Forum (AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA SPACE Conference**	Orlando, FL	
25–29 Sep†	**68th International Astronautical Congress**	Adelaide, Australia	

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.

From the Corner Office

LET'S GET TO WORK!

James G. Maser, AIAA President

As I begin my term as AIAA President, I would like to thank Jim Albaugh for his two years of service to AIAA in this role. I have enjoyed working with him over the past year and look forward to doing so in his continuing role as Past President. Also, I would like to thank you for putting your trust in me to help lead AIAA for the next two years.

Both former presidents Mike Griffin and Jim Albaugh felt that evolving the governance structure of AIAA was vital to ensure the long-term health of our Institute. Toward that end they launched AIAA on a course to make those needed changes a reality. Mike began the process under his presidency by communicating the need for change in his writings and by forming a Blue Ribbon Panel to study the Institute's governance structure. Jim continued those efforts, ultimately working with the Board to propose much-needed changes to the governance structure. In March, voting began to approve or reject those changes. Your votes show that by an overwhelming margin you agree with the importance of modernizing the AIAA system of governance.

Your approval of the governance changes means that we will now have the flexibility to adapt to rapidly changing conditions in the aerospace community, to expand into new areas of activity and interest, and to be more responsive to your needs as members. I am indebted to Mike and Jim, the Board of Directors, the Blue Ribbon Panel, and the Governance Working Group for their excellent leadership and work on this issue – none of it could have happened without them. This will be an exciting time for the Institute as we find our footing with the new changes, and I'm confident that we will make the most of this opportunity.

Much important work is still ahead – the implementation plan that rolls out these changes over the next two to three years must be deliberate and incremental, ensuring minimal disruption to the Institute's activities. We must craft new policies and procedures for the implementation of the Bylaws, and incorporate them into AIAA's culture as we move forward. Voting was the easy part! We will be looking for help in discussing, drafting, and documenting the new policies and procedures that accompany the changes you approved. This process began in June when the Board of Directors met to approve the changes, discuss the Bylaws, and lay out plans for their implementation over the next few years.

In addition to approving the Bylaw proposals and transition timeline, the Board will also be working on an updated strategic plan consistent with our vision for the next five years. Part of this activity will be to create a Relevancy Working Group. We understand that the aerospace community and environment around us has changed dramatically over the past decades and will continue to change into the future. We want to be certain we understand the implications of the current and potential changes and ensure AIAA adapts to maintain our relevance in advancing its mission to inspire and advance the future of aerospace for the benefit of humanity.

The Institute is only as strong as we—its members—are informed. To that end, we will regularly communicate the progress of our newly created Transition Working Group in implementing the Bylaw changes and what the changes mean to you and the Institute. Updates will be posted on our governance webpage and communicated in emails and "From the Corner Office" columns by Sandy Magnus or me. We will definitely keep you "in the loop," as we tackle these important changes. Your feedback, questions, and thoughts will be in important to us as we move forward; I hope you will take the time to communicate with us as we communicate with you.

I look forward to working with the Board, Jim, Sandy and the membership to improve and enhance the long-term relevance and health of AIAA as we go forward over the next few years, and as we implement the Bylaw changes, and meet our goals. I am confident that with all of us working together, we will ensure a bright future for AIAA.

Class of 2016 Fellows and Honorary Fellows.

2016 BOARD OF DIRECTORS ELECTION RESULTS

AIAA is pleased to announce the results of its 2016 Board of Directors (BoD) election. The newly elected board members began their terms in June.

Vice President-Elect, Member Services—Laura Richard, United Launch Alliance LLC

Vice President-Elect, Technical Activities—Jim Keenan, U.S. Army, Aviation and Mission Research, Development, and Engineering Center

Director–Technical, Information Systems Group—James M. Rankin, The University of Arkansas

Director–Technical, Propulsion and Energy Group—Jeff Hamstra, Lockheed Martin Aeronautics

Director–Region IV—Terry Burress, Lockheed Martin Corporation

Director–Region V—John Eiler, Stellar Solutions LTD

Director–Region VII—Luisella Giulicchi, European Space Agency

Director–At-Large—Woodrow Whitlow Jr., Cleveland State University

Director–At-Large, International—Konstantinos Kontis, University of Glasgow

The call for 2017 BOD nominations will open the first week of August. Election vacancies will be announced shortly. Please keep in mind the responsibilities of the board members when considering whether to run for a position:

AIAA BoD Duties Highlights

- Volunteer Board service (commitment to attend 3–4 meetings per year in person)
- Need employer time and travel commitment
- Support Institute mission and vision
- Provide strategic discussion and input when required
- Duty to protect assets and exercise fiduciary prudence
- Serve in BoD leadership or support capacity as required
- Be vigilant of the aerospace landscape and identify business opportunities for the Institute
- Support AIAA Executive Director and staff as appropriate

AIAA K–12 STEM ACTIVITIES

The K–12 STEM Outreach Committee would like to recognize outstanding STEM events in each section. Each month we will highlight an outstanding K–12 STEM activity; if your section would like to be featured, please contact Supriya Banerjee (1Supriya.Banerjee@gmail.com) and Angela Diggs (Angela.Spence@gmail.com).

I LOVE Science, Northwest Florida Section

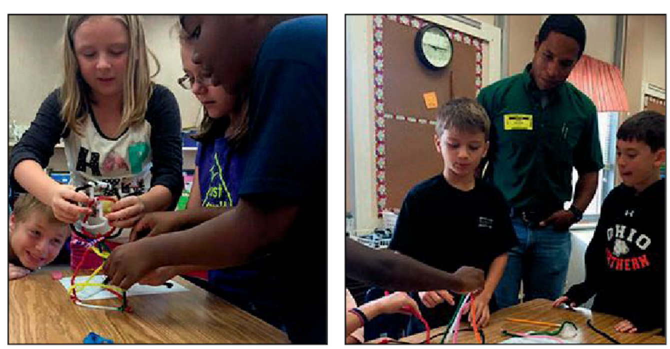
The AIAA Northwest Florida Section sponsors lessons and materials for I LOVE Science, a program in which local professional STEM volunteers teach hour-long lessons once a month during the school year. The I LOVE Science program at Edge Elementary in Niceville, FL, reaches about 100 students in five 4th grade classrooms and about 85 students in four 5th grade classrooms. The lessons are designed so that students will not repeat the STEM experiences over the two years.

At Edge Elementary, the program is coordinated by AIAA Senior Member Angela Diggs and Karen Sledge, with other local AIAA members and nonmembers volunteering in the classroom. The lessons tie directly into Florida state standards for mathematics and science and were developed in close coordination with local educators. All lessons feature the scientific method (ask a question, discuss background information, form a hypothesis, test hypothesis, collect and analyze data, and report conclusions), with emphasis on forming the hypothesis and collecting/analyzing that data. The lessons topics range from engineering design challenges to basic biology, chemistry, and physics, to understanding measurement systems, estimation, and forces. All lessons also include graphing and mathematics exercises.

AIAA Senior Member Kevin Diggs mentors students building marble mazes.

AIAA Senior Member Angela Diggs discussing building strategy for the marble mazes (left) and students compete to see who can complete the mazes fastest (right).

The I LOVE Science lesson materials are available on the Northwest Florida AIAA Sharepoint site (navigate to: Education Outreach, Engineers for America, I LOVE Science). Each lesson includes the volunteer background/orientation, the student data sheet, and any graphing materials suggested. The Northwest Florida section welcomes others to use the materials.



Students use pipe cleaners to build structures under evolving engineering constraints (loss of materials, switching team members, one hand behind back, no talking) during the Steeple Sequel lesson.

AUSTIN TO PRESENT LECTURE ON ENGINEERING LEADERSHIP

AIAA and the National Academy of Engineering (NAE) are pleased to announce that Dr. Wanda M. Austin, president and CEO of The Aerospace Corporation, is the recipient of the second Yvonne C. Brill Lectureship in Aerospace Engineering.

Austin will present her lecture, "Engineering Leadership: The Need for Technical Excellence and Diversity," on Thursday, 15 September 2016, 1830–1930 hrs, in conjunction with the AIAA Space and Astronautics Forum and Exposition (AIAA SPACE 2016) at the Long Beach Convention Center in Long Beach, CA. The lecture is open to the public.

AIAA, with the participation and support of the NAE, created the Yvonne C. Brill Lectureship in Aerospace Engineering to honor the memory of the late, pioneering rocket scientist, AIAA Honorary Fellow, and NAE Member, Yvonne C. Brill. Brill was best known for developing a revolutionary propulsion system that remains the industry standard for geostationary satellite stationkeeping. The lecture emphasizes research or engineering issues for space travel and exploration, aerospace education of students and the public, and other aerospace issues such as ensuring a diverse and robust engineering community.

For more information about the lectureship, go to **http://www.aiaa.org/brillLectureship/** or contact Carol Stewart at carols@aiaa.org or 703.264.7538.

DR. KARL BILIMORIA APPOINTED AS NEW EDITOR-IN-CHIEF OF THE *JOURNAL OF AIR TRANSPORTATION*

On 16 June 2016, AIAA President James G. Maser formally appointed **Dr. Karl Bilimoria** as editor-in-chief of AIAA's newest journal, the *Journal of Air Transportation* (*JAT*). The *Journal of Air Transportation* was previously published by the Air Traffic Control Association as *Air Traffic Control Quarterly*. Publishing operations for the journal transitioned to AIAA in late 2015, and publication under the new name and with an expanded scope commenced this year, with Karl Bilimoria serving as the interim editor-in-chief.

Bilimoria currently is the Technical Lead for advanced air traffic flow management systems at NASA Ames Research Center. He earned a Ph.D. in aerospace engineering from Virginia Polytechnic Institute and State University in 1986, and then he joined the aerospace engineering faculty at Arizona State University, working as an Assistant Professor and Research Scientist in the areas of flight dynamics and control. Since joining NASA Ames in 1994, Bilimoria has conducted research on various aspects of air traffic management for over 15 years. He has received numerous professional awards, including the NASA Exceptional Technology Achievement Medal for his research on airborne self-separation. He is a co-inventor of the Future ATM (Air Traffic Management) Concepts Evaluation Tool (known as FACET), which has received two U.S. patents and prestigious awards from AIAA, the Federal Aviation Administration, and NASA.

From a publications standpoint, Bilimoria has published over 90 technical articles on the dynamics and control of aerospace vehicles and he has served as an Associate Editor for the *Journal of Guidance, Control, and Dynamics*. He has also served on the AIAA Publications Committee, including the Publications Ethical Standards Subcommittee and as Chair of the Books Subcommittee. Bilimoria was a long-term supporter of *Air Traffic Control Quarterly* and a significant advocate for the journal's transition to AIAA last year. He is an AIAA Associate Fellow and a recipient of the AIAA's Sustained Service Award. He has also served on three AIAA technical committees, including the Committee of Air Transportation Systems.

Karl Bilimoria was recommended for the permanent editor-in-chief position by an ad hoc search committee chaired by John Daily from the University of Colorado, Boulder and Chair of the Journals Subcommittee of the AIAA Publications Committee.

AIAA ROCKY MOUNTAIN SECTION'S MOVIE NIGHT

AIAA Rocky Mountain Section's (RMS) movie night, organized by Lisa Holowinski, RMS Young Professionals chair, and featuring "The Martian," was held on 23 May at the Alamo Drafthouse in Littleton, CO. The section leveraged the theme of the evening, incorporating several special guests and events. There were over 150 attendees at the event.

The outgoing Section Chair Paul Anderson opened the evening by welcoming the attendees and introducing the pre-movie agenda. John Brackney, vice chair of Colorado Citizens for Space Exploration, gave a speech. Following this talk, Kay Sears, AIAA Rocky Mountain Section Chair-Elect, presented the Mayor of Littleton Bruce Beckman with a flag that flew aboard NASA's Orion spacecraft during its EFT-1 flight test in 2014.

Rounding out the agenda, and foreshadowing the movie, AIAA member Rob Chambers introduced moviegoers to Lockheed Martin's Mars Base Camp – a 12-year conceptual plan to introduce humans to the red planet. At the conclusion of the "Mars Base Camp" video, the featured movie "The Martian" was launched, making the evening educational as well as entertaining and involving the larger community in the excitement of human space exploration.

At the event, 12 people requested AIAA membership information, and 2 have already become members. Reception and feedback of the event was very positive from both moviegoers and the Alamo Drafthouse staff. Everyone is looking forward to the next movie night!

EFT-1 Flag presentation to Mayor Bruce Beckman of Littleton.

MEMBERSHIP ANNIVERSARIES

AIAA would like to acknowledge the following members on their continuing membership with the organization.

25-Year Anniversaries

Henry F Geer	Connecticut
Charles W Haldeman	Connecticut
Clifford B Smith	Connecticut
Derrick E Talbot	Connecticut
Sandra A Wells	Connecticut
Carol A Meyers	Greater Philadelphia
James D Ott	Greater Philadelphia
Scott W Wacker	Greater Philadelphia
Jarvis J Arthur, III	Hampton Roads
Brian M Howerton	Hampton Roads
Charles P Leonard	Hampton Roads
David P Lockard	Hampton Roads
Robert W Maddock	Hampton Roads
Jason R Neuhaus	Hampton Roads
Lee R Rich	Hampton Roads
David W Sleight	Hampton Roads
Steven D Young	Hampton Roads
Anthony Castrogiovanni	Long Island
Dean P Modroukas	Long Island
Kevin G Ailinger	Mid-Atlantic
Richard P Bousquet	Mid-Atlantic
Peter N Harrison	Mid-Atlantic
Fred V Hellrich	Mid-Atlantic
James C Leary	Mid-Atlantic
Mark O Mathews	Mid-Atlantic
Tharen Rice	Mid-Atlantic
Marsha R Schwinger	Mid-Atlantic
Dennis L Skelton	Mid-Atlantic
Michael S Smith	Mid-Atlantic
Robert A Summers	Mid-Atlantic
Karen R Thomas	Mid-Atlantic
Norman R White, Jr	Mid-Atlantic
Thomas A Becher	National Capital
David L Black	National Capital
Kenneth J Bocam	National Capital
Francesco Bordi	National Capital
Lawrence T Brekka	National Capital
Sandra A Cauffman	National Capital
James A Drakes	National Capital
Jan S Drobik	National Capital
Walter D Grossman	National Capital
Jose J Guzman	National Capital
Paul M Hederstrom	National Capital
Robert Jacobsen	National Capital
Quang M Lam	National Capital
John F McCarthy	National Capital
Jeff A Meech	National Capital
Chandru Mirchandani	National Capital
Carlos G Niederstrasser	National Capital
Mark E Pittelkau	National Capital
David L Richards	National Capital
Janet M Sater	National Capital
Mary L Snitch	National Capital
Peter Stuckey	National Capital
Sakura S Therrien	National Capital
Joseph Vaz	National Capital
Lakshmi Vempati	National Capital
Joseph W Whitacre, Jr	National Capital
Elisabeth A Youmans	National Capital
Kenneth H Yu	National Capital
Barry M Zilin	National Capital
David J Borowsky	New England
David L Darmofal	New England
Mark E Furber	New England
Robert Haimes	New England
Eric J Yarrow	New England
Paul E DesJardin	Niagara Frontier
Brian J Woycechowsky	Niagara Frontier
Daniel M Lauzon	Northeastern New York
Thomas M Sorensen	Northeastern New York
Frederick C Link	Southern New Jersey
Michael E Canipe	Atlanta
Vincent E Mokry	Atlanta
James C Neidhoefer	Atlanta
Scott M Martin	Cape Canaveral
Winston E Scott	Cape Canaveral
Adam Zaricki	Cape Canaveral
Michimasa Fujino	Carolina
Victor Giurgiutiu	Carolina
Charles E Hall, Jr	Carolina
Kevin W Kinzie	Carolina
Robert P Nance	Carolina
Harry B Anderson	Central Florida
Mark K Jacobs	Central Florida
Fritz M Jost	Central Florida
Eric Blades	Greater Huntsville
Jeffrey S Elder	Greater Huntsville
William J Emrich, Jr	Greater Huntsville
Carolyn S Griner	Greater Huntsville
Joseph P Hale, II	Greater Huntsville
Edward B Kiker	Greater Huntsville
Joseph Majdalani	Greater Huntsville
William S Meredith	Greater Huntsville
Harry J Nichols	Greater Huntsville
Semih M Olcmen	Greater Huntsville
Theron E Ruff	Greater Huntsville
John (Phil) P Sumrall	Greater Huntsville
David Weeks	Greater Huntsville
Bruce A Jolly, Sr	Northwest Florida
Larry J Andrews	Tennessee
Aaron Altman	Dayton/Cincinnati
Lynnette D Blaney	Dayton/Cincinnati
Richard D Cedar	Dayton/Cincinnati
Sean C Coghlan	Dayton/Cincinnati
Rick E Graves	Dayton/Cincinnati
Frank S Gulczinski, III	Dayton/Cincinnati
Robert D Hancock	Dayton/Cincinnati
Michael V Ol	Dayton/Cincinnati
Marc D Polanka	Dayton/Cincinnati
Mark F Reeder	Dayton/Cincinnati
Cynthia S Robertson	Dayton/Cincinnati
R Kevin Rowe	Dayton/Cincinnati
Ricky Leavell	Illinois
George H Miley	Illinois
William A Crossley	Indiana
Tom Jaquish	Indiana
Donald W Mueller, Jr	Indiana
Zane D Parzen	Indiana
Terry Kammash	Michigan
Brett A Bednarcyk	Northern Ohio
Jeffrey E Haas	Northern Ohio
Mark J Hyatt	Northern Ohio
Hani Kamhawi	Northern Ohio
Daniel E Paxson	Northern Ohio
Christopher J Pestak	Northern Ohio
George E Mavroudis	Wisconsin
Shin-Juh Chen	Albuquerque
Mohamed S El-Genk	Albuquerque
Paul Lin	Albuquerque
Gregory Mehle	Albuquerque
Larry E Bell	Houston
Frank A Burgett	Houston
HsienLu Huang	Houston
A S David Khemakhem	Houston
Vikram K Kinra	Houston
Tony Ng	Houston
Ellen Ochoa	Houston
Hanching Grant Wang	Houston
Darrell W Cribbs	North Texas
Adam T Drobot	North Texas
KokSum R Jui	North Texas
Peter Laing	North Texas
Loren G Seely	North Texas
Brian T Van Lear	North Texas
Nicholas J Wyman	North Texas
Paul Scott Zink	North Texas
Brian R Lisles	Oklahoma
Christina T Chomel	Southwest Texas
Dale E Klein	Southwest Texas
A C Rogers	Southwest Texas
John F Whiteley	Southwest Texas
Eliot H Winer	Iowa
Jason E Baugher	Rocky Mountain
Jeffrey R Boyd	Rocky Mountain
William M Brooks	Rocky Mountain
Robert J Butler	Rocky Mountain
Richard O Covey	Rocky Mountain
Scott J Dixon	Rocky Mountain
Jeffrey M Forbes	Rocky Mountain
Joshua B Hopkins	Rocky Mountain
Timothy P Jung	Rocky Mountain
David J Kalman	Rocky Mountain
Jason S Kuchera	Rocky Mountain
Anthony J Marchese	Rocky Mountain
Douglas V McKinnon	Rocky Mountain
Adrian F Nagle, IV	Rocky Mountain
David J Richie	Rocky Mountain
Bernard H Schwartze	Rocky Mountain
Ronald M Sega	Rocky Mountain
Richard Harrison Truly	Rocky Mountain
Peter M Van Wirt	Rocky Mountain
Glenn G Whiteside	Rocky Mountain
Derek A Hebda	St. Louis
Bryce L Meyer	St. Louis
Paul J Strykowski	Twin Cities
Ronald M Barrett-Gonzalez	Wichita
George C Datum	Wichita
Harold Schelin	Wichita
Michael D Thacker	Wichita
Dustin J Tireman	Wichita
Carol A Reukauf	Antelope Valley
Wayne M Ringelberg	Antelope Valley
Elsa J Hennings	China Lake
Steven L Apfel	Los Angeles-Las Vegas
Alan E Arslan	Los Angeles-Las Vegas
Michael J Gabor	Los Angeles-Las Vegas
Charles S Galbreath	Los Angeles-Las Vegas
Paul S Griffin	Los Angeles-Las Vegas
Roy A Haggard	Los Angeles-Las Vegas
Alan Keisner	Los Angeles-Las Vegas
Robert J Noble	Los Angeles-Las Vegas
Adrian B Som de Cerff	Los Angeles-Las Vegas
Bruce A Bartos	Orange County
Christopher M Kelley	Orange County
Eugene Lavretsky	Orange County
Charles Lowry	Orange County
Jeffrey L Norr	Orange County
John Z Tidwell	Orange County
George T Tzong	Orange County
Steven L Baughcum	Pacific Northwest
John J Broderick	Pacific Northwest
Lawrence E Fink	Pacific Northwest
Joseph L Henderson	Pacific Northwest
Justin H Lan	Pacific Northwest
Robin G Melvin	Pacific Northwest
Jason P Palmer	Pacific Northwest
Richard S Rich	Pacific Northwest
Stephen Ridlon	Pacific Northwest
Adam R Weston	Pacific Northwest
David P Young	Pacific Northwest
Michael K Fabian	Phoenix
Ronald A Madler	Phoenix
Robert H Smith	Phoenix
Walter A Grady, Jr	Sacramento
John Hallett	Sacramento
Donald G Messitt	Sacramento
Douglas A Meyer	Sacramento
Susana Munoz	Sacramento
Benjamin D Shaw	Sacramento
Dario H Baldelli	San Diego
Ralph W James	San Diego
Douglas S Abraham	San Fernando Pacific
Lawrence M Enomoto	San Fernando Pacific
Edward A Hirst	San Fernando Pacific
Henry M Minami	San Fernando Pacific
James T Nichols	San Fernando Pacific
Chris D Wright	San Fernando Pacific
William E Berry	San Francisco
Gregory C Carr	San Francisco
Mary M Connors	San Francisco
Chengjian He	San Francisco
Allen L Holzman	San Francisco
E Bickford Hooper	San Francisco
Brian J Howley	San Francisco
Ross Koningstein	San Francisco
Michael B McFarland	San Francisco
Nelson Pedreiro	San Francisco
Barry J Porter	San Francisco
Norbert M Ulbrich	San Francisco
Maverick T Wong	San Francisco
Tim Colonius	San Gabriel Valley
Mark A Cowdin	San Gabriel Valley
Lorraine M Fesq	San Gabriel Valley
Alfred R Paiz	San Gabriel Valley
Marco B Quadrelli	San Gabriel Valley
John A Rohr	San Gabriel Valley
Leslie A Wickman	San Gabriel Valley
Patrick N Hinchy	Tucson
Vergil L Wesley	Tucson
Eric A Jackson	Utah
Takakage Arai	International
Abdulrahman H Bajodah	International
Itzhak Barkana	International
Christian Bes	International
Hideo Bito	International
Harald Buschek	International
Francisco M Caballero	International
Omar F D`Angelo	International
Mario D`Ischia	International
Guillermo Jenaro De Mencos	International
Moshe M Domb	International
Terry S Edwards	International
Mark L Ford	International
Francesco Franco	International
Ilham A Habibie	International
Nobuhiro Harada	International
Santiago Hernandez	International
Jose N Hinckel	International
Yoshiya Itakura	International
Subramaniam Krishnan	International
Hiroyuki Kumazawa	International
Shinichi Kuroda	International
Philippe Lafon	International
ChoiHong Lai	International
Boris Laschka	International
Yuval Levy	International
Hiroki Matsuo	International
David J Mee	International
Francesco Mercolino	International
Hiroshi Mizuno	International
Stephane Moreau	International
Juerg C Mueller	International
Yoshimasa Ochi	International
Antonio M Pascau	International
Paul J Penna	International
Tomas Prieto Llanos	International
Ning Qin	International
Pierre G. Richard	International
Ignacio Romero	International
Giancarlo Rufino	International
Joseph M Rullan	International
Farooq Saeed	International
Ahmed Sbaibi	International
Yoshikazu Shinohara	International
Takeshi Sugimoto	International
Minoru Suzuki	International
Takeshi Tachibana	International
Sten Wiedling	International
Gerhard Wulff	International
Nobuyuki Yajima	International
Koichi Yonemoto	International
Russell R Boyce	Sydney
Kevin M Moran	Sydney

40-Year Anniversaries

Philip J Morris	Central Pennsylvania
Martin Haas	Connecticut
William J McVey	Connecticut
Maxwell Blair	Greater Philadelphia
Nicholas P Cernansky	Greater Philadelphia
Thomas L Fagan	Greater Philadelphia
Thomas D McLay, Jr.	Greater Philadelphia
Peter W Yost	Greater Philadelphia
Mark G Ballin	Hampton Roads
John T Batina	Hampton Roads
John Dorsey	Hampton Roads
Michael G Gilbert	Hampton Roads
Michael W Hyer	Hampton Roads
Ajay Kumar	Hampton Roads
Thomas M Moul	Hampton Roads
Elizabeth P Plentovich	Hampton Roads
Frank Quinto	Hampton Roads
Judith J Watson	Hampton Roads
Jean A Boudreau	Long Island
John E Raha	Long Island
Giuseppe Volpe	Long Island
ChiCheng Yang	Long Island
Arthur A Duke, III	Mid-Atlantic
William H Kelly	Mid-Atlantic
Thomas N McKnight, Jr	Mid-Atlantic
Ameer G Mikhail	Mid-Atlantic
Robert L Wiley	Mid-Atlantic
Arnold D Aldrich	National Capital
Robert M Avjian	National Capital
Arthur D Barondes	National Capital
Ivan Bekey	National Capital
Dominick Bruno	National Capital
Albert J Glassman	National Capital

Francis M Goeser	National Capital
David J Olney	National Capital
Clifford E Rhoades	National Capital
Cecil C Rosen, III	National Capital
Isaac Weissman	National Capital
Michael D Barg	New England
F. Landis Markley	New England
Roger J Racine	New England
Paul W Richmond, III	New England
John Y Sos	New England
Reich L Watterson	New England
Prabhat Hajela	Northeastern New York
William McE Miller	Northern New Jersey
Krishan K Ahuja	Atlanta
Robert M Coopersmith	Atlanta
Everitt W Howe, Jr	Atlanta
Frederick C Macey	Atlanta
Suresh Menon	Atlanta
James R Shaw	Atlanta
Daniel C McAlister	Cape Canaveral
Gerard J Caron	Central Florida
Walter E Hammond	Greater Huntsville
David A Leonard	Greater Huntsville
James S Wilbeck	Greater Huntsville
Bruce D Willis	Greater Huntsville
Mark McCandless	Greater New Orleans
Joaquin H Castro	Palm Beach
George W Moore	Palm Beach
Eric E Abell	Dayton/Cincinnati
Steward J Cline	Dayton/Cincinnati
Ms Keigh L Davis	Dayton/Cincinnati
Dean G Matz	Dayton/Cincinnati
William T Smith	Dayton/Cincinnati
J Craig Dutton	Illinois
Joseph F Jonakin	Illinois
Eric J Jumper	Indiana
David J Unger	Indiana
Andrew A Adamczyk	Michigan
Thomas J Baca	Albuquerque
James A Horkovich	Albuquerque
Teresa M Jordan-Culler	Albuquerque
Rudolf M Balciunas	Houston
Davy M Belk	North Texas
Daryl D Bender	North Texas
Mark E Dreier	North Texas
Samuel W Ferguson, III	North Texas
Steven L Ferguson	North Texas
Michael R Griswold	North Texas
Christopher L Reed	North Texas
Dara Batki	Southwest Texas
John M Macha	Southwest Texas
Frederick A Schmidt	Iowa
Graeme Aston	Rocky Mountain
John M Coyle	Rocky Mountain
John W Daily	Rocky Mountain
Mark C Dickerson	Rocky Mountain
Robert B Eddington	Rocky Mountain
Susan G Janssen	Rocky Mountain
Clark D Mikkelsen	Rocky Mountain
Lowell K Rudolph	Rocky Mountain
William L Weiford	Rocky Mountain
Michael A Guntorius	St. Louis
Charles L Hall	St. Louis
Andrew A Hesketh	St. Louis
Randal C Knoblauch	St. Louis
David W Lund	St. Louis
Ed V White	St. Louis
Dale F Enns	Twin Cities
James R Nelson	Twin Cities
Ronald K Rathgeber	Wichita
Robert Clarke	Antelope Valley
Thomas P Bauer	Los Angeles-Las Vegas
David A Blancett	Los Angeles-Las Vegas
Chia-Chun Chao	Los Angeles-Las Vegas
Leslie J Cohen	Los Angeles-Las Vegas
John L Insprucker	Los Angeles-Las Vegas
Harry D Ivey	Los Angeles-Las Vegas
Raymond P Johnson	Los Angeles-Las Vegas
Dale J Lorincz	Los Angeles-Las Vegas
Robert A Mabli	Los Angeles-Las Vegas
Roy D McGregor	Los Angeles-Las Vegas
Daniel P Raymer	Los Angeles-Las Vegas
Jerald T Swenson	Los Angeles-Las Vegas
A. Telal Wassel	Los Angeles-Las Vegas
Kenneth L Wong	Los Angeles-Las Vegas
Ms Susan R York	Los Angeles-Las Vegas
Gabriel G Georgiades	Orange County
Michael L Hand	Orange County
Joseph E Justin	Orange County
Hayden B Macurda	Orange County
Edward T Mc Cullough	Orange County
Larry L Simmons	Orange County
John E Tiehen	Orange County
William A Sirignano	Orange County
Dana G Andrews	Pacific Northwest
Delmar M Fadden	Pacific Northwest
Gerard A Kordonowy	Pacific Northwest
Victor A Munsen	Pacific Northwest
Steven C Runo	Pacific Northwest
John L White	Pacific Northwest
Clyde P Bankston	San Fernando Pacific
Sukumar R Chakravarthy	San Fernando Pacific
Sherman N Mullin	San Fernando Pacific
Terrence H Murphy	San Fernando Pacific
James D Richardson	San Fernando Pacific
Eberhard E Schodensack	San Fernando Pacific
John F Wilby	San Fernando Pacific
Michael V Brown	San Francisco
Cecil W Acree	San Francisco
Ramarao V Digumarthi	San Francisco
Michael W George	San Francisco
A Stewart Hopkins	San Francisco
Ike C Hsu	San Francisco
Gary C Hudson	San Francisco
Erwin H Johnson	San Francisco
Lawrence J Mistretta	San Francisco
Bernard L Pfefer	San Francisco
Omer Savas	San Francisco
Ross M Jones	San Gabriel Valley
Charles P Minning	San Gabriel Valley
John L West	San Gabriel Valley
Shawn P Buchanan	Utah
Richard C Laramee	Utah

50-, 60-, and 70-Year Anniversaries will appear in the September AIAA Bulletin.

ASAT 2016 – A SUCCESSFUL CONFERENCE IN SOUTHERN CALIFORNIA

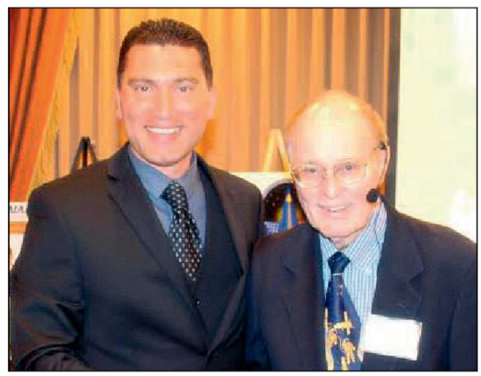
Dr. Amir S. Gohardani, AIAA Orange County Section Chair

The AIAA Orange County (OC) Section recently hosted the 13th Annual AIAA Southern California Aerospace Systems and Technology (ASAT) Conference and Banquet on 30 April 2016. ASAT 2016 brought together engineers, researchers, educators, students, leaders, and enthusiasts for unclassified presentations on all aspects of aerospace systems, technology, vehicle design, program management, policy, economics and education and was structured in three major categories: aircraft systems and technology, space systems and technology, aerospace public policy and education. The program consisted of 30 presentations and two keynote speakers: Dr. Garrett Reisman, former NASA astronaut, and Dr. Karl E. Garman, chair of the AIAA Flight Testing Technical Committee, who gave talks on Human Spaceflight – Recent, Past, and the Future and Aerospace Mythology: Our Parables, Our Profession, Ourselves, respectively. The banquet speaker, Tom Logsdon from The Applied Institute, spoke about Six Ways the Global Positioning System Can Save Your Life. The banquet also included an overview of section activities for the year and presentation of awards for the 2016 Student of the Year, Karla Marron (University of California, Irvine), and the 2016 Engineer of the Year, Dr. Omid Gohardani (Honeywell Aerospace). Dr. Frank O. Chandler was presented with a 50-year anniversary award and Dr. Joseph E. (Gene) Justin with a 40-year anniversary award.

For the second year, the Gohardani Presentation Award in Aeronautics and Aerospace was also presented to two of the most thought-provoking and exceptional all-around presentations delivered during ASAT 2016: Dev Bhatia and David Elias Rodriguez, Cerritos High School (Junior Category), and J. Philip Barnes, Pelican Aero Group (Senior Category).

ASAT 2016, co-chaired by John Rose and Dino Roman, was carefully planned to provide a forum to exchange new ideas, review achievements and to enable networking opportunities for future aerospace endeavors. Dr. Amir S. Gohardani, AIAA OC Section Chair, thanked all AIAA OC council members, and especially the co-chairs, for having gone above and beyond to enable this regional conference, which serves as a local hub for students, engineers, managers, policymakers, leaders, and enthusiasts to share their accomplishments, network with others, and to learn about the latest and greatest in the industry.

Top: Dr. Gene Justin and Karla Marron (2016 AIAA OC Student of the Year). Middle left: Dr. Omid Gohardani (2016 AIAA OC Engineer of the Year) and Dr. Justin. Middle right: Dr. Amir S. Gohardani (AIAA OC Section Chair) and keynote speaker, Tom Logsdon.



Left image: Dr. Amir S. Gohardani, J. Philip Barnes (2016 Gohardani Presentation Award Senior Category Awardee), and Dr. Omid Gohardani. Right Image: Dr. Amir S. Gohardani with Mr. Dev Bhatia Barnes (2016 Gohardani Presentation Award Junior Category Awardee), Mr. David Elias Rodriguez (2016 Gohardani Presentation Award Junior Category Awardee), and Dr. Omid Gohardani.

CALL FOR NOMINATIONS

Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 October**. AIAA members in good standing may serve as nominators and are urged to read award guidelines carefully. Nominations can be submitted online after logging into www.aiaa.org with your 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/**.

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

Premier Awards & Lectureships

Distinguished Service Award is presented to give unique recognition to an individual member who has provided distinguished service to the Institute over a period of years.

Goddard Astronautics Award, named to honor Robert H. Goddard—rocket visionary, pioneer, bold experimentalist, and superb engineer—is the highest honor AIAA bestows for notable achievement in the field of astronautics.

International Cooperation Award recognizes individuals who have made significant contributions to the initiation, organization, implementation, and/or management of activities with significant U.S. involvement that includes extensive international cooperative activities in space, aeronautics, or both.

Reed Aeronautics Award is the highest award AIAA bestows for notable achievement in the field of aeronautics. The award is named after Dr. Sylvanus A. Reed, aeronautical engineer, designer, and founding member of the Institute of the Aeronautical Sciences in 1932.

Dryden Lectureship in Research was named in honor of Dr. Hugh L. Dryden in 1967, succeeding the Research Award established in 1960. The lecture emphasizes the great importance of basic research to the advancement in aeronautics and astronautics and is a salute to research scientists and engineers.

von Kármán Lectureship in Astronautics honors Theodore von Kármán, world-famous authority on aerospace sciences. The award recognizes an individual who has performed notably and distinguished himself technically in the field of astronautics.

Technical Excellence Awards

Aeroacoustics Award is presented for an outstanding technical or scientific achievement resulting from an individual's contribution to the field of aircraft community noise reduction.

Aerodynamics Award is presented for meritorious achievement in the field of applied aerodynamics, recognizing notable contributions in the development, application, and evaluation of aerodynamic concepts and methods.

Aerodynamic Measurement Technology Award is presented for continued contributions and achievements toward the advancement of advanced aerodynamic flowfield and surface measurement techniques for research in flight and ground test applications. (Presented odd years)

Aerospace Communications Award is presented for an outstanding contribution in the field of aerospace communications. Candidates are individuals or small teams (up to 4 members) whose achievements have had a positive impact on technology and society.

Aircraft Design Award is presented to a design engineer or team for the conception, definition, or development of an original concept leading to a significant advancement in aircraft design or design technology.

Chanute Flight Test Award recognizes significant lifetime achievements in the advancement of the art, science, and technology of flight test engineering. (Presented even years)

Engineer of the Year is presented to an individual member of AIAA who has made a recent significant contribution that is worthy of national recognition. Nominations should be submitted to your AIAA Regional Director.

F. E. Newbold V/STOL Award recognizes outstanding creative contributions to the advancement and realization of powered lift flight in one or more of the following areas: initiation, definition and/or management of key V/STOL programs; development of enabling technologies including critical methodology; program engineering and design; and/or other relevant related activities or combinations thereof which have advanced the science of powered lift flight. (Presented every 30 months)

Fluid Dynamics Award is presented for outstanding contributions to the understanding of the behavior of liquids and gases in motion as related to need in aeronautics and astronautics.

Ground Testing Award recognizes outstanding achievement in the development or effective utilization of technology, procedures, facilities, or modeling techniques or flight simulation, space simulation, propulsion testing, aerodynamic testing, or other ground testing associated with aeronautics and astronautics.

Hap Arnold Award for Excellence in Aeronautical Program Management is presented to an individual for outstanding contributions in the management of a significant aeronautical or aeronautical-related program or project.

Hypersonic Systems and Technologies Award recognizes sustained, outstanding contributions and achievements in the advancement of atmospheric, hypersonic flight and related technologies. (Presented every 18 months)

Jeffries Aerospace Medicine & Life Sciences Research Award is presented for outstanding research accomplishments in aerospace medicine and space life sciences.

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

Multidisciplinary Design Optimization Award is presented to an individual for outstanding contributions to the development and/or application of techniques of multidisciplinary design optimization in the context of aerospace engineering. (Presented even years)

Otto C. Winzen Lifetime Achievement Award is presented for outstanding contributions and achievements in the advancement of free flight balloon systems or related technologies. (Presented odd years)

Piper General Aviation Award is presented for outstanding contributions leading to the advancement of general aviation. (Presented even years)

Plasmadynamics and Lasers Award is presented for outstanding contributions to the understanding of the physical properties and dynamical behavior of matter in the plasma state and lasers as related to need in aeronautics and astronautics.

Jay Hollingsworth Speas Airport Award is presented to the person or persons judged to have contributed most outstandingly during the recent past toward achieving compatible relationships between airports and/or heliports and adjacent environments. The award consists of a certificate and a $7,500 honorarium. Jointly sponsored by AIAA, the American Association of Airport Executives, and the Airport Consultants Council. (Nominations due 1 November)

Theodor W. Knacke Aerodynamic Decelerator Systems Award recognizes significant contributions to the effectiveness and/or safety of aeronautical or aerospace systems through development or application of the art and science of aerodynamic decelerator technology. (Presented odd years)

Thermophysics Award is presented for an outstanding singular or sustained technical or scientific contribution by an individual in thermophysics, specifically as related to the study and application of the properties and mechanisms involved in thermal energy transfer and the study of environmental effects on such properties and mechanisms.

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

Service Award

Public Service Award honors a person outside the aerospace community who has shown consistent and visible support for national aviation and space goals.

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

Notice for *AIAA Journal* Subscribers

AIAA Journal (*AIAAJ*), covering pioneering theoretical developments and experimental results across a far-reaching range of aerospace topics, will be moving to an online-only format in 2017. *AIAAJ* was launched along with AIAA in 1963 and is once again leading the way. Print customers transitioning to the online format will be able to maximize the user experience with research tools and access to the most up-to-date versions of articles in Aerospace Research Central (**http://arc.aiaa.org**).

If you have questions about online access and features, go to **http://arc.aiaa.org/page/aiaajonlineonly**.

AIAA FOUNDATION proudly presents

2ND ANNUAL ASTRONAUT *STORIES FROM THE COSMIC FRONTIER*

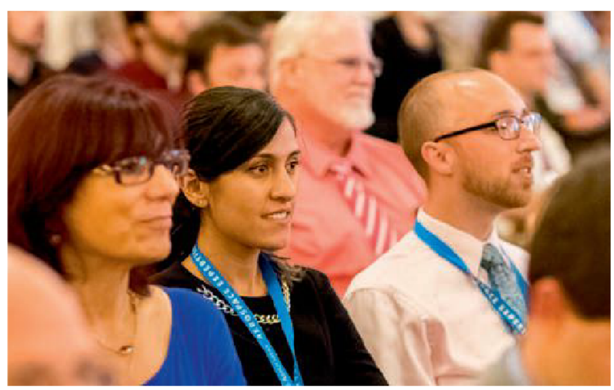
Wednesday Evening, 14 September 2016
Hyatt Regency Long Beach, Long Beach, CA

A panel of astronauts will share their stories from the cosmic frontier! There will be ample opportunity to ask questions and interact with the panelists.

This free event is open to the public and attendees of AIAA SPACE 2016. A $20 per person donation to support the AIAA Foundation is encouraged.

The AIAA Foundation's mission is to promote education and recognize excellence in the aerospace community.

For more information, please contact Merrie Scott at merries@aiaa.org or visit www.aiaafoundation.org



SPACE 2016

16-1074

SPACE 2016

AIAA Space and Astronautics Forum and Exposition

Open Space: Opportunities for the Global Community

13–16 September 2016
Long Beach Convention Center
Long Beach, California

Featuring
AIAA/AAS Astrodynamics Specialist Conference
AIAA Complex Aerospace Systems Exchange (CASE)

Executive Steering Committee
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General Chair
Carissa Christensen, The Tauri Group, LLC

Forum 360 Chair
Aaron Parness, NASA Jet Propulsion Laboratory

Technical Chair
Sarah Shull, NASA Johnson Space Center

Sponsors

AIAA SPACE 2016 combines the best aspects of technical conferences with insights from respected leaders, providing a single, integrated forum for navigating the key challenges and opportunities affecting the future direction of global space policy, capabilities, planning, research and development, funding, security, environmental issues, and international markets.

Plenary Program

- Commercializing Low Earth Orbit (LEO)--Charles F. Bolden Jr, Administrator, NASA
- Election 2016
- Next Stop: Mars

Forum 360

- Icy Moons and Ocean Worlds
- Commercial Crew Update
- Envisioning a Free Market Space Economy
- Earth Observations – Space & The Paris Agreement
- Current Launch Vehicle Update
- On-Orbit Satellite Servicing
- Technologies for the New LEO Economy
- Space Traffic Management
- Outside Perspectives

Technical Program

The technical program contains more than 650 technical papers from about 600 government, academic, and private institutions in 28 countries reporting on the latest in space and astronautics research, and offering scores of opportunities for collaboration and discussion. Browse the Detailed Agenda (**https://aiaa-msp16.abstractcentral.com/itin.jsp**) and the list of paper presenters (**http://www.aiaa-space.org/uploadedFiles/AIAA-Space_Site/Program/AuthorList.pdf**).

Courses and Workshops

- Systems Engineering Fundamentals
- Introduction to Space Systems
- Space Standards and Architecture Workshop

Recognition

- von Kármán Lecture in Astronautics
  Rethinking Propulsion: Enabling the Future of Space Transportation and Exploration
  Vigor Yang, Chair, Daniel Guggenheim School of Aerospace Engineering, George Institute of Technology
- William H. Pickering Lecture (*The Juno Mission*)
  Rick Nybakken (Invited), Project Manager, Juno Mission, Applied Physics Laboratory
  Scott Bolton (Invited), Juno Principal Investigator, Southwest Research Institute
- Recognition Luncheon—Celebrating Achievements in Space and Astronautics
- AIAA/NAE Yvonne C. Brill Lecture in Aerospace Engineering
  Engineering Leadership: The Need for Technical Excellence and Diversity
  Wanda M. Austin, President & CEO, The Aerospace Corporation

Networking and Special Events

- Student Welcome Reception
- Rising Leaders in Aerospace program
- Reception and Poster Session in Exposition Hall
- Luncheon in the Exposition Hall
- An Evening of Astronaut Stories (sponsored by Northrop Grumman)
  Sandy Magnus – served on three shuttle missions and lived on the International Space Station for four and half months
  Garrett Reisman – logged more than 3 months in space and participated in three spacewalks
  Michael Lopez-Alegria – flew on three space shuttle missions between 1995 and 2002. His fourth space mission began in September 2006 when he flew on a Russian Soyuz capsule to the international space station. His seven-month mission set a new American record for longest spaceflight.
- AIAA Foundation Silent Auction

Exposition

2016 Exhibitors

- Aerojet Rocketdyne
- Aerion Technologies
- Airborne Systems
- ATA Engineering, Inc.
- ESTECO
- M&P International, Inc.
- Orbital ATK
- TEN TECH LLC

Lodging

Hyatt Regency Long Beach
200 South Pine Avenue
Long Beach, California, USA, 90802
Tel: +1.562.491.1234

For your convenience, AIAA has booked a block of rooms at the Hyatt Regency Long Beach. The regular attendee rate is $199 and the government rate is $150 per night plus taxes for both single and double occupancy. The block rates will be available until 19 August 2016, or until the block is full.

Book your regular attendee hotel room: https://aws.passkey.com/g/53722277
Book your government rate hotel room: https://aws.passkey.com/g/53844296

Explore a premier waterfront setting steps away from Long Beach Convention and Entertainment Center and Aquarium of the Pacific when you stay at Hyatt Regency Long Beach. When it comes time to venture out, you are in the heart of it all with over a 100 restaurants within walking distance, shopping at The Pike across the street and the fascinating Aquarium of the Pacific less than a mile away.

Register now!
aiaa-space.org/Register

Upcoming AIAA Continuing Education Courses

Courses and Workshop at AIAA Propulsion and Energy Forum 2016 (AIAA Propulsion and Energy 2016)
www.aiaa-propulsionenergy.org/CoursesWorkshops
23–24 July 2016

3rd AIAA Propulsion Aerodynamics Workshop (Organized by the AIAA Air Breathing Propulsion System Integration Technical Committee)
The focus of the workshop will be on assessing the accuracy of CFD in obtaining multi-stream air breathing system performance and flow structure to include nozzle force, vector and moment; nozzle thrust (Cv) and discharge (Cd) coefficients; and surface pressure prediction accuracy. Experimental data are available for the test cases; however, the CFD studies will be performed as a blind trial and compared with the experimental data during the PAW02 workshop. Models will be provided for multiple cases featuring isolated inlets, isolated nozzles, and nozzles with or without a ground plane. A statistical framework will be used to assess the CFD results. Baseline computational grids will be provided for structured solvers. Geometry will also be available to those interested in developing their own meshes or employing an unstructured grid. Participants may run one or more cases if the required example grid solution is completed. The workshop provides an impartial forum to present findings, discuss results, exchange ideas, and evaluate the effectiveness of existing computer codes and modeling techniques.

Topics include:

- Analysis of flow in a diffusing S-duct with and without AIP instrumentation, and with and without flow control
  - Comparisons of AIP total pressure recovery and distortion both steady-state and dynamic
  - Comparisons of steady-state surface static pressure distributions
- Analysis of flow in a Dual Separate Flow Reference Nozzle (DSRN) and Dual Mixed Flow Reference Nozzle (DMFR)
  - Comparisons of thrust coefficient

Advanced High-Speed Air-Breathing Propulsion (Instructors: Dr. Dora E. Musielak, Dr. Tomasz Drozda, Mr. Robert Moehlenkamp, Dr. Steven Russell, Dr. Venkat Tangirala)
Revolutionary methods of high-speed air-breathing propulsion are needed to extend the flight regime of aircraft, missiles, and improve Earth-to-orbit spacecraft. Advanced High-Speed Air-Breathing Propulsion will introduce students to the design and development processes of high-speed propulsion, including ramjet/scramjets and TBCC concepts. The course will present a comprehensive overview of the state of the art, including highlights of current high speed propulsion programs in the world. An introduction to multidisciplinary design optimization (MDO) will help students appreciate the challenges of developing this breakthrough propulsion technology. Instructors actively engaged in high-speed propulsion R&D will discuss the challenges, and development trends of this advanced propulsion technology. This course is sponsored by the AIAA High-Speed Air-Breathing Propulsion Technical Committee (HSABPTC).

Electric Propulsion for Space Systems (Instructor: Dan M. Goebel, Ph.D.)
Over 120 spacecraft presently use electric thruster systems for primary or auxiliary propulsion. Electric thrusters are now being used to provide most of the post-LEO propulsion demands for both geosynchronous and deep space missions. The availability of practical, high-specific-impulse electric thrusters with long life, and the development of electrical power-systems required to sustain them, has resulted in extremely rapid growth in the applications of this technology. This course describes the fundamental operating principles, performance characteristics and design features of state-of-the-art systems in each of the three classes of electric thrusters (electrothermal, electromagnetic and electrostatic). The impacts of the thruster performance and life on mission planning; mission analysis techniques; and on-board spacecraft systems will be addressed. The extension of spacecraft capabilities afforded by electric propulsion and issues associated with its integration into spacecraft will also be discussed.

Fundamentals of Liquid Chemical Propellants and Applications for Less-Toxic Alternatives (Instructor: Dr. Timothée Pourpoint)
Liquid propulsion systems are critical to launch vehicle and spacecraft performance, and mission success. This two-day course, taught by a team of government, industry and international experts, will cover propulsion fundamentals and topics of interest in launch vehicle and spacecraft propulsion; non-toxic propulsion; microsat and cubesat propulsion; propulsion system design and performance; and human rating of liquid engines.

Hybrid Rocket Propulsion (Instructors: Dr. Joe Majdalani and Dr. Arif Karabeyoglu)
This short course is quintessential for all professionals specializing in chemical propulsion. The mechanisms associated with hybrid combustion and propulsion are diverse and affect our abilities to successfully advance and sustain the development of hybrid technology. It is our penultimate goal to promote the science of hybrid rocketry, which is safe enough to be used in both academia and the private sector. A historical demonstration of hybrid rocket capability is the 2004 X-prize winner SpaceShipOne. This technology can also be used in outreach activities when used in conjunction with hands-on design projects and payload launches that involve student teams. Interest in hybrid rocketry can thus be translated into increased awareness in science and technology, helping to alleviate the persistent attrition in our technical workforce. This course reviews the fundamentals of hybrid rocket propulsion with special emphasis on application-based design and system integration, propellant selection, flow field and regression rate modeling, solid fuel pyrolysis, scaling effects, transient behavior, and combustion instability. Advantages and disadvantages of both conventional and unconventional vortex hybrid configurations are examined and discussed.

Courses at AIAA Space and Astronautics Forum 2016 (AIAA SPACE 2016)
www.aiaa-space.org/CoursesWorkshops

11 September 2016

Space Standards and Architecture Workshop (Instructors: Frederick A. Slane, Mike Kearney, Ramon Krosley)
This workshop is geared toward mission users, not standards developers and is intended for individuals and organizations that desire to increase their teams' understanding of the benefits of and the usability of 1) space standards and 2) architecture framework. Spaceflight mission planners, designers, and engineers who seek guidance on the broad standards environment and techniques to "harvest" the most beneficial standards to be applied to their missions would benefit from participating in the workshop. This applies to all engineering domains, but is especially valuable where systems interface across organizational boundaries.

11–12 September 2016

Introduction to Space Systems (Instructor: Prof. Mike Gruntman, Ph.D.)
This course provides an introduction to the concepts and technologies of modern space systems. Space systems combine engineering, science, and external phenomena. We concentrate on scientific and engineering foundations of spacecraft systems and interactions among various subsystems. These fundamentals of subsystem technologies provide an indispensable basis for system engineering. The basic nomenclature, vocabulary, and concepts will make it possible to converse with understanding with subsystem specialists. This introductory course is designed for engineers and managers – of diverse background and varying levels of experience – who are involved in planning, designing, building, launching, and operating space systems and spacecraft subsystems and components. The course will facilitate integration of engineers and managers new to the space field into space-related projects.

Systems Engineering Fundamentals (Instructor: John C. Hsu, Ph.D., P.E., AIAA Fellow, INCOSE ESEP)
In today's globalized environment, manufacturing and designing companies compete for business. To be successful, companies need to practice strategies that minimize the possibility of degradation of product quality, cost overrun, schedule slippage, customer dissatisfaction and system development failures. In this course you will learn why do we need systems engineering, the systems engineering fundamentals including Requirements Analysis and Development, Functional Analysis and Allocation, Design Decision Analysis based on requirements; Risk Management throughout the development and design cycle; Integrated Master Plan/Integrated Master Schedule and Work Breakdown Structure for development and design management; Technical Performance Measurement for measuring, tracking and validating design; Interface Management across in-house disciplines, supplier, and customer; and Verification and Validation to prove the right system was built and the system was built right.