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AEROSPACE AMERICA

Über drones

Pentagon wants tech that can zap targets anywhere in under an hour. Some are reassured, others nervous

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A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

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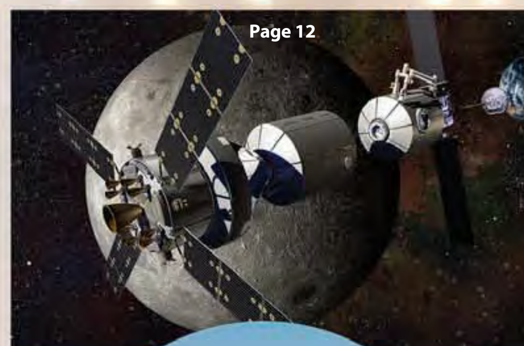

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ON THE COVER
An artist's rendering of Falcon HTV-2.
Credit: Lockheed Martin

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

40,000 copies of this issue printed. This is Volume 54, No. 5.

AEROSPACE AMERICA

is a publication of the American Institute of Aeronautics and Astronautics

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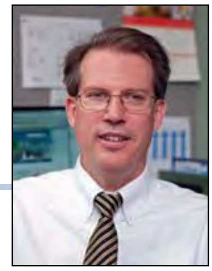
May 2016, Vol. 54, No. 5

Shaping the Future of Aerospace

Editor's Notebook



Hard questions for fast weapons

It's good that the Pentagon wants to master hypersonic gliders and boosters before someone else does. Researching and testing is one thing, but building and deploying these Conventional Prompt Global Strike weapons would be quite another. The task for advocates of this potential new class of weapons will be to articulate how they would be used in the real world without unintentionally making the U.S. and its allies less secure.

The fundamental problem is that military action always comes with a risk of miscalculation by regional bystanders. That's why the U.S. alerted nuclear-armed Pakistan to the 1998 Tomahawk cruise missile attacks on terrorist camps in neighboring Afghanistan. A new class of boost-glide weapons racing through the upper atmosphere would create even more risk of miscalculation than those low-altitude Tomahawks. Just as with the 1998 attacks, the U.S. would have to wait to the very last moment before alerting the bystander or risk losing operational secrecy. With hypersonic weapons, the bystander would have just moments to trust America's assurances that it is not the target, and the U.S. would need to trust that the bystander's military intelligence apparatus would correctly judge that the weapon is flying too low to be a nuclear-armed ballistic missile.

That's a lot of trust to ask for in an uncertain world.

Then there are the attributes of the target to consider. Before approving the strike, U.S. leaders would need to be confident about the identity of the target and its intent. Pentagon lawyers would demand lots of details before rendering legal advice. Some of the necessary intelligence collections could be gathered by spy satellites and high-altitude reconnaissance planes. Human intelligence would be invaluable, but it's hard to come by in the most dangerous places on Earth.

When the trust and intelligence factors are considered, the argument for Conventional Prompt Global Strike quickly circles back to where we are today. U.S. leaders have come to depend on high-definition video and real-time communications intercepts from unmanned aircraft to give them the confidence to say "go." Once such an aircraft is patrolling over the target, it would make more sense to strike the target from that aircraft, if warranted, than to launch a weapon from a ship or submarine thousands of kilometers away. Additional risks of targeting mistakes and miscalculation would come with that approach.

For now, Conventional Prompt Global Strike appears to be a technology in search of a viable concept of operations.

Ben Iannotta
Editor-in-Chief

Visiting other stars

Some responses to our April cover story, "Proxima Centauri"

Urgent justification

Michael Peck's article on interstellar travel was a great job and a fine read. However, his last paragraphs on "Justification" could have been stronger.

From the (hopefully) long-term perspective, the day will come when Earth is no longer habitable by human life. Sooner or later, the arrival of that state, whether caused by an impactor, solar aging or some other event, will leave few options for our survival, all of which involve adapting to conditions on another celestial body.

Mars, an obvious possibility, may or may not be able to be terraformed to an extent that, at the far edge of our sun's habitable zone, can provide sufficient energy to support human life as well as continuing upward (vs. retrogressive) development.

Success would definitely not be a mole-like existence in caves for a few thousand years or so before humankind finally flickered out. Our best, perhaps only, option could well be an earth-like world light years away.

We pride ourselves to think that, despite an existence of only a million years or so, we have already trumped the dinosaurs and their 150 million+ years of dominance. While we claim success as a result of our evolutionary development of intelligence, self-awareness and an understanding of the physical world around us, it is not clear whether these attributes are sufficient or even if they matter in the grand overall scheme.

Unless our understandings can reach an ability to develop long-term will and sustained follow through that projects our species to other worlds, the end of this one will leave just another evolutionary dead end in a universe that does not allow for inability to adapt to its vagaries.

We may be close to knowing the cosmos and its workings, but if, before we achieve the needed higher level of mastery, we sight a large asteroid headed our way — or even worse — a blue shifted star with no proper motion, all of our achievements will not matter a bit.

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Jupiter instead?

The article on interstellar travel offers the wisdom from Sten Odenwald that such trips to very distant planetary systems need to be justified by more than an urge for technological adventure.

Indeed, profound scientific and philosophical questions could be answered, if we discovered life on other, possible worlds. There are, however, much closer and more certain planetary systems than Proxima Centauri and the like. These are the multiple planets surrounding Jupiter and Saturn.

While finding fossil indications of life formerly on Mars might be intriguing, the oceans farther out at Europa, Enceladus and Titan could offer evolved life, i.e., stuff with fins and claws perhaps. Jupiter and Saturn certainly provide different kinds of "stars," heating their planets thanks to gravity and magnetic fields. Creatures on these worlds would clearly redefine the possibilities for life in the universe as readily as similar exotic locations much farther away.

The propulsion systems for exploring around Jupiter and Saturn are well within expected capabilities for the present century. In fact, today's technologies can already enable precursor missions, such as the recently proposed notion of analyzing life-chemicals in the vapors emanating from the ice volcanoes of Enceladus. These nearer-term missions could provide the necessary and tantalizing

justifications for larger, crewed voyages to follow.

It is certainly exciting for those of us interested in advanced space propulsion to consider technologies that may take us to the stars, including controlled fusion. Some of these concepts can be applied sooner for our nearby "solar systems." While we voyage to these systems and engage in lengthy explorations — think of the challenge of exploring our own oceans — who knows what advances in quite separate fields, e.g., genetic engineering, may change our presently perceived constraints for interstellar travel?

Some of us recall from the early 1960s, for example, that any mission beyond (and even including) Mars was supposed to be the domain of electric propulsion. The Silicon Revolution, not new insights in thermodynamics, allowed us to obtain photographs of Pluto taken with a spacecraft launched from the surface of the Earth by chemical propulsion.

If we can entertain the "embryonic" space propulsion concepts outlined in April's article, we should certainly allow for the unexpected in the next century.

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Breaking barriers

In 1890, when people were told that in a few years man would fly in a machine, they may have locked up the person pushing these crazy ideas.

In 1930s, when some said in a few years we will break the sound barrier, people were concerned that Chuck Yeager might not live.

In the article, "Proxima Centauri," no one indicated when we will break the light barrier.

We may not do it by 2099, but we will.

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Correction

The article "Visualizing shockwaves" [February, page 14] misidentified the NASA researcher who came up with the idea of using the desert floor as a background for imaging shockwaves from supersonic aircraft. Daniel Banks, an aerospace engineer at NASA's Armstrong Flight Research Center in California, came up with the idea during discussions with James Heineck, a NASA photographic technologist at Ames Research Center in California. Heineck had previously conceived of using a natural background for schlieren images of shockwaves. The desert technique was first tested in 2011.

Why not wait?

Conventional aircraft top speeds increased by roughly a factor of two every 10 years from 1910 to 1960. Shouldn't we be able to estimate spacecraft speeds to have a similar increase?

This table shows how that increase would influence travel times.

It makes no sense to plan a 100-year trip. The spacecraft will have been passed up by its faster successors. A 25-year trip could make sense, and its builders may live to see the data return.

Sam Losh
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Launch Date	Flight Time	Arrival	Data Received
2030	100 years	2130	2134
2040	50 years	2090	2094
2050	25 years	2075	2079
2060	12.5 years	2072	2076
2070	6.25 years	2076	2080

Fewer acronyms, please

I read with much interest the article "Fresh Thinking" [March, page 34] about NASA's considerations about getting humans to Mars. Unfortunately, I had trouble following the article because of the use of abbreviations.

I am an electrical engineer, so I knew the meaning of TRL [technology readiness level]. However, ISRU stumped me. I found the original words [in situ resource utilization] two paragraphs above the abbreviation. Maybe the term is familiar to some of your readers, but not me and I am sure not to some others. This leaves the uninitiated clueless.

I can understand that the authors of the article are so familiar with their terminology that they naturally write with these acronyms. However, it should be the job of the editors to make the articles more meaningful and clear to the wider audience.

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All letters addressed to the editor are considered to be submitted for possible publication, unless it is expressly stated otherwise. All letters are subject to editing for length and to author response. Letters should be sent to: Correspondence, Aerospace America, 12700 Sunrise Valley Drive, Suite 200, Reston, VA 20191-5807, or by email to: beni@aiaa.org.

Getting a grip

Astronauts on the International Space Station are testing adhesive devices inspired by a gecko's remarkable ability to climb walls and cross ceilings by applying force to millions of microscopic hair-like structures on their toes.

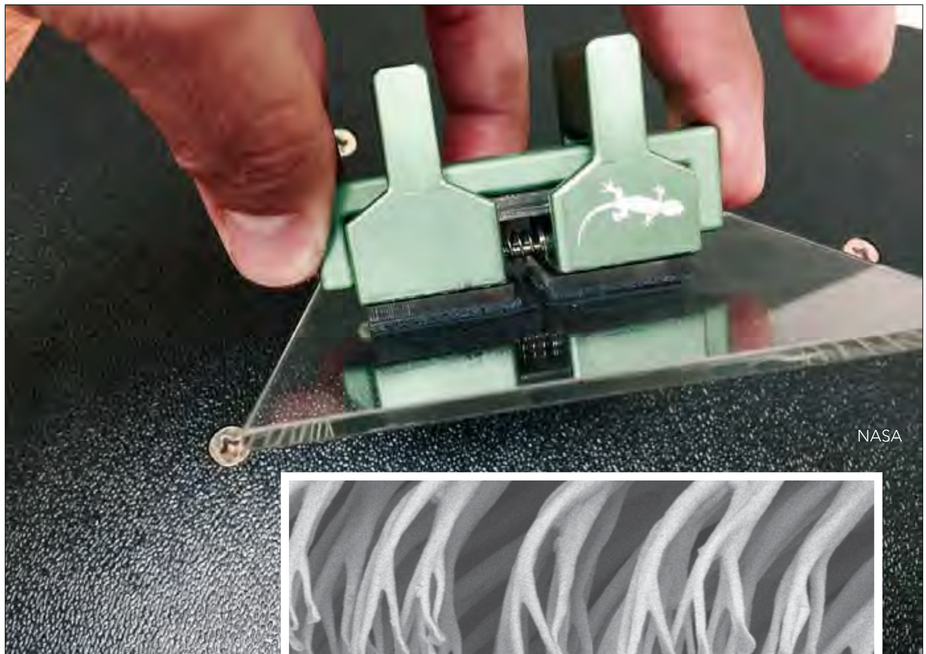
The Gecko Grippers were made at NASA's Jet Propulsion Laboratory. If the test aboard the station goes well, the grippers could have all sorts of applications, from capturing orbital debris to holding sensors or servicing robots to the surfaces of larger spacecraft.

Astronaut Jeffrey Williams stuck five of them to a bulkhead in the space station's U.S. Destiny laboratory in March and attached a force gauge to measure the strength of their adhesive power in various directions. Two of the grippers were to remain in place for two weeks and a third for a year to show whether the adhesive force lessens over time.

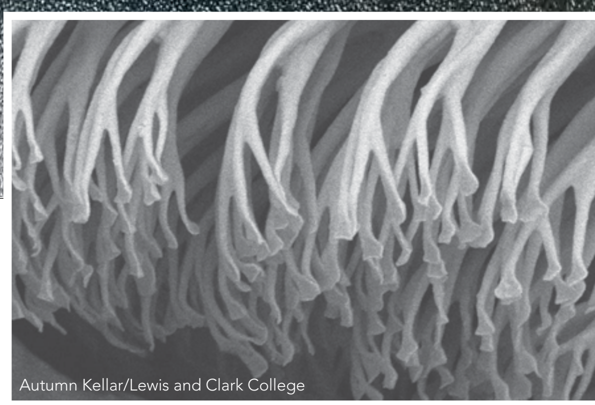
Principal investigator Aaron Parness watched by video as Williams attached the grippers. The technology "appears to work well, which is a relief," he says. NASA does not plan to announce detailed results until Parness and his team analyze data from the complete series of tests.

If the gripper is still stuck after a year in microgravity, Parness plans to test robotic crawlers that might someday climb the exterior walls of a spacecraft looking for structural flaws caused by the impact of micrometeoroids or orbital debris. NASA might also grab large debris like spent rocket stages and move them out of the way of orbiting spacecraft, Parness says.

Parness began investigating adhesives in 2005 while working toward a Ph.D. in mechanical engineering at Stanford. He studied insects and worms before settling on geckos, which he calls "nature's most amazing climbers."



NASA



Autumn Kellar/Lewis and Clark College

The small fibers in this image from a scanning electron microcope are the gecko's gripping hairs, called setae. Synthetic versions are holding the gripping device to a piece of glass.

Gecko feet are not sticky. The reptiles climb smooth surfaces by applying force in a specific direction to the tips of millions of tiny hair-like structures, called setae, on the bottoms of their feet. This produces an electrostatic attraction between the setae and the adjacent wall or ceiling. When geckos stop applying pressure, the electrostatic attraction stops.

In the synthetic version, hundreds of thousands of pyramid-shaped setae jut from one side of a pad made from an epoxy material. Mother Nature still has the edge when it comes to nanotechnology, though. The synthetic setae are much stubbier than a gecko's. Each is 10 to 15 micrometers in diameter and 60 to 70 micrometers long while a gecko's setae have diameters of about five micrometers and lengths ranging from 30 to 130 micrometers. The average diameter of a human hair is 100 micrometers.

"We aren't able to manufacture something that exists on all those scales with all those geometries," Parness says.

To copy the gecko's ability to turn on and off its sticking power, each Gecko Gripper is composed of two square pads covered with setae and attached to two handles for the person applying the grippers. Before touching the pads to the surface, the user squeezes the handles together to pull on steel springs that pull the pads in a direction that will produce the adhesive effect. The person touches the pads to the surface and lets go.

"It will stay stuck indefinitely," says Parness. To release the gripper, the user pinches the handles together again, removing the preferred load.

Parness and his colleagues tested larger versions of the Gecko Gripper in 2014 and 2015 during parabolic airplane flights designed to simulate microgravity. Those tests showed the devices could grab and hold onto a 100-kilogram person wearing a vest with a smooth surface.

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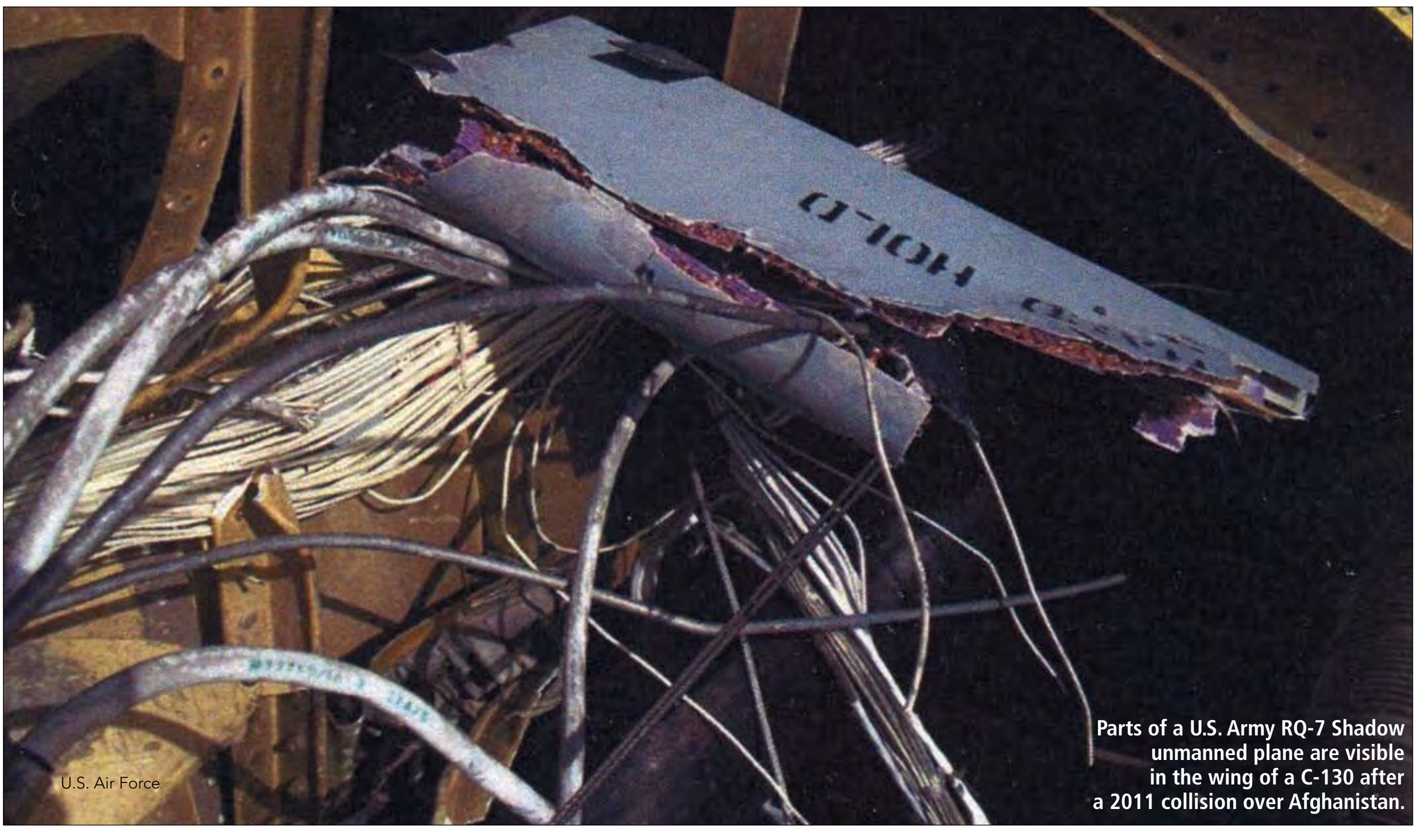
New details released about 2011 drone collision

"We got hit by a UAV! We got hit by a UAV!"

Those were among the first words uttered by the navigator of a U.S. Air Force C-130 transport plane that collided in midair with an Army RQ-7 Shadow unmanned aircraft over Afghanistan in 2011.



Parts of a U.S. Army RQ-7 Shadow unmanned plane are visible in the wing of a C-130 after a 2011 collision over Afghanistan.

The incident made the news at the time and it is often cited as an example of the possible dangers posed by drones in civilian airspace. The documents I received from the Air Force in response to a Freedom of Information Act request underscore how harrowing the incident was for the crew, and also suggest that the plane's Traffic Collision Avoidance System, or TCAS, did not issue an audible "traffic" warning to the crew.

The incident begins abruptly with a "Holy sh-t!" from the C-130's navigator, who then informs the crew that the aircraft, call sign Torque 5-6, has been hit by an unmanned aircraft, according to the cockpit transcript.

The Shadow's operator, call sign Doggie 01, informs the Sharana airbase tower that the drone is ready to land; aboard the C-130, the crew is quickly assessing the damage.

"Number 1 motor, Number 1 motor!" shouts the C-130's flight engineer, who also announces that the aircraft has "hot air everywhere" and an "outer wing hot light." The pilot adds, "There's a big frickin' hole in the airplane." The navigator reports smoke but no fire coming from the left wing.

The Shadow operator informs the tower, "I've lost comms with my aircraft."

Moments later, the tower informs him: "We had a, ah, C-130, um, that hit a UAV. I'm suspecting that it's yours."

The Shadow was obliterated, but the crew landed the C-130 safely.

What caused the collision? The FOIA documents do not include the investigation board's findings. After the incident, the Army said it wasn't the fault of the RQ-7 or its operator, and the Washington Post reported that an air traffic controller had been disciplined. The new documents include a "deficiency report" about the C-130 involved in the incident: "The Aircraft was involved in a mid-air collision with an RG7, and did not get the aural 'Traffic' warning." An inspection report by Honeywell found the C-130's TCAS system was working properly.

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Seeing the future in the

John Tracy, Boeing chief technology officer

When John Tracy was laid off three times from his job as a California high school physics teacher, his wife told him it was time to find another line of work. So he did. When Tracy retires from Boeing on July 15 – Boeing's 100th anniversary date – it will mark the end of his 35-year career at the company, including the last 10 years as chief technology officer.

Tracy, one of the 2016 class of AIAA Honorary Fellows, spoke by phone with Michael Peck about the technology development strategy his team created, his forecast for space innovation and the aviation landscape he sees in 2050.

Hint: He sees a need for speed.

What was your technology strategy over the last 10 years?

We knew we had to find ways to create value in a way that was repeatable, measurable and affordable. We basically came up with a complete taxonomy. We started with an inventory of the technology programs throughout the company. They were sort of disconnected with each other. For the first time in the company's history, we came up with an enterprise-wide technology plan. It started by creating a uniform language. We called it the technology domains. We were

Boeing's John Tracy addresses employees about the company's engineering approach. Tracy says of a possible human mission to the moon or Mars: "There is zero doubt in my mind that we can do it technically. But do the American people want to do it?"

Boeing

past

Interview by Michael Peck
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able to identify gaps and overlaps. Then we had a conscious strategy to invest in three horizons. Horizon One has to do with technologies you could implement today. A Horizon One technology would be laminar flow control for our winglets. Horizon Two is midrange, while Horizon Three is disruptive technologies that certainly wouldn't be seen in our products or factories for five or 10 years. Active flow control would be an example, or graphene or nanotube structures, or structural health monitoring embedded into the structure. If the defense and space side needed aluminum alloy, and so did the commercial side, there was no sense doing it twice.

On the space side, something that we're doing now that's Horizon One is additive manufacturing for structural parts, metallic parts. We just implemented all-electric propulsion for satellites, where the only propellant you're carrying is xenon for thrusters. As for Horizon Three, there is so much going on in terms of real-time processing and adaptive beam forming. There will be capability on demand, the cloud in the sky. You're also going to see development of much larger spacecraft, but also much smaller spacecraft as you see capabilities disaggregated into small satellites that work collectively. So you could have centralized control of a distributed set of very small, very affordable assets that could produce more capability than any single large satellite you could ever imagine.

Any particular cases when your intuition or instincts came into play, and you advised the customer to go with a certain technology that they were reluctant to embrace?

On the aircraft side, that's pretty easy. It's the 787. People were afraid that composites wouldn't be able to stand up to normal impact events like hail, ramp rash, lightning, etc. We ended up taking a small composite panel and a hammer to many meetings to let people literally pound on it. On the space side, the all-electric 702SP satellite. Stacking these satellites together so you can launch two at a time and achieve a 20 percent reduction in cost. I think customers were hesitant about sharing a ride that way, but it proved to be successful.

What about the human element?

The history of aerospace is not a history of machines. It's a history of people. You called it "instincts," but I call it beliefs. What they believe they can create, and their commitment to seeing those beliefs come to life. Then the left-brain logical thinking comes in, which can break down the mission logically. To reach the moon, we had Mercury, then Gemini, then Apollo. All logical steps, but something set that whole chain into motion, and that was the belief we were going to the moon. It didn't matter that we had to talk to computers through punch cards and everyone had to use slide rules. The country stuck to the mission.

Whether it's a company of 5,000 engineers or five engineers, it all comes down to good ideas being discussed, debated and brought to reality. You can ask [747 designer] Joe Sutter, "What was it like when you had to get the funding for the 747, and nothing like that had ever been done before, and people told you that you were crazy?" That's the same problem as you have when you're talking about building the replacement for the Saturn [5 rocket], the Space Launch System, which will be bigger than Saturn.

So what do you see as the future of space launch capabilities, such as the Space Launch System?

We've got a plan there that makes excellent use of a whole bookcase of proven technologies. It goes back to [public support for] Apollo. The reason Apollo was successful was because we stayed the course. I remember playing baseball in the middle of the street when my friend's dad yelled at us to come inside to watch the moon landing. Because I remember that, I know we can do it again. I know we can go to Mars. There is zero doubt in my mind that we can do it technically. But do the American people want to do it?

By the way, what really inspired me was the X-15, which was actually the first step in the journey to the moon. My father worked at North American Aviation at the time, and he brought home a model of the X-15, which I had hanging over my bed. I looked at it every night before I fell asleep. And I know I'm not unique in this even today. The desire to go to space is still there.

What about the commercial sector?

In the commercial arena, the thing that drove the backlog – we've got a huge backlog in commercial airplanes – is because we've made them so incredibly efficient and environmentally responsible. Compared to the 707, which first flew in 1957, the airplanes we produce today are 75 percent more fuel efficient and 90 percent quieter. The fuel efficiency of a 787 is actually better than that of a Toyota Prius, when you look at fuel efficiency per passenger. We have really been able to crack the code in terms of using advanced composites, advanced aerodynamics to reduce drag, advanced systems that make the planes more electric and get rid of bleed air from the engines. We are actually committed to improving the fuel efficiency of the fleet by 1.5 percent every year.

How do you think the aviation landscape will look in 2050?

We now have something like 3.5 billion passengers a year flying. This number will dramatically go up, and that's driving the aviation landscape. The ATM [air traffic management] system will look radically different, because if it doesn't, we can't support that growth. I think there are opportunities around mixed-mode transportation where you get picked up at your house at one end and delivered to your destination at the other end. I actually am convinced that supersonics and hypersonics will be part of this world. Supersonic transportation will be coming back. I also think you'll see unmanned freighters by 2050.

Are there any projects that fell through that you wish had come to fruition?

We had worked on the High Speed Civil Transport, and before that the Supersonic Transport. The large commercial supersonic transport projects were fantastic. I think they will come back. The reason they didn't come to fruition was because of the state of the economy at the time, and people valued economy over speed. We can resolve issues over sonic boom so you can fly over land. We'll have planes that are fuel-efficient enough that we can overcome the [efficiency] penalty you pay [for supersonic flight]. On the military side, the one program I think we'll see coming back is directed energy, like Airborne Laser. There is clearly a need for good missile defense.

What was your proudest moment at Boeing?

My proudest moment at Boeing was the same on the very first day and [as it will be on] the last day. For 35 years, I've been able to say I'm an engineer at Boeing.

John Tracy

Title: *Chief technology officer, Boeing (retiring July 2016)*

Age: *61*

Birthplace: *Los Angeles*

Education: *Ph.D. in engineering, Univ. of California-Irvine; M.S. in physics, California State University-Los Angeles; B.S. in physics, California State University-Dominguez Hills.*

Residence: *Chicago*

Family: *Wife, Katherine Katsumata Tracy. Children Scott Tracy and Wendy MacGinnis.*

Interest: *Advocating for science, technology, engineering and math (STEM) education.*

Favorite quote: *"It behooves no one to dismiss any novel idea with the statement, 'It can't be done.'"*
William Boeing

Living Lunar

NASA's Orion spacecraft, left, delivers a cylindrical logistics module to an astronaut habitat in this artist's rendering.

Facing a possibility that an Orion crew will not have anywhere to go in deep space in the near term, NASA has revived a dormant idea to build a lunar-vicinity orbit outpost. Tom Jones explains how a cislunar habitat could serve as a training waystation as astronauts prepare for future journeys to Mars.

NASA is getting serious about sending astronauts beyond low Earth orbit again. In 2012, the agency examined the possibility of stationing an outpost beyond the far side of the moon as a waystation for exploring the lunar surface and gaining experience needed for reaching Mars. But the Obama administration didn't adopt the outpost plan, proposing instead NASA's Asteroid Redirect Mission, ARM, where astronauts would rendezvous with a boulder retrieved from an asteroid.

NASA is now reviving the idea of assembling a small outpost, including a habitat module, in cislunar space between the Earth and moon or in orbit around the moon. Why? The need to acquire operational experience in deep space, meaning at the moon or beyond, coupled with widespread opposition in Congress to the asteroid mission.

NASA plans to test its Orion spacecraft and Space Launch System rocket combination in a series of flights progressing into the 2020s. First, the SLS will boost an unmanned Orion on a loop around the moon in late 2018. Then, no earlier than 2021, the rocket will launch an Orion crew into lunar orbit. After one or more additional SLS-Orion tests, NASA hopes to send a crew around the moon to rendezvous with an asteroid in 2026.

However, the federal funding outlook for the asteroid mission is very shaky. If the mission fails to win support in 2017 from the new president and Congress, Orion will have no destination a decade from now. Repeated visits to lunar orbit will look like NASA is marking time until a Mars mission sometime after 2035.

NASA thus would like to have another near-term destination for Orion in deep space. That could be an outpost near the moon, where astronauts could live and work beyond low Earth orbit for the first time since Apollo ended in 1972. The outpost would also enable visiting astronauts to conduct scientific operations around the moon, as they would on later journeys to the Mars system. Although American Scott Kelly and Russian Mikhail Kornienko returned in March from spending nearly a year aboard the International Space Station, even extended stints in low Earth orbit can't simulate solar and cosmic radiation and other deep-space conditions that humans will encounter on journeys to Mars.

NASA is examining how it might use the SLS and Orion to assemble a bare-bones outpost near the moon. The agency is hoping it can get started on the job as early as the first Orion crewed flight in 2021, with that spacecraft providing power, life support (oxygen, water, carbon-dioxide removal), control of the outpost's orientation, or attitude, and a radiation shelter.

Next steps

Last year, NASA invited the industry to study the architectures and technologies needed for a possible cislunar outpost. The agency's Next Space Technologies for Exploration Partnerships, or NextSTEP, program aims to advance technologies for deep-space habitats and also solar electric propulsion and small satellites.

Jason Crusan, who runs NextSTEP as director of the Advanced Exploration Systems Division of NASA's Human Exploration and Operations Mission Directorate, points to the work on deep-space habitats as key for NASA.

"We'll have launchers and space vehicles," Crusan says, "but staying anywhere in deep space will require a habitat. Orion itself can sustain two astronauts for 20-plus days around the moon, but we know for stays of a month or longer, we'll need a habitat."

NASA awarded seven one-year study contracts to the industry last year. Each firm received up to $1 million, which the companies had to match. Boeing, Lockheed Martin, Orbital ATK and Bigelow will develop habitat operations concepts, while Dynetics, Hamilton Sundstrand and Orbital Technologies will focus on specific life-support solutions. Each of the habitat industry partners will examine habitat technologies, operations and assembly milestones. Results are due to NASA by Sept. 30, along with a proposal from each for a phase-two study.

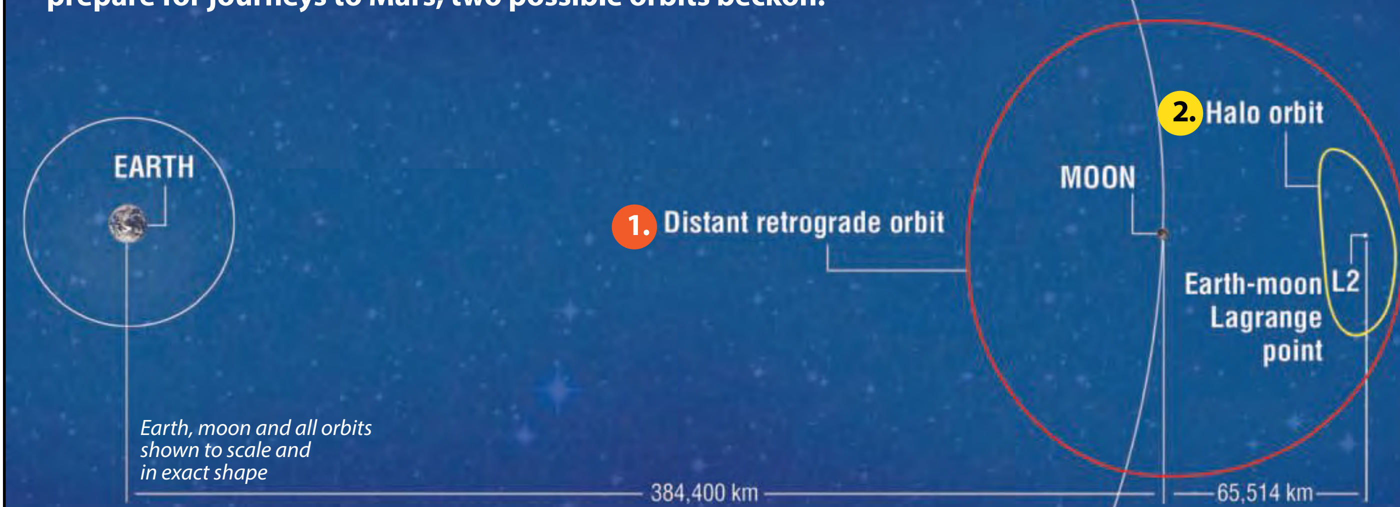
Crusan says that on deep-space missions, crews will need a module that provides living space, exercise gear and life support capacity. Building a cislunar habitat would firmly establish NASA in deep space, stretching its abilities toward Mars while helping the industry transition from supporting the space station to building commercial stations in LEO.

Habitat on a budget

The habitat effort results from "a rare alignment in human exploration priorities between the [Obama] administration and Congress," Crusan says. "They both agree the habitat is the

Two locations for a deep-space outpost

As NASA examines building an astronaut habitat around the moon to prepare for journeys to Mars, two possible orbits beckon.

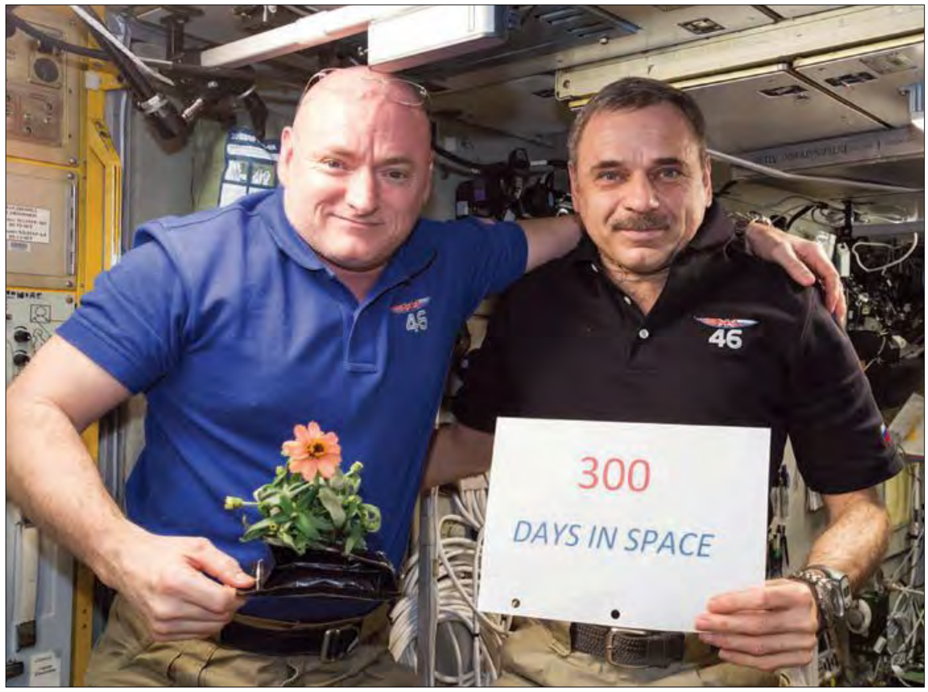


1. **DISTANT RETROGRADE ORBIT:**
   A highly stable orbit that requires fewer maneuvers and less propellant than an orbit closer to the moon.
2. **HALO ORBIT:**
   Orbiting around the Earth-moon L2 Lagrange point would be fuel efficient and allow astronauts to observe the moon's far side while staying in continuous communication with Earth.

Source: Lockheed Martin; Graphic by Anatoly Zak / RussianSpaceWeb.com next thing we need to do in engineering for deep space."

Congress has agreed to fund $53 million in habitat studies in fiscal 2016; NextSTEP is part of that package. NASA envisions a lunar-vicinity habitat that would be tended by astronauts visiting for a few weeks a year, rather than manned continuously like the International Space Station. Crusan says the outpost would start small, be adaptable and affordable, and serve as a science platform as astronauts gain experience in deep-space operations. What NASA does not want is a costly, complex duplicate of the space station — this time around the moon.

For habitat designers, there's good news and bad news around the moon. The thermal environment in a high lunar orbit is more benign than in low Earth orbit or in a lower, Apollo-style lunar orbit, where radiated heat from the Earth or the moon requires larger radiators and cooling capacity. The lunar vicinity is devoid of man-made space debris, but natural micrometeoroids are still a hazard. Among the negatives, there are no quick abort options from lunar orbit. Getting home takes days, not the hour or two needed for an emergency return to Earth from the space station. A cislunar outpost is also at the end of an expensive and tenuous supply chain, requiring careful management of consumables and spare parts. The biggest challenge is radiation: A cislunar outpost, unlike one in low Earth orbit, is exposed to solar proton storms and a steady stream of galactic cosmic rays. Yet with each problem solved, NASA will be that much closer to understanding how to get crews to and from Mars.



NASA

Scott Kelly, left, of the U.S. and Mikhail Kornienko of Russia set a record in March 2016 after spending 340 days aboard the International Space Station. Even extended stints in low Earth orbit can't fully prepare astronauts for deep-space conditions they would encounter on the way to Mars.

Room for four

Lockheed Martin's Josh Hopkins, acting space exploration architect, and Bill Pratt, the company's manager for NextSTEP habitat work, say that their team is examining a human-tended, cislunar outpost with an operational life of at least 10 years. It would consist of a habitat module, airlock, and propulsion and power modules with thrusters, solar arrays, and batteries. Four-person Orion crews could visit the habitat for 30-day stays, eventually extending that to two months or longer.

Because Orion was designed with circumlunar missions in mind, its systems can supply some of a habitat's initial needs for heating and cooling, power, attitude control and life support, Hopkins says. Using Orion, NASA could start visiting a habitat more quickly and cheaply than if it waited for a fully outfitted version. The module the astronauts would occupy could be built from modified versions of space station cargo transports like Europe's Automated Transfer Vehicle or Japan's H-2 Transfer Vehicle. Subsequent Orion visits would add solar arrays, propulsion and more capable environmental control systems.

The outpost would travel in either a lunar distant retrograde orbit or a halo orbit around the Earth-moon L2 Lagrange point. The highly-stable distant retrograde orbit would require fewer maneuvers than an orbit closer to the moon. In the L2 option, balanced gravitational forces would allow the habitat to orbit with little fuel expenditure some 65,000 kilometers beyond the moon's far side.

Astronauts could teleoperate rovers down on the surface. The rovers would explore geologically intriguing features such as the ancient South Pole-Aitken impact basin, and perhaps undertake the layout of sensitive radio-astronomy antennae on the radio-quiet lunar far side. Similar telescience operations would be possible between astronauts on the Mars moons, Phobos and Deimos, and rovers on the red planet.

Habitat as a stepping stone

If ARM does deliver its asteroid boulder to lunar orbit by the mid-2020s, the fragment could be docked at the cislunar habitat, where a visiting Orion crew could use the habitat airlock to conduct multiple spacewalks to probe and sample the asteroid. By contrast, the current ARM plan includes just one or two spacewalks conducted from Orion's depressurized crew cabin. Should ARM be canceled, the cislunar habitat would still give

NASA a place to practice its deep-space skills in the 2020s.

Lockheed's Pratt notes that a single 45-day crew stay in lunar orbit would surpass the entire deep-space experience of the Apollo era. His colleague Hopkins says: "Over time, we can work our way up to a year-long stay in deep space. We won't need to do many like that, but it's probably a box we'll need to check before we head for Mars."

Getting real

Even with nearly flat budget projections, NASA's Crusan is optimistic that the agency can fund the incremental construction of a cislunar habitat. By the mid-2020s, the sun will be setting on International Space Station operations, and development costs for Orion and SLS will be winding down, too. The first SLS to fly with an Exploration Upper Stage could launch Orion and an additional 10-ton habitat element to a distant retrograde orbit around the moon. Subsequent annual SLS-Orion launches could then expand the habitat and support 30- to 60-day stays by the late 2020s. Hopkins is eager to get started.

"NASA has told us they want to get a toe-hold in cislunar space as soon as possible, perhaps as early as" Exploration Mission 2, the first Orion-crewed mission planned for around 2021.

A natural question is whether this round of habitat planning will prove any more fruitful than the cislunar waypoint idea that failed to get traction in 2012, or the now-shaky prospects for retrieving an asteroid boulder. How will these current outpost studies survive the shock of first contact with a new administration's space priorities?

Answers Crusan: "If we're going to Mars, you'll still want to test [solar electric propulsion] and a hab in deep space, no matter what happens to ARM. Both ARM and the cislunar habitat are essential elements in NASA's plan to establish humans in deep space."

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Very fast hypersonic weapons pose challenges with materials and control. DARPA's Hypersonic Technology Vehicle-2, shown in an artist's rendering, crashed in 2011 when its skin peeled off.

Über drones

by Michael Peck
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In an isolated farmhouse in a remote region of a Central Asian nation, the terrorist leaders gather, their goal to plot a deadly attack on American soil. But the secret meeting has been detected by U.S. intelligence, and within minutes the attack order comes from the White House.

From under the Arabian Sea, a U.S. submarine launches a rocket that soars almost to the edge of space before releasing an unpowered glider, which then descends at Mach 8 toward its target 5,000 kilometers away.

If the Pentagon is right, the glider will strike the farmhouse and its occupants before the terrorists have a chance to disperse, and long before cruise missiles, drones, attack jets or commandos could arrive. But if critics are right, Russia could mistake a hypersonic missile headed near


Lockheed Martin

The Pentagon loves its propeller-driven armed drones, but putting them on patrol requires negotiating basing rights. They're slow, easy to shoot down and worthless where the U.S. doesn't control the airspace. So, why not put a hypersonic glider on a missile and fire it at a target? The Pentagon likes the idea of Prompt Global Strike and wants to boost spending on the technologies. Michael Peck probes the promise and risks of this highly classified effort.

its border as a prelude to an American nuclear attack.

The debate over the wisdom of developing and deploying such weapons has simmered for nearly two decades. With the Pentagon now asking for a sharp increase in Conventional Prompt Global Strike funding, actual weapons could be on the horizon, and that has critics asking hard questions about the strategy.

Painful history

The goal of CPGS is to make hypersonic weapons that can hit targets several thousand kilometers away in as little as one hour. That would be a big step toward solving an age-old problem: Between the time a target is detected and the strike arrives, the target might slip away. The Pentagon calls this the TST problem, short for time-senstive target.

The impetus for solving this conundrum comes, at least in part, from the results of a Tomahawk cruise missile attack launched after the 1998 attacks on U.S. embassies in Kenya and Tanzania that killed 224. Tomahawks roared from U.S. subs in the Arabian Sea bound for multiple sites in Afghanistan, but the missiles missed killing Osama bin Laden by a matter of hours, according to the 9/11 Commission. How might history have changed if those missiles had traveled at Mach 8 or Mach 18 instead of plodding along subsonically at 900 kilometers per hour?

After the embassy attacks, the Pentagon and civilian leaders were determined to find a better way to strike time-sensitive targets. In 2000, the Clinton administration began flying video-camera-equipped Predator drones over Afghanistan to provide real-time intelligence, and in 2001, the

Turning-point attacks: The 1998 terrorist bombings of the U.S. embassies in Kenya and Tanzania, right, inspired the the Pentagon to pursue weapons that would strike distant targets more quickly.


Associated Press

George W. Bush administration took up the question of whether to arm those drones with Hellfire missiles. That way, if bin Laden were spotted, the drone could be commanded to shoot. The armed-drone debate ended with the Sept. 11 terror attacks, and the modern era of drone warfare was upon us. Also at about that time, the Air Force announced it would pursue the Prompt Global Strike mission.


U.S. Navy

The U.S. launched Tomahawk cruise missiles at terrorist camps in Afghanistan after the 1998 bombings of U.S. embassies in Kenya and Tanzania. But the Tomahawks missed Osama bin Laden by hours.

It was another possible way to get at time-sensitive targets, but one that would take years of research.

The prompt-strike concept has followed many twists and turns in the years since conventionally armed intercontinental ballistic missiles were first suggested in the 1970s. In the early 2000s, the Air Force and Navy pursued conventional warheads on ICBMs, until the idea was dropped because Congress feared that those ICBMs could be mistaken for a nuclear strike. In 2008, Congress consolidated the Air Force and Navy programs into the Conventional Prompt Global Strike program. The Obama Pentagon switched the emphasis to boost-glide systems, in which rockets would loft gliders to nearly the edge of space, after which the gliders would descend on their targets at hypersonic speeds, defined as greater than Mach 5. Because gliders remain in the atmosphere rather than arcing through space like ICBMs, their trajectory should in theory not be mistaken for ballistic missiles. The gliders would probably be slower and have a shorter range than ICBMs, so current plans focus on launching gliders from ships positioned within range of a target.

Secretive program

Most details of what the U.S. military is doing to develop these weapons remain classified. The Pentagon responded to my inquiries with a written statement: "The Department is evaluating and conducting risk reduction activities on a wide variety of potential future hypersonic capabilities," it says. "However, due to national security reasons, no information is available on the specifics of these efforts."

I was able to discern the basic picture from budget documents, press releases and analyses by arms control experts who have followed Prompt Global Strike for years.

First, there is the Pentagon's planned funding increase. The fiscal year 2017 budget request asks for $181.3 million to develop Conventional Prompt Global Strike. While that figure is relatively modest — about the price of a mere two F-35 fighters — it is almost double the $95.6 million that Congress allocated in fiscal 2015. By 2021, proposed funding would rise to $225.4 million, according to the Pentagon's long-range budget plan.

For now, the focus seems to be on developing the glider part of the boost-glide package, and the Army has joined the picture. Most of the requested funding is for development of the Advanced Hypersonic Weapon, or AHW. In 2011, it flew for the first time when it was launched atop a retired Polaris A3 ballistic missile and completed a 30 minute flight over the Pacific Ocean. A booster malfunction in 2014 doomed the second flight.

ICBMs, such as the land-based Minuteman and submarine-launched Trident, travel at Mach 23 and can reach targets 10,000 kilometers away, but AHW's goal appears to be more modest. A clue can be found in a 2008 National Academy of Sciences report on Prompt Global Strike, which describes the Pentagon's goal as a hypersonic glider with a range of about 7,800 kilometers. During its 2011 flight, the AHW traveled 3,700 kilometers, from Hawaii to Kwajalein Atoll.

"The AHW is intercontinental, but it's not global," says James Acton, a critic of Prompt Global Strike and co-director of the Nuclear Policy Program at the Carnegie Endowment for International Peace. As he sees it, the weapon might not achieve the "prompt" in CPGS either. "If you have to move the submarine or ship to be within range of the target, then the time-scales for the weapon reaching the target are much longer than an hour."

Traveling 3,700 kilometers in less than 30 minutes suggests a speed for the AHW of at least Mach 6. This would be much slower than envisioned under DARPA's FALCON, or Force Application and Launch from Continental United States, program that aimed to demonstrate a booster-launched glider that could reach any target on Earth from a launch site in the U.S. The FALCON Hypersonic Technology Vehicle-2 achieved a sizzling Mach 20 in 2011 on its first flight. The flight ended with the HTV-2 crashing into the Pacific Ocean after its skin peeled off in the intense heat, a reminder that very fast hypersonic speeds present control and materials challenges.

Most of the Pentagon's 2017 budget request for Conventional Prompt Global Strike is for the Army's Advanced Hypersonic Weapon, which lacks the range to span the globe.

U.S. Army

The rocket-launched Hypersonic Technology Vehicle-2 is DARPA's effort to develop a weapon that could strike any target on Earth from the U.S.

Lockheed Martin

As for how the AHW will be deployed, the evidence points to a sea-based system. Though AHW is an Army project, the 2017 Pentagon budget lists two scheduled "Navy Flight Experiments" for the glider, the first to have begun in 2014 and end in 2017, and the second to begin in 2017 and end in 2020. One possibility is that the AHW will be launched from the Navy's Virginia-class attack submarines, according to a 2015 Congressional Research Service report on CPGS. The Navy is developing a hull extension for the subs, called the Virginia Payload Module, which contains four tubes for launching Tomahawk cruise missiles. If used to launch AHW, this suggests that the booster can't be any bigger than a Tomahawk.

Meanwhile, DARPA is working on a weapon called Tactical Boost Glide. Though not part of Prompt Global Strike — the funding is under DARPA rather than the Department of Defense's Conventional Prompt Global Strike account — the agency has requested $22.8 million for fiscal year 2017, with development of the initial flight test plan, preliminary and critical design review, and assembly, integration and test scheduled for the remainder of fiscal year 2016 and 2017.

DARPA won't comment on Tactical Boost Glide, but its budget documents suggest a sea-based system to launch weapons of a particular size. The agency's 2017 budget document says "the program will also consider traceability to, and ideally compatibility with, the Navy Vertical Launch System." Vertical launch systems such as the U.S. Navy's MK 41 VLS, manufactured by Lockheed Martin, consist of rows of launch tubes installed on the decks of surface ships and some submarines. They can fire Tomahawks as well as anti-aircraft and anti-submarine missiles. The desire for compatibility suggests that the Tactical Boost Glide weapon must be small enough to fit into these existing canisters.

Another technology that could apply to CPGS would be a supersonic combustion ramjet, or scramjet weapon patterned after the X-51 Waverider technology demonstrator built by Boeing for the Air Force Research Lab. It cruised at Mach 5.1 in 2013, using its Rocketdyne-built scramjet to compress air from the atmosphere for combustion.

"This technology remains in its early stages, and could not contribute to the [Prompt Global Strike] mission for several years," notes the 2015 Congressional Research Service report. "However, because these vehicles would not leave the atmosphere or fly on a ballistic missile trajectory, they may address the nuclear ambiguity issues raised by long-range ballistic missiles in the [Conventional Prompt Global Strike] program."

Unanticipated consequences

Ambiguity has been at the core of the controversy over Prompt Global Strike since the early 2000s, when the Navy proposed replacing the nuclear missiles on several ballistic missile submarines with conventionally armed Tridents. Horrified at the thought of how Russia might react to uncertainty over whether a submarine is launching a nuclear-armed or conventional missile, Congress refused to fund the idea.

I asked the Pentagon about the risk of such a mistake. "Russia is less likely to misinterpret a boost-glide system flying a non-ballistic trajectory as a nuclear strike," the statement says. That's especially true if the weapon were "launched from a non-nuclear base/platform." The statement goes on to say that "Boost-glide technology would also enable launch trajectories that avoid overflying Russia."

Proponents say Prompt Global Strike is a feasible alternative to the near-unthinkable option of using nuclear weapons. The new weapons "would increase options available to the President in crises and conflicts, including the ability to hold at risk key high-value targets with rapidly executed, high-precision attacks," the Pentagon says. Studies, notably a 2009 Defense Science Board report, have proposed multiple uses for Prompt Global Strike, such as wiping out terrorists, destroying weapons of mass destruction, knocking out an adversary's anti-satellite weapons, or as defense suppression to neutralize anti-ship or aircraft missiles in areas like the Persian Gulf or South China Sea.

Critics like Acton fear that these hypersonic weapons would turn out to be as politically destabilizing as conventionally armed ICBMs. Paradoxically, nuclear-armed ICBMs make adversaries less nervous in one sense: An enemy would see the missiles coming. That's because their ballistic trajectories arc up to 1,000 kilometers into space, making them easy for radars to spot, says Acton, author of "Silver Bullets," a 2013 Carnegie Endowment book on Prompt Global Strike. In his view, the danger of boost-glide weapons springs from this element of surprise. "Boost glide flies at relatively low altitudes, from tens of kilometers up to 100 kilometers high." The curve of the Earth would shield the weapons from view, and they wouldn't be visible on early warning radar until very late, he explains.

Imagine you're a commander in Russia: "If Russia had a satellite in the right place, it would see the launch, and then it would see nothing at all." The weapon would appear and disappear from Russian radar screens, and unlike a ballistic missile, Russia could not predict the impact point. "It is not clear to me that this is more reassuring from a Russian perspective," Acton adds. The Russian arsenal could be put on a hair trigger that would leave the U.S. vulnerable to miscalculation. For example, Moscow might detect a hypersonic weapon and worry it could suddenly materialize over Russia in a blast of electromagnetic pulse radiation that would disable radar and communications networks as the opening salvo of a first strike.

Paranoid as that might sound, history shows that leaders in Moscow can be predisposed to believe the worst. The Soviets were convinced in the early 1980s that the Reagan administration was planning a nuclear first strike. Fears of U.S. capabilities and a mistrust of U.S. intentions linger today. This raises the question of whether Mach 8 missiles fired at anti-satellite rockets on the ground in China or Russia, for example, could end up triggering nuclear war.

> ***"Russia is less likely to misinterpret a boost glide-system flying a non-ballistic trajectory as a nuclear strike ... ."***
> **—Pentagon statement**

Prompt Global Strike also raises arms control questions. During the negotiations over the 2010 New Strategic Arms Reduction Treaty, the U.S. rejected Russian attempts to ban conventionally armed ICBMs. Washington did agree to count any such missiles against the number of missiles allowed by the treaty, but it argued that boost-glide weapons aren't covered by that language. Without any bilateral or multilateral restrictions on these new weapons, Russia has deployed hypersonic anti-ship missiles, and China has developed a hypersonic glider, raising fears that

Prompt Global Strike could trigger a hypersonic arms race.

There are also concerns about the military utility of Prompt Global Strike, given how much commanders would have to know about a target to justify using the weapons. A 2008 Government Accountability Office report concluded that the Pentagon was not paying sufficient attention to "critical enabling capabilities" for Prompt Global Strike, including "intelligence collection and dissemination, surveillance and reconnaissance, and command and control, communications, and battlefield damage assessment."


U.S. Navy

The U.S. Navy's Virginia-class attack submarines, such as the Minnesota under construction in Newport Beach, Virginia, could serve as the launch platform for Advanced Hypersonic Weapons.

Acton also questions the survivability of boost-glide weapons against a sophisticated adversary. Unlike ballistic missiles that spend most of their trajectory in the cold of space, hypersonic gliders generate tremendous heat while plowing through the atmosphere. If such weapons were launched at the U.S., the infrared-sensing Terminal High Altitude Area Defense rockets would easily detect and engage them, especially given the slower speed of a glider compared to a ballistic warhead, Acton says. Tactically speaking, he suggests that stealthiness might be more important than speed. "If the weapon takes hours to reach the target, but the Chinese have no warning, the strike may be successful. If the weapon reaches the target in an hour but the Chinese have warning, then the strike may fail."

"If I were the U.S., I would much prefer that China shoot gliders at me in the Western Pacific than ballistic missiles," Acton adds. "I think that if the U.S. makes the right investments, it can defeat Chinese gliders more easily than Chinese ballistic missiles."

FLYING ON electrons

NASA and European researchers are testing electric-propulsion technologies on small planes in hopes of having a big impact on the kinds of planes we fly in the next 10 to 15 years. Keith Button examines just how far the technology can go in that time, and considers what could lie beyond.

by Keith Button
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Engineers at NASA's Armstrong Flight Research Center in California expect to take delivery in May of a new Tecnam P-2006T twin propeller, four-seat airplane, then promptly tear it apart. The Tecnam's 34-foot-long stock wing, which bolts to the top of the fuselage, will be replaced with one with a dozen electric motors and propellers along its leading edge and two motors with propellers on the wingtips. In place of the two fuel tanks, 800 pounds of lithium-ion batteries will be installed. The resulting all-electric plane will be called SCEPTOR, short for Scalable Convergent Electric Propulsion Technology and Operations Research. Engineers from Armstrong and NASA's Langley Research Center in Virginia plan to fly it in 2018 to test how well this distributed electric propulsion technique increases aerodynamic efficiency.

SCEPTOR and other projects underway in Europe could well determine whether airline passengers of the future will climb aboard strange but highly efficient electric aircraft with propellers and motors arrayed strategically on wings or fuselages.

Today's passenger jets have lots of electricity aboard, but it's not used for propulsion. A Boeing 787's electrical generators produce 1.45 megawatts, and some of this electricity is stored in two lithium batteries in the fuselage. This electricity starts the engines, powers the brakes, pressurizes the cabin and keeps it a comfortable temperature. One reason airplane designers haven't pushed for electric propulsion is that until now it's been possible to meet fuel efficiency goals with traditional tube-and-wing designs and combustion engines. That status quo is beginning to shift as some policy makers begin to look for ways to eliminate even more carbon dioxide from all sectors of the economy, including the air transportation sector.

For skeptics, the concept of electrically powered flight has conjured images of airplanes straining under the weight of clunky electric motors and heavy batteries that are bound to run out of juice mid-flight. While batteries are indeed a limiting factor for the boldest visions, some engineers are convinced that there are ways around this problem in the near term. Small combustion engines could serve as generators to recharge batteries in flight aboard mid-sized, electrically propelled passenger planes.

NASA engineers are preparing to modify an Italian-built Tecnam P2006T with electric motors and propellers and lithium-ion batteries to conver it to an all-electric plane.

Future vision

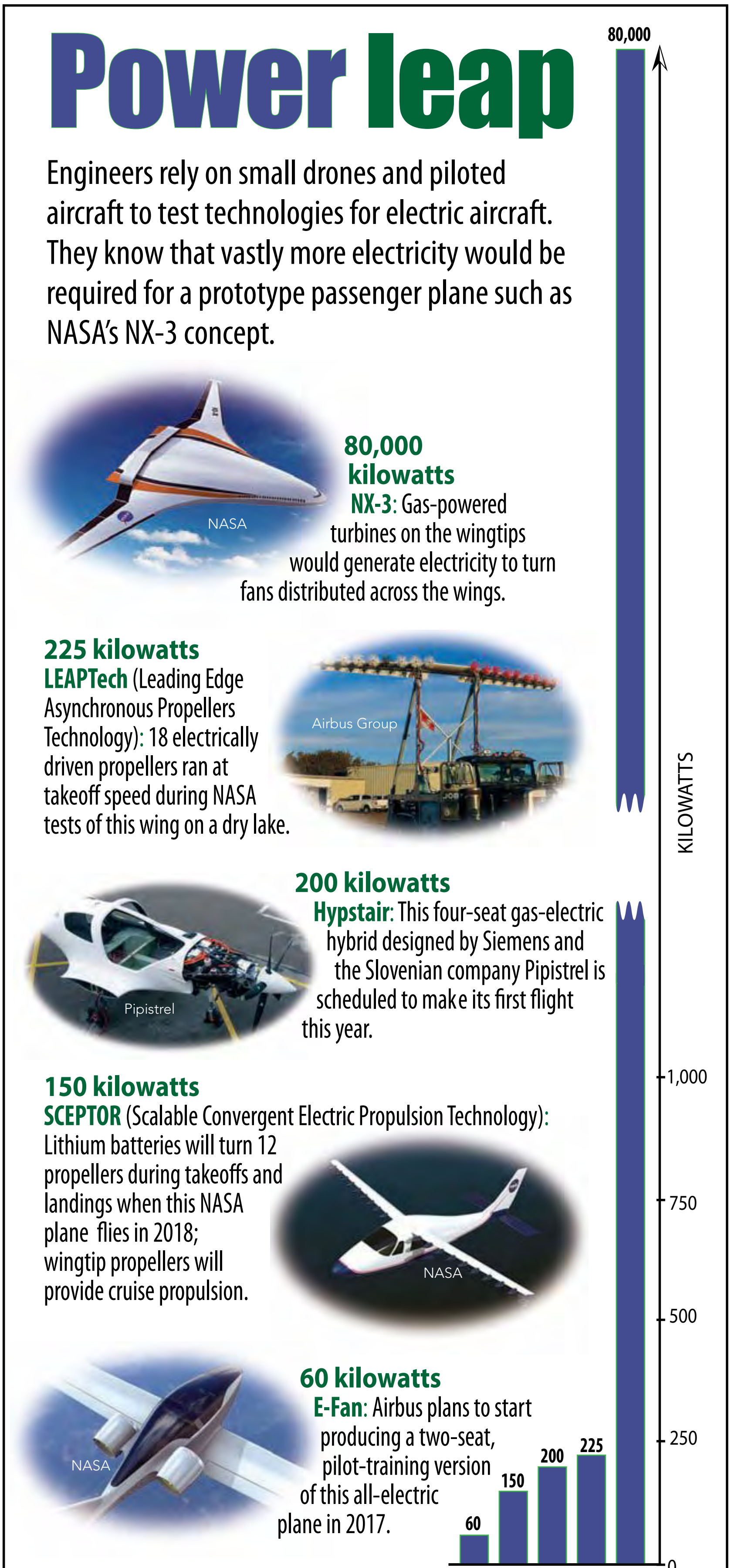
Other engineers continue to think big. Engineers at NASA Glenn Research Center in Ohio are examining the breakthroughs that would be required to build an 80 megawatt hybrid-electric, distributed propulsion, blended wing body airplane in about 15 years. The passenger capacity range and cruise speed of the projected plane, called the N3-X, would be comparable to the 300-passenger Boeing 777-200LR. The N3-X aircraft would need superconducting motors, generators and power lines that would operate at temperatures below minus 340 degrees Fahrenheit to eliminate electrical resistance. Superconducting would make electric motors and generators extremely light. Conventional electric motors and generators would be far too heavy at the scale required for a 300-passenger plane.

The N3-X also would tap some innovations in current and near-future electric planes. Power supplies could be linked to propulsion by wires or electrical buses instead of machinery. A variety of sizes of fans and propellers could be used, and combustion engines could drive electric power generation in a hybrid-electric arrangement. These concepts have been tested or are in development for small electric aircraft, and that's why engineers are excited by these projects.

"NASA would love to build a 400- or 600-passenger airplane that uses hybrid electrical technologies, but there's a lot of lessons we need to learn along the way, and it would be very expensive for us to learn" on a large test aircraft, says Sean Clarke, NASA's co-principal investigator for SCEPTOR. "So if we can take a lot of what we learn on small, inexpensive and easy-to-execute projects, and apply those to progressively bigger ones, then the whole process is much more efficient."

Comfortable at the controls

Before the SCEPTOR engineers replace the Tecnam's wing with their own, they will remove the two stock piston engines from the plane and mount two electric motors in their place to turn the plane's propellers, with electricity provided by lithium-ion batteries added in the fuselage. Flying the dual-motor electric version of the Tecnam will help the test pilots familiarize themselves with how the batteries and electric motors perform before they have to take on the challenge of flying with the modified wing. Once the stock wing is removed and the



Source: Aerospace America reporting

modified wing installed, the new wing will present different handling properties for the pilots, with its distributed propulsion, motors on the wingtips and other differences in the lift and drag.

For the SCEPTOR flight testing, the NASA engineers decided to fly a piloted plane instead of a drone because having a human pilot in the feedback loop would be simpler and more reliable.

"You end up designing fairly complex fail-safe mechanisms and redundancy controls when you have to automate everything, because you need to be able to handle communication interruptions and telemetry dropouts and all kinds of real, real problems that come up when you're actually testing," Clarke says. A skilled pilot in the airplane can handle just about any problem, and testing is more efficient and much less complex.

When the new wing and its 14 electric motors are added, cruising efficiency will be measured against a stock Tecnam that NASA rented, flew and measured in September 2015. Once the new wing is installed, the 12 smaller motors on the wings will provide propulsion during takeoff and landing. The wingtip propellers will gradually take over as the plane enters cruise.

SCEPTOR is expected to be about five times more efficient in terms of energy use than the stock plane during cruise conditions because of its smaller wing surface area, its use of batteries instead of internal-combustion engines and its reduction of wingtip vortex drag.

One contributing element to the overall efficiency is the SCEPTOR wing design, which has one third the surface area of the stock Tecnam wing. Most aircraft wings have to be designed for less-than-optimum efficiency at cruise because of compromises necessary to accommodate takeoffs and landings. The SCEPTOR wing is smaller than the stock wing, but it can generate the additional lift required during takeoffs and landings because of the distributed motors. The wing is designed for optimum efficiency at cruise speeds, generating much less skin-friction drag, in part because of its smaller surface area.

"We're adding this distributed propulsion system," Clarke says, but the plane isn't "really about propulsion; it's about energizing the air flow over the wing."

NASA is testing an experimental wing with electrically driven propellers as part of its Leading Edge Asynchronous Propeller Technology program.

The lithium-battery system also contributes to efficiency. The SCEPTOR team expects it to be about three times more efficient than internal-combustion engines in terms of how much of the stored chemical energy is converted to torque. For a modern combustion engine, typically 25 percent to 30 percent of the stored chemical energy in fuel is converted to torque, with the rest converted to heat. Electric motors like those on SCEPTOR can be more than 90 percent efficient.

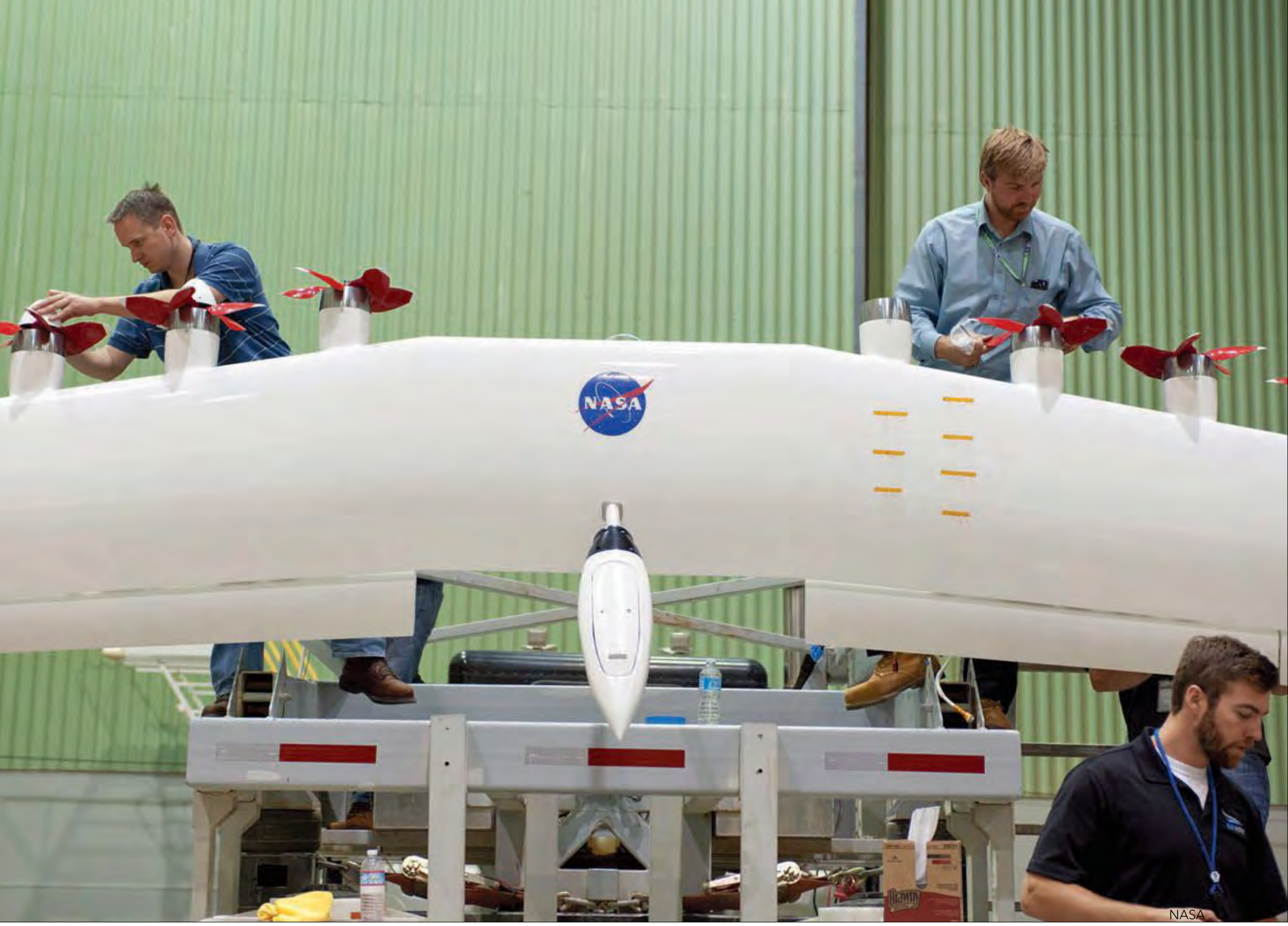
The wingtip propellers are another key. They should contribute 5 to 10 percent of the expected improvement in efficiency. The propellers will rotate in the opposite direction of the vortices normally created as wingtips pass through the air, and the swirl of the propellers will partially reduce the swirl of the vortices, reducing their drag.

A wing and a truck

Engineers honed the SCEPTOR wing design under a project called LEAPTech, short for Leading Edge Asynchronous Propeller Technology. NASA engineers mounted the LEAPTech wing on a tractor-trailer truck and then buzzed up and down runways on the Rogers Dry Lake bed at Edwards Air Force Base, California, during a year of testing that ended in February. Eighteen electrically driven motors with propellers were mounted on the front of the single, 31-foot-long wing. Each motor drew 12.5 kilowatts of battery power for a total of 225 kilowatts, or 300 horsepower, of propulsion. In addition to the teams from Langley and Armstrong, NASA engineers from Glenn Research Center in Cleveland and Ames Research Center in Moffett Field, California, worked on the project.

Preliminary results from LEAPTech suggested that the experimental wing, at takeoff and landing speeds, produced two to three times more lift than the wings on the Cirrus SR22, the general aviation single-propeller five-seater aircraft that the experimental wing was modeled after. And that was despite the fact that the LEAPTech wing had a smaller surface area than the SR22 wings.

That points to one of the main advantages of distributed propulsion: It can optimize efficient flight under various conditions, not just the most taxing conditions. Distributing propellers across an airplane's wings — or a single span in the case of the Tecnam — should boost lift during takeoff and landing. The wings can be designed for optimal performance during cruise, the longest part of the flight.



Engineers at NASA's Armstrong Flight Research Center modify the wing of an experimental plane called SCEPTOR, Scalable Convergent Electric Propulsion Technology and Operations Research. NASA is also replacing the aircraft's two fuel tanks with lithium-ion batteries.

"The beauty of using electric motors is that their weight penalty for carrying around extra engines is minimized because they are so light, and the operating and maintenance burden of owning so many more propulsion devices is minimized because electric motors are so reliable," Clarke says. Building an airplane that used 14 piston motors, instead of 14 electric motors, would be impractical because the maintenance and operating costs would be so high. Electric motors are more reliable because their only moving parts are bearings.

Unique opportunity

Unlike combustion engines, small and large electric motors can be equally efficient, relative to each other, in performing a range of tasks, including spinning propellers or fans. Also, the propeller motors don't have to be right next to where the power is generated or stored. The two can be connected by wire instead of a mechanical drive shaft. An airplane designer is free to distribute them to the locations on the airframe that makes the most sense in terms of efficiency. They could be positioned to push more of the slow-moving air that accumulates near the surface of the fuselage at the back of the plane and less of the already-fast-moving air flowing over the wings. This would enhance propulsion and reduce drag.

"There is this massive opportunity in the decoupling of power generation and thrust generation," says Tine Tomažič, director of research and development for Pipistrel, a Slovenian builder of small airplanes. "That's why people are getting excited."

Pipistrel and Siemens, the German aircraft engine manufacturer, have partnered to design and build a four-seat hybrid electric airplane under their Hypstair program, short for hybrid propulsion system for general aviation aircraft. Siemens has designed and built a 200-kilowatt, lightweight motor to spin the plane's single propeller. The team tested this drivetrain in February by wheeling a partial fuselage outside, blocking the wheels and running the electric-powered propeller in three modes: battery-only, generator-only and hybrid. This last mode combines electricity from the battery with that from a modified piston-engine generator.

Hypstair's engineers plan to take the airplane through at least six to nine months of ground testing before flight testing to establish a baseline of data that can one day help airplane builders demonstrate their compliance with aviation safety regulations. Such rules don't currently exist for hybrid-electric airplanes.

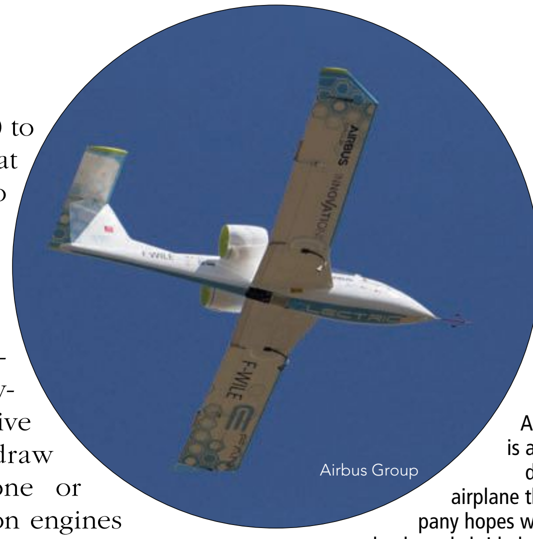
Learning by producing

Airbus is designing and building small electric aircraft with the goal of developing technology and gathering reliability data that would someday be applied to larger, commercial plane designs. The E-Fan all-electric airplane has been piloted across the English Channel and flown at air shows. Airbus plans to put the two-seat plane into production in 2017. Airbus says it plans to use the E-Fan model to better understand the challenges toward developing a hybrid-electric regional airliner or helicopter. This April, the company announced a partnership with Siemens to develop and demonstrate a hybrid-electric propulsion system for such an aircraft by 2020. At Siemens, engineers predict that by 2035 hybrid electric aircraft will be in use for 60- to 100-passenger commercial aircraft.

Waiting for batteries

If electric aircraft have an Achilles heel, it's battery technology. Power storage will probably limit the range of the fully or partially electric aircraft that are fielded over the next 10 to 15 years, says Mark Moore, co-principal investigator at NASA's Langley center for the SCEPTOR project. With battery technology progressing at an annual rate of about seven percent, by 2025 batteries could power flights of 400 nautical miles, even without a hybrid power system.

In the short term, battery-only aircraft with up to 10 seats would have to be limited to shorter flights of up to two hours, Tomažič says. But with a hybrid design, engineers could target a regional passenger airplane with 70 to 100 seats that would fly up to 800 nautical miles, he says.



Airbus's E-Fan is an all-electric demonstrator airplane that the company hopes will eventually lead to a hybrid-electric regional airliner or helicopter.

While technologists work to improve battery capacity, hybrid-electric drive trains will draw power from one or more combustion engines generating electricity on board to augment the batteries. A combustion engine powering a generator can be much smaller than one engine directly powering a propeller, and it doesn't have to be as reliable. Failure of a generator would mean relying on battery power while diverting to a closer airport.

A generator or alternator running on hydrocarbon fuels could be tuned to operate at the point where it's generating power most efficiently. There would be no need to provide surges of power for takeoffs and landings.

Another major hurdle for electric airplane engineers is the power of electric motors relative to their weight. For a normal motor used for industrial applications, the power-to-weight ratio is about 1 kilowatt per kilogram of the motor's weight. For an aircraft application, the ratio has to increase to at least 6 kilowatts per kilogram, says Frank Anton, head of electric aircraft development for Siemens.

But overall, electric airplanes that are heftier than conventional planes shouldn't be an issue because they will be cheaper to operate, says NASA's Moore. Even with 70 percent of the weight of an electric plane tied up in its batteries, they will carry the advantages of significantly lower maintenance costs and improved efficiency.

While it's sometimes said that the primary goal of aircraft designers is to keep the gross weight as low as possible without compromising safety, the broader objective is to safely minimize the cost of operation. New electric airplanes will be designed to be heavier, "but who cares?" Moore says. "They have a far lower cost of operation, and that's what the key is."

10 questions for the

We decided to pose specific, written questions about aerospace to the presidential candidates in the belief that you live in a world of facts rather than campaign platitudes. Did the candidates rise to the challenge? You be the judge.

1. NASA has been criticized for not having a vision. What is your vision for NASA?

Bernie Sanders: NASA may not have a single overarching goal like the one it had in the 1960s, but the agency continues to play a critically important role enhancing our understanding of our planet and the universe, and incubating technological advances that have widespread public benefit.

Human exploration of Mars does seem to be emerging as a top goal of NASA. As I will elaborate below, my administration would consult with stakeholders — including Aerospace America — to prioritize where to focus NASA's efforts.

That said, the value of NASA should never be underestimated: Its work paved the way for technological advances such as advanced computers, cellphones, global positioning systems and other satellite communications. NASA's innovations help keep us connected, track sea level changes and drought conditions, save lives and minimize damage during hurricanes, earthquakes and forest fires.

Donald Trump: NASA has been one of the most important agencies in the United States government for most of my lifetime. It should remain so. NASA should focus on stretching the envelope of space exploration for we have so much to discover and to date we have only scratched the surface. At some point, humans will need to find alternative energy sources, living space and greater technological innovation if we are to thrive as a world society. NASA should be on the point as we go forward.

EDITOR'S NOTE:
The Kasich campaign declined to respond to our questions, but submitted an essay from an adviser (page 34).
The Clinton and Cruz campaigns had not responded by press time.

2. Do you think the U.S. spends too much on NASA, too little or is the budget about right?

Sanders: I support fully funding NASA, not only because of the potential of space exploration and revealing the mysteries of our universe, but also because of the many benefits our society receives from cutting-edge NASA research.

However, I am not prepared to say what the appropriate funding level should be for NASA until we get a handle on the revenue side of the budget. Otherwise, it is a zero sum game: To increase funding for NASA just means cutting some other domestic discretionary program.

We live in an era of manufactured budget crises because for decades, we have given massive tax cuts to the wealthiest Americans and hugely profitable corporations — and then we debate which agencies and programs to cut. As president, I will demand that the wealthy and large corporations pay their fair share in taxes, which will allow us to adequately fund the programs and services that bring widespread benefits to the American people — including NASA.

Trump: I am not sure this is the right question. What we spend in NASA should be appropriate for what we are asking them to do. We also have to balance our spending priorities based on our economic circumstances, and right now, those circumstances are quite challenging. Our first priority is to restore a strong economic base to this country. Then, we can have a discussion about spending.

3. Would your administration continue planning to send astronauts to Mars in the 2030s? Why or why not?

Sanders: In the short term, I would continue planning for human exploration of Mars. However, as I mentioned above, this will require an "all-in" effort by the agency that my administration would evaluate in consultation with stakeholders to determine NASA prioritizes.

Trump: A lot of what my administration would recommend depends on our economic state. If we are growing with all of our people employed and our military readiness back to acceptable levels, then we can take a look at the timeline for sending more people into space.

4. What do you see as the role of government in space exploration compared to the private sector?

Sanders: While space exploration was once the exclusive realm of governments, the private space industry is increasingly commercializing space tourism, satellite launches, and more. This shift coincides with the U.S. government pullback from space exploration — exemplified by the end of the shuttle program, and the globalization of both government-sponsored space exploration and industry-sponsored investment.

The rise of the private space industry has many benefits, but it also raises serious issues, including safety and national security. Irrespective of a growing private sector space industry, there will always be a critically important role for government research, development and implementation, particularly in areas where there is no clear profit motive but where there is a huge potential return for the public.

Research at federal agencies like NASA, the National Science Foundation and the National Institutes of Health have launched countless technologies, new drug treatments and medical devices, cleaner air and water, better nutrition, and many consumer products that have benefitted humankind in so many ways. Federal research and development also plays a critical role incubating ideas that the private sector later harvests: creating jobs, hundreds of billions of dollars a year in economic activity, and significant new tax revenues. There simply would be no private space industry without the groundbreaking work of NASA.

We need to support government-sponsored research to incubate the next wave of innovation and generate new knowledge and ideas that will help regain our economy's competitive edge and improve the quality of life for Americans and all of humankind.

Trump: This is a great question. I think there needs to be a growing partnership between the government and the private sector as we continue to explore space. There seems to be tremendous overlap of interests so it seems logical to go forward together.


Boeing

5. What do you think should be done to improve tracking of commercial aircraft?

Sanders: I find it incredible that two years since flight 370 vanished and more than six years since the disappearance of Air France flight 447, commercial flights are still not required to have tracking technology to locate aircraft when "flying black."

While I would prefer the International Civil Aviation Organization to adopt global standards for aircraft tracking, I believe that should ICAO fail to act in a timely manner, Congress should enact requirements for all U.S. flagged airships and foreign flagged planes that fly in U.S. airspace. Not only would this improve airline safety, but also it would be enormously helpful in terms of national security.

However, flight tracking is just the first step. The goal should be to move toward the ability to stream data in real time from aircraft that are experiencing an emergency.

Trump: Technology will allow us to do more in the future. Using space assets seems an idea worth exploring. If it is economically feasible, placing tracking satellites in orbit may be one step on the way to better international flight safety.

6. How great an impact do you think commercial aviation has on climate change and would your administration continue NASA's Environmentally Responsible Aviation program?

Sanders: While the aviation sector produces less than 3 percent of human-caused carbon dioxide emissions, it is imperative that the fast-growing industry continues to improve aircraft efficiency and seek alternative biofuels to displace traditional hydrocarbon-based jet fuels. To my mind, climate change is the single biggest environmental threat facing our planet, and we must drastically reduce carbon emissions from the combustion of fossil fuels if we have any hopes of avoiding its worst consequences.

The federal government and the aviation industry must work together to develop viable biofuels that meet the understandably rigorous quality requirements for high performance aviation fuel. That is why I strongly support government-funded research into low-CO_2 aviation biofuels, including NASA's Environmentally Responsible Aviation program. In 2013, I introduced the Climate Protection Act that would triple funding for advanced energy research, including biofuels research.

I am optimistic about recent advances in advanced biofuels — including those derived from oil crops like Jatropha and Camelina, cellulosic ethanol, waste fats and oils, biomass sugars, and algae — that could not only move us away from fossil fuels, but also provide an economic boost to rural economies in many parts of our nation.

Trump: I think the level of impact commercial aviation has on climate change is minimal. We should spend our resources on programs and activities that advance and protect the interests of the United States.

7. What is your position on development of technologies for a supersonic air transport?

Sanders: While I understand the allure of civilian supersonic travel, given the enormous challenges facing our country, this would not be a priority for my administration. While I do support NASA's High Speed Civil Transport re-

SANDERS' RESPONSE, continued next page

Trump: The free market will determine if supersonic air transport is feasible. I trust the free market system to inform of when and how this is to be done.

SANDERS' RESPONSE, continued

search program, I do not believe we should be investing significant additional taxpayer funds on something with such limited public benefit.

I believe the private sector should and will respond when and if there is sufficient demand for civilian supersonic transport. In the post-Concorde era, that response seems to be limited to the design and early development of business jets, an industry that does not, in my opinion, need subsidy or support from the federal government.

8. Should drones be allowed to travel in U.S. airspace alongside piloted aircraft?

Sanders: Clearly, the domestic use of drones has enormous potential for commercial and public safety applications. In my state of Vermont, public agencies are using drones to monitor remote roads and rivers during storms, and out West drones have been enormously helpful fighting wildfires.

The recent surge in availability of unmanned aircraft has created a host of issues related to privacy, safety, nuisance concerns, and differentiating between recreational versus commercial use of these craft. Many model plane enthusiasts believe recent FAA rules are too restrictive, while many businesses want to see a loosening of limits on commercial activity. Meanwhile, civil liberties groups are concerned about the potential for violations of personal privacy, and overreach by government agencies. Moreover, the FAA is becoming increasingly concerned about model airplane operators who endanger the safety of others because of reckless use of model aircraft.

Clearly, there are competing interests that must be weighed against each other. As a bottom line, I believe domestic drones must not negatively affect the safety of commercial or general aviation. Moreover, given the sordid recent history of NSA [the National Security Agency] spying on Americans, we must have a national discussion on the privacy ramifications of drones to balance use of these aircrafts with the right to privacy.

Trump: Right now, it is hard to fathom drones operating in the air route structure of the United States. It seems prudent to keep drones and manned vehicles separate until technology has improved and our ability to deconflict is more certain.

DJI

9. What would be your administration's top defense priorities in aviation and space?

Sanders: Under a Sanders administration, the U.S. will continue to have a strong national defense program that will meet our domestic and foreign challenges, including a robust Air Force and Air Reserve component. However, getting our country's bloated military budget under control will be one of my top priorities. At a time when our national debt is more than $18 trillion and when we spend more on defense than the next nine countries combined, we can address the rampant waste, fraud and financial mismanagement that have plagued the Pentagon for decades, without negatively affecting military readiness.

Trump: In military aviation, to explore all options that improve survivability and lethality. In space, to make sure we have redundant and robust systems to satisfy navigation, surveillance, communication and other needs.

10. How would you rank government spending on aviation and space technologies compared to other priorities?

Sanders: I would not rank these priorities against other domestic needs. However, I will say that in regards to aviation, our airports are clearly not keeping pace with increasing passenger and cargo demand.

The North America Airports Council says our airports need $76 billion over the next five years to accommodate growth and improve safety by replacing antiquated 1960s radar technology with a new satellite-based air traffic control system. The FAA estimates airport inefficiencies cost our economy almost $25 billion a year.

We must make it a priority to pass a long-term FAA reauthorization bill that fully funds the Airport Trust Fund and lifts the cap on passenger facility fees. However, we must go much further. That is why I introduced the Rebuild America Act last year, to modernize our nation's infrastructure, from roads and bridges to the electric grid and broadband. The bill would invest an additional $12.5 billion over five years to improve airports across the country, and $17.5 billion to deploy NextGen satellite technology that will make our skies safer and our airports more efficient.

Trump: This, again, may not be the right question to ask. We ought to place our priorities on spending where that spending does the most to advance and protect the national interests of the United States. The people, Congress and the executive branch will determine those priorities in a deliberate and intentional manner.

EDITOR'S NOTE:
The Kasich campaign declined to respond to our questions, but submitted this essay written by campaign adviser Robert Walker, a retired Republican congressman from Pennsylvania and a former chairman of the House Science, Space and Technology Committee.

Maintaining U.S. 'superiority' in space, aviation


John Kasich

America's space program is in need of a 21st century vision. The three phases of our space endeavors — military, civilian and commercial — all need to be given renewed focus. Our military space program is essential to all of our warfighter missions, but its vulnerabilities to attack must be addressed and new generations of satellites based upon modern technologies must be deployed. NASA's role must be redefined. NASA has become too much a logistics agency concentrating on space station resupply and environmental projects. The civil space program must reorient itself to focus on exploration and the development of the technology that would enable exploration of the moon, Mars and beyond.

Space has become steadily more important to our economy, our defense and our everyday pursuits. Swiping your credit card at the gas pump involves satellite technology, a small piece of billions of dollars of transactions that are space dependent. Every phase of military deployment relies on space-based assets and the development and launch of those assets is a multi-billion dollar enterprise. Yet, despite its importance in our economic and security calculations, space policy is uncoordinated within the federal government. A Kasich administration would end that lack of proper coordination by reinstituting a national space policy council headed by the vice president,

Kasich Campaign essay, *continued next page*

***Kasich Campaign essay**, continued*

which would have as its mission to assure that each space sector is playing its proper role in advancing U.S. interests. Such a council would create lower costs through greater efficiencies such as insisting that space products developed for one sector, but applicable to another, get shared and not duplicated. It makes little sense for numerous launch vehicles to be developed at public expense, all with essentially the same payload capacity. Coordinated policy could end such duplication of effort and perhaps determine that there are private sector solutions that do not require government investment.

A 21st century space program must be increasingly agile to address real threats and real opportunities. It is increasingly clear that government bureaucracies are incapable of acting with the speed required to maintain a technological edge. Therefore, the commercial sector of the space community must be integrated and relied upon to deliver more of our space capabilities. The Defense Department needs to restructure its acquisition policies so that commands have sufficient funding to buy commercially available products that fulfill their missions at lower costs. It is recognized that here are certain high-value space assets that will never be duplicated by commercial products, but the vast majority of defense satellite usage is obtainable from commercial vendors. Moreover much of the launch capacity needed for Defense missions can be done in the future using launch service provided by commercial companies.

Government must recognize that space is no longer the providence of governments alone. All across the globe investments are being made and technologies developed, which will allow non-government entities greater space access. Today, commercial communication satellites and commercial observation satellites are vital parts of the economy outside the government's direct responsibility. Space tourism, allowing hundreds, then thousands, then millions, of average citizens their chance to leave the bounds of Earth is in its infancy, but it holds the promise of a new and exciting economic opportunity and the promise of significant technological breakthroughs. Government's role in these developments must be to stay out of the way as much as possible, assist where it can in technological advances and regulate lightly so that relative safety can be maintained, but regulatory overreach cannot strangle the industry.

A Kasich administration space policy will strengthen our military space mission and assets, reorient our civilian space program toward deep space science and exploration, and promote increased cooperation with the commercial space industry to provide the capabilities the nation needs to maintain its day-to-day presence in low earth orbit and beyond. We believe such ambitious goals are achievable within current budget allocations if missions are clearly defined, duplicative programs are eliminated, efficiencies are achieved through better coordination, the commercial sector is used more effectively, and space leadership has the regular attention of the president and his administration.

With respect to aviation, development and implementation of the technologies needed for the NextGen air traffic control system should provide for better aircraft tracking. Climate change should be addressed, but the component parts of the program must be evaluated, and the next NASA administrator will have that evaluation as one of his or her responsibilities. While the commercial sector can and should be a driving force behind the development of supersonic transportation, the federal government can lend technical expertise and research assistance where necessary and helpful, in a neutral fashion.

Drones have to be considered a part of future air safety calculations and appropriately regulated, with the additional knowledge that the potential of the NextGen system anticipates the use of pilotless aircraft at some future date. Our defense policies with respect to space and aviation must be focused on maintaining technological and strategic superiority. Our highest spending priority is to balance the federal budget during an eight-year Kasich administration, and we believe we can maintain the focus on the objectives above by approaching these issues thoughtfully and working together to achieve common sense reforms to our spending policies, procurement policies and regulations.

In Europe, controllers are beginning to direct aircraft in virtual control towers located far away from crowded airports. The trend has now come to the U.S., specifically to a small, but busy airport outside Washington, D.C. The FAA is getting a firsthand look at the technology. Jim Hodges asks the experts whether virtual towers can take off in the U.S.

Clear

Cameras on an unmanned tower at Ornskoldsvik Airport in northern Sweden provide video for air traffic controllers 140 kilometers away.

Stefan Kalm/Saab Sensis AB

Retired FAA air traffic controller Jerry McDaniel sat behind three computer screens in a room in the terminal of Leesburg Executive Airport in the Virginia suburbs of Washington, D.C. He listened to pilots on a radio, checked the weather and looked out at 14 high-definition televisions arranged in an arc. The TVs were linked to 14 video cameras in an unmanned crow's nest atop the terminal. McDaniel could see planes approaching from three to five kilometers away and monitor their landings and takeoffs. McDaniel was not controlling the traffic, but he explained to me and other reporters how control would be done if the FAA eventually approves the technology, which is meant to emulate the view from a physical control tower.

for takeoff

That was last November. Saab Sensis, the Washington, D.C., subsidiary of the Swedish company, brought McDaniel in to guide air traffic controllers during a demonstration in which data was collected for review by the FAA. This year, the company hopes to start a new phase of the demo in which controllers would for the first time control flights via its Remote Air Control Tower technology.

Advocates of virtual control tower technology at Saab Sensis and elsewhere would like to carve a large, if still-undefined, role in the U.S. The FAA and local aviation authorities have just begun assessing how widely the technology should be applied and at which airports, and whether American air traffic controllers will embrace it.

At Leesburg, the TV screens and computers were set up in a room at the airport, but in the marketplace, a customer could choose to pipe the video a hundred kilometers away to a remote center where controllers would manage traffic at several airports. That's how the technology is used today in some locations in Europe.

For now, advocates are keeping their ambitions in check.

"Nobody at this stage is talking about this technology taking over [air traffic control] functions at a very busy place, like Atlanta or Chicago," says Keith McCrae, who heads Virginia SATSLab, the research arm of the Virginia Department of Aviation.

"Even Richmond International would probably be too busy and too complex for this technology at its current design stage," McCrae says. "But this technology might augment some tools they have at busy airports. Keep in mind, disruptive technologies change rapidly and surprise us as they develop."

The technology has taken hold in Europe, at such airports as the one in Ornskoldsvik, Sweden. In March 2015, it became the first airport to use the Saab Sensis remote tower. A single controller in Sundsvall, about 140 kilometers away, manages daily traffic that typically consists of 16 takeoffs and landings, mainly for flights to and from Stockholm 530 kilometers to the south. Saab Sensis plans to add two airports to the Sundsvall Control Center within a year. A single controller will manage traffic at all three airports.

In Norway, Saab Sensis is working on setting up remote towers at 75 small airports. Saab Sensis also has signed a contract with Ireland to establish a remote center in Dublin to control airports in Shannon and Cork.

For now, the U.S. remote tower test is limited to Leesburg, where 100,000 general aviation takeoffs and landings, called operations, occur annually. Traffic is diverse: corporate jets, a jet charter service, hobbyists' airplanes, medivac helicopters, two flight schools with basic craft. The airport is about 16 kilometers from Washington Dulles International, one of the busiest on the East Coast.

"This stuff has been worked with in Europe, for the most part in low-activity locations, which is where you want to start," McCrae says. "Now we're bringing it into a pretty busy place with some really tricky airspace. It needs to be ramped up into a more real-world scenario, rather than a remote outpost scenario."

Jim Hodges
jimhodgeswrite@gmail.com

Saab Sensis is expanding its Remote Air Control Tower technology from Europe into the U.S. The technology enables off-site controllers to direct flights into non-towered airports, which otherwise require pilots to follow specific operating rules to take off and land.

Generation gap

Whether American controllers will embrace remote towers is an open question. Older controllers might be more comfortable working in a physical tower with binoculars and computers displaying radar tracks.

"If you stand there, looking out the window, unless the tower blows up or you have a heart attack and die, you have a lot of control," says an FAA controller who asked not to be named because he is not authorized to be quoted. "If you're 100 miles away and a camera fails — and anything mechanical can fail — you're in real trouble."

He acknowledges that young controllers, raised on video games, might feel more comfortable with the remote tower concept.

McDaniel, who worked as a controller for 24 years, says for him, the transition to the remote tower wasn't too cumbersome.

"It took me about three weeks to get used to it all," he says. Other controllers in the demo took varying times to acclimate to the screens.

Making their case

Saab Sensis's push in the U.S. was propelled partly by its success overseas, and by concerns raised by the FAA's decision — later rescinded — to close 149 towers in response to a federal budget impasse in 2013.

Leesburg's proximity to Washington and its status as an "untowered" — aviators recoil at the term "uncontrolled" — airport with diverse traffic made it an attractive test site. At Leesburg, as at other untowered general aviation airports, pilots manage the air traffic. Speaking over a "Unicom" frequency, they organize themselves in the air and on the ground by aircraft location and capability.

The U.S. has 517 towered airports that managed 49.7 million operations in 2015, according to the FAA Operations Network, which collects data about air traffic control. That was only 29 percent of all operations.

Cautious test

The first phase of the two-phase Leesburg test was conducted last August through November with six groups of three volunteers from the National Air Traffic Controllers Association, the controllers' union. Working with Saab Sensis equipment, they listened to the pilots whose planes they were seeing on the monitors.

The controllers, including McDaniel,

asked questions about the technology and provided feedback to Saab Sensis. By now, the company had hoped to begin the second phase of the demo in which controllers would converse with pilots and manage flights, backstopped by other controllers in a mobile FAA tower. The start has been delayed, because the FAA said it needs more information to convene a Safety Risk Management Panel to review the data from the first phase before authorizing phase two.

An issue in the first phase was depth perception of the cameras beyond the runway, according to Bill Payne, an engineer and tower architect who helped set up the equipment at Leesburg. Another is the sun's effect on camera images.

"The Saab Sensis system is well thought out," Payne says. "However, if you're going to deploy cameras … why not improve the view and not just simply have one set of cameras at a specific point? If you array cameras around the airport, you can have stitching technology [software that fuses imagery] to give controllers a far better view of the approaches to the runway."

The FAA says it is withholding comment because the technology is still in testing. Saab Sensis declined to discuss the camera's depth-perception performance, but a spokesman says a radar feed could be added as a "plug-in" to extend tracking beyond the cameras' capability.

The company is marketing its towers in the U.S. as a way to link multiple airports with a single center that would house a team of air traffic controllers. The company doesn't envision one controller working traffic at multiple U.S. airports, as in Europe.

An FAA official who asked not to be named says he has visited the Leesburg site multiple times and anticipates that phase two could begin in June or July, with adoption of the technology by 2017.

Hybrid approach

The lack of a control tower can be problematic for airports that want to expand or maintain services. The Loveland-Fort Collins Airport lost airline service from Allegiant in 2012, partly because it lacked a tower. So authorities decided to start a remote tower initiative, with Payne, the engineer who assisted in Leesburg, acting as the project manager. Mountains posed a special

Leesburg Executive Airport in Virginia is the first U.S. airport to test the Remote Air Control Tower by Saab Sensis.

Saab

Offsite air traffic control: Loveland-Fort Collins Airport in Colorado does not have a physical control tower, so it plans to feed video and data from sensors in moutain passes to controllers at another location.

problem for the airport because of its location along the Front Range of the Rockies. Loveland-Fort Collins now plans to tap into a network of tracking sensors that Colorado previously paid $3.8 million to the FAA to help develop, mainly for ski-resort airports. These tracks eventually will be fed to controllers at a remote site. The mountains block conventional radar signals, so the Wide Area Multilateration, or WAM, sensors send radio signals aloft, where airplane responders receive and return them to the ground. Triangulation generates an airplane track. Authorities at Loveland-Fort Collins have high hopes for the technology. It has "allowed some airports that were only able to get in four airplanes an hour during bad weather to quadruple that. It also enhanced safety for the pilots," says Jason Licon, manager of Loveland-Fort Collins, which handles 100,000 operations a year.

Now that Payne has seen the cameras at work in Leesburg, he is undergoing a metamorphosis of sorts. "When I started out … I was 100 percent track-based," he says, referring to the data from the WAM sensors. "I thought cameras weren't going to do the job for us."

Now Payne embraces a hybrid of cameras and WAM sensors in Colorado.

Complex operations

Chris Lawson, who manages the Lewis University Airport for the Joliet Regional Port District near Chicago, has visited Leesburg and keeps track of developments there and in Colorado. He remains unconvinced that a remote tower can meet the future needs of his untowered airport, which handles 120,000 operations a year.

"They need to test at an airport with intersecting runways" like those at his facility, he says. "We're in the Chicago metropolitan airspace, we've got a diverse flight mix, and we don't have a traffic light at the intersection."

Today, he can see that a plane is inbound by tapping open an app on his smartphone. He describes a scenario to show how this works: "Our ground support equipment is plowing snow, trying to get the runways clean, and we're literally on our cellphones, watching airplanes on Flight Tracker," Lawson says. "We're trying to get off that runway before a plane pops out of a cloud."

With a tower, a pilot could call the controller, and the controller can call a ground person and tell him to get off the runway. In theory, the same could be done by controllers viewing video of the airport at a remote tower, but Lawson wants a traditional tower at Lewis and has applied to be included in the FAA Contract Tower program. Established in 1993, the program took the agency out of the business of building towers at smaller airports. But if the locality can provide an equipped tower, and can justify the operation through a complicated cost-benefit analysis, as Lewis has, the FAA will pay for controllers.

There are 253 such towers, staffed by contracted FAA-approved controllers.

Lawson gives another example of why he wants a physical tower. He says residents of a neighborhood complained about airplane noise at night. He met with the tower chief and got him to redirect traffic after 9 p.m.

"If your tower chief is in Boise, Idaho, I guess you can have meetings over a computer," he says. "But I think there are just so many more things you can do when you have a staff member you can sit down with and have a cup of coffee."

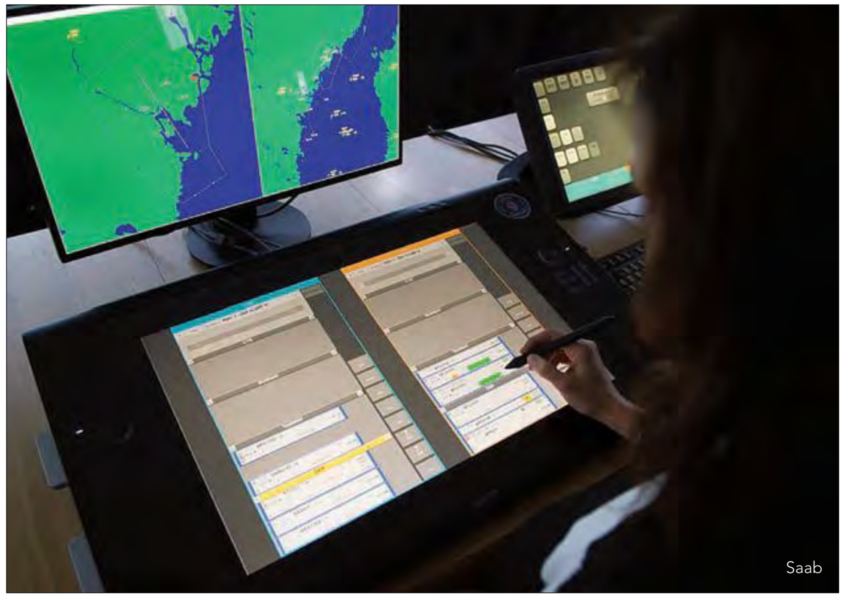
Cost comparison

Technologists began testing remote tower and camera technology at NASA's Ames Research Center as far back as 2001. At the time, traditional towers could be built and equipped for about $1 million, so there wasn't a lot of interest in the technology. Costs have risen since then. Payne says his most recent tower, which opened in Missoula, Montana, in 2012, came in at $7.1 million. In February, Fort Lauderdale Executive Airport opened a $15.4 million tower.

Saab Sensis does not answer media questions about the cost of its remote technology, except to say it is "multiples less than a brick-and-mortar tower."

Two airport managers say they have been told the cost ranges between $1.5 million and $2.5 million.

"The FAA is interested in remote towers because there are still people on their doorstep saying, 'we want a tower,' " says David Byers, who teaches airport management and consults at Lewis and other airports. "The FAA also has a vision for low-activity towers, those which might have reached a point of diminishing returns."



Saab

A remote air traffic controller in Sundsvall, Sweden, guides an airplane to a landing at the Ornskoldsvik airport about 140 kilometers away. In 2015. Ornskoldsvik became the world's first airport to use the Saab remote tower technology.

Byers touts his own air-traffic-control technology, which uses a converted bird-monitoring radar developed after the 2009 "Miracle on the Hudson" emergency ditching. Both jet engines on the A320 failed after ingesting Canada geese shortly after takeoff from New York's LaGuardia Airport.

Byers suggests that his radar would warn pilots when they are too close to each other. He also suggests remote towers could be used in times of traffic stress for small airports, such as on weekends or heavy travel seasons.

Those ideas appear to have traction among some on Capitol Hill. The Aviation, Innovation, Reform and Reauthorization Act introduced in the House of Representatives in February would fund seven remote air traffic control demonstration projects, three at untowered airports.

Most experts agree that camera technology and remote air traffic control are parts of the country's future. Engineers "aren't altering the methodology used in controlling aircraft," McCrae of Virginia SATLab says. "We're still delivering optics to the human, who is in control. The difference is the human being isn't standing in a tower. He's collecting optics via camera technology, which means he can be remotely situated."

At which airports and to control what kinds of air traffic are among many questions awaiting answers.

Out of the

25 Years Ago, May 1991

May 18 Russia launches Soyuz TM-12. Among the crew is Helen Sharman, the first astronaut from the U.K. She is the first woman on the Mir space station and first non-U.S., non-Soviet woman in space. Flight International, May 15-21, p. 13; and May 29-June 4, p. 17.

May 24 As part of an attempt to evacuate 14,000 Ethiopian Jews to safety in Israel, an El Al Boeing 747-200C passenger-freighter convertible airlifts 1,200 densely packed refugees. This was the first time that more than 1,000 people are carried in one aircraft. The aircraft was designed to carry 760 people in high-capacity seating, but room was made for almost 500 more. David Baker, Flight and Flying: A Chronology, p. 485.

50 Years Ago, May 1966

May 5 Britain's solid-propellant Skylark sounding rocket, carrying solar X-ray instruments built by U.K.'s University College in London and Leicester University, makes its sixth flight from the Woomera rocket range in Australia. The Skylark takes X-ray pictures and other measurements to study the distribution of X-ray phenomena associated with the sun. Flight International, May 19, p. 853.

May 11 The descent system of the Surveyor soft-landing moon probe is dropped 300 meters from a balloon in a test at Holloman Air Force Base in New Mexico. This is the first time the system operates all the way to a soft landing. In previous tests, the vehicle was lowered by parachute for the final 150 meters. Aviation Week, May 16, p. 37.

May 18 British aviatrix Sheila Scott takes off from London Airport in a Piper Comanche 260B for a 49,279-km round-the-world flight that is expected to take six weeks and is the longest solo flight ever attempted to date. She makes her first stop in Rome and on May 22 reaches Karachi, Pakistan. During those phases of her flight, Scott experiences the temporary breakdown of the autopilot and other electronics problems. Flight International, May 26, p. 860.

May 23 For the first time, the full-scale test version of the Saturn 5 launch vehicle, the Saturn/Apollo 500F model, is rolled out of the Vehicle Assembly Building at Cape Kennedy on a crawler-transporter and moved toward the launch pad 5.6 kilometers away at a speed of less than 1.6 kph. Missiles and Rockets, May 30, p. 17.

May 24 The first Europa 1 launch vehicle of the European Launcher Development Organization is flown at Woomera range in Australia. The vehicle is composed of a British Blue Streak first stage, and dummy French and German second and third stages. Aviation Week, May 30, p. 32.

May 26 Learjet Model 24 light-twin executive jet lands at the municipal airport in Wichita, Kansas, and becomes the first business jet to circle the globe. En route, the plane also sets 18 world speed records. The plane flew 37,104 kilometers at an average speed of 805 kph over 65 hours and 40 minutes, including fuel stops. Flight International, June 9, p. 956 and June 16, p. 1009.

May 30 Gustav Lachmann, the Austrian-born aviation pioneer famed for his studies of airflow phenomena and development of slotted wing, dies in Hertfordshire, England, at 70. Flight International, June 16, p. 1014.

75 Years Ago, May 1941

May 4 The first commercial airliner crossing of the Atlantic, from Montreal to Great Britain, is made by a BOAC Consolidated Liberator, a converted heavy bomber. Albert van Hoorebeeck, La Conquete de L'Air, p. 15.

May 6 The prototype of the single-seat Republic XP-47B Thunderbolt makes its first flight. It soon becomes one of the three outstanding American fighters of World War II. The aircraft has a maximum speed of over 400 mph at 26,000 feet and earns a well-deserved reputation for ruggedness once it enters combat. Eugene Emme, ed., Aeronautics and Astronautics 1915-60, p. 41.

Past

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

May 10-11 Rudolf Hess, deputy führer of Germany, makes a solo flight in a Messerschmitt Bf 110 to Britain for the purpose of persuading the British government to conclude peace with Germany. He parachutes to the ground, and is arrested and remains a prisoner of war until 1945, when he is convicted as a war criminal and sentenced to life imprisonment. "Rudolf Hess" file, National Air and Space Museum.

May 15 Britain's first jet-propelled airplane, the Gloster E.28/39 with a Whittle WIX centrifugal flow turbojet engine, conducts its first official flight of about 17 minutes at the RAF base at Cranwell, England. Ft. Lt. Gerry Sayer is the pilot. Eugene Emme, ed., Aeronautics and Astronautics 1915-60, p. 41; Charles Gibbs-Smith, Aviation, p. 211.

May 20 The Luftwaffe's Operation Mercury sees the landing of 22,750 paratroopers on Crete, Greece. It is the largest airborne assault during the war, and results in the seizure of the island after a long and difficult battle. Although successful, the Germans sustain so many casualties that large-scale paratroop actions are abandoned for the rest of the war. David Baker, Flight and Flying: A Chronology, p. 262.

May 29 The Army Air Corps Ferrying Command, the forerunner of the Air Transport Command, is created. By May 1945 it consists of 2,461 aircraft, 798 of which are four-engined machines. Eugene Emme, ed., Aeronautics and Astronautics 1915-60, p. 41.

100 Years Ago, May 1916

May 17 The first airplane takeoff from another plane is carried out when a Bristol Scout C, piloted by Flt. Lt. M.J. Day, Royal Naval Air Service, is launched from a Baby flying boat, with John Porte as pilot, at 1,000 feet in Harwich, England. Charles Gibbs-Smith, Aviation, p. 247; Francis Mason and Martin Windrow, Know Aviation, p. 18.

May 18 Lt. Kiffin Rockwell becomes the first American pilot to shoot down an enemy aircraft when he destroys a German two-seater from his Nieuport 11 while flying as a member of the Escadrille Americaine. The squadron is soon renamed the Escadrille de Lafayette. Rockwell is killed in September 1916 while attacking another German two-seat light bomber. David Baker, Flight and Flying: A Chronology, p. 84.

May 22 Air-to-air gunpowder rockets of French Navy Lt. Yves Le Prieur are used in combat for the first time on the Verdun front in World War I against German observation balloons called Drachens (Dragons). The rockets are fired from tubes fitted onto the wings, four on each side, of a Nieuport 11 biplane of the Escadrille N.65 squadron. Ignition is achieved electrically from switches in the cockpit. Altogether, about 50 balloons and two aircraft are claimed to have been shot down by the rockets, but they are unreliable and wind often deflects them. They are withdrawn by 1917 in favor of Rankin incendiary darts or other weapons. Mike O'Connor, "The Le Prieur Rocket and Its Inventor," Over the Front, Summer 1987, pp. 173-179.

Introducing

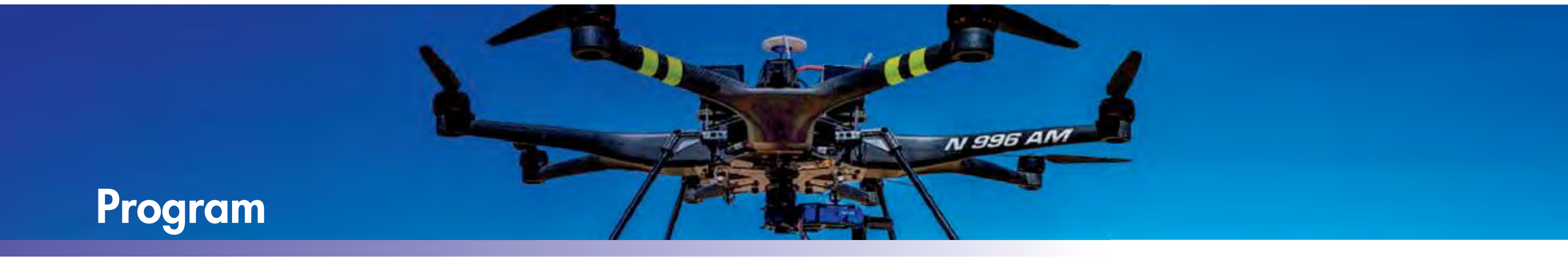
DEMAND FOR UNMANNED

Catalyst for the Machine Intelligence Revolution

Unmanned, autonomous systems are the ultimate catalyst for intelligence in vehicles. AIAA's role in advancing relevant technologies has helped autonomous systems operate safely and successfully in space for decades. This dedicated symposium—held in conjunction with **AIAA AVIATION 2016**—brings together stakeholders to identify research and operational challenges and opportunities for the Unmanned Aerial Systems (UAS) community.

"Small UAS are proliferating with these least-capable machines invading the most complex, obstacle-rich environments. The aerospace community, with its rich understanding of both flight and technology is best positioned to undertake the challenge!"

—**Mike Francis,** Chief, Advanced Programs & Senior Fellow, United Technologies Research Center



Program

The Changing Face of Aerospace: The Impact of UAS on Aviation

Applications for autonomous systems are myriad as technology continues to improve. What advancements need to occur in order for unmanned systems and technologies to transform flight and air transportation? Radio-controlled aircraft have not received the same level of attention and anxiety as UAS. What's different now? How much of the response is due to media hype? What steps need to be taken to change public perception?

Invention, Entrepreneurship, and Unmanned Systems

How were early technologies and systems developed and what lessons can be adopted today to move from remotely piloted to fully autonomous systems operations?

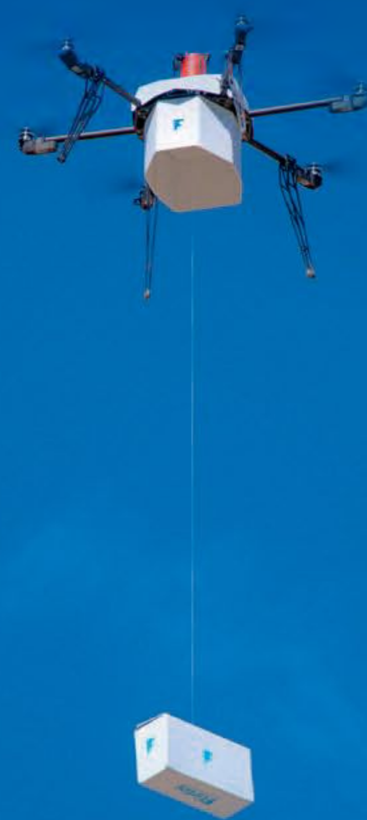
Perspectives on the Future of Autonomous Systems and Technology

Robots and autonomous systems are being increasingly integrated into modern society, on the battlefield, the road, and factory floor…in business, education, and health. What is the impact on society? Do they help or hinder? Who is responsible when something goes wrong?

Learn More! www.aiaa-aviation.org/UNMANNED2016

"The confluence of machine intelligence and aeronautics is the next great revolution in air transportation. We are attempting to introduce an entirely new approach to vehicle management into the incredibly safe air transportation system, and this means the merger of two entirely different cultures. There is no better organization than AIAA to bring together diverse groups with a common goal. Our rich history of merging basic science with solid engineering means that AIAA has the right experience to make this happen."

—**Richard Wlezien,** Professor and Vance and Arlene Coffman, Endowed Department Chair in Aerospace Engineering, and Director, Iowa Space Grant Consortium



The Autonomy "Dream"

As is pointed out in *Autonomy Research for Civil Aviation: Toward a New Era of Flight*, published by The National Academies Press, civil aviation is on the brink of potentially revolutionary improvements in aviation capabilities and operations. Hurdles and substantial barriers to be overcome for UAS integration into the national airspace system will be discussed.

An Aeronautics Autonomy Roadmap

Discover roadmaps to the future for technology, operations, and implementation with representatives from NASA Aeronautics Research Mission Directorate, The Robotics Institute at Carnegie Mellon University, and the Department of Defense.

Transformation in the National Airspace System

The National Airspace System stands on the verge of transformation. The convergence of robotics, intelligent machines, autonomy, hybrid-electric propulsion methods, advanced aeronautic design, and work-anywhere, be-anywhere culture is driving our society into a new era. This panel will discuss the transformations being driven by UAS, and potential outcomes from the convergence of these driving technologies, issues and events in our increasingly connected society.

ASSURE: The FAA's Center of Excellence for UAS Research

Panelists from ASSURE: The FAA's Center of Excellence for UAS Research, the FAA's UAS Focus Area Pathfinders Initiative, and Center for Unmanned Aircraft Systems will provide updates.

UAS Traffic Management System

End users engage with the research, development, and test community to communicate challenges and needs of small UAS users and missions.

Visions of the Future

Speakers will address their visions for Robotics, UAS missions, UAS design, and the NextGen air traffic management systems.

DEMAND for UNMANNED Student Competition Alpha Test

Teams from the University of Michigan, University of Maryland, and McKinley Technology High School in Washington, D.C. will use a UAV quadrotor to participate in a two-part competition that includes autonomy and manual flight skills.

AIAA
Shaping the Future of Aerospace

AIAA Bulletin

The 20th annual Design/Build/Fly (DBF) Competition took place on 15–17 April 2016, at Textron Aviation in Wichita, KS. Congratulations to the San Jose State University team for winning this year's competition! Shown here are the team and contest organizers. Back, from left: Russ Althoff of Raytheon Missile Systems and the Design/Build/Fly organizing committee; David Levy of Textron Aviation and the contest administrator; Ray Girardo, Textron Aviation director of engineering; Sandy Magnus, AIAA executive director; San Jose State University team leader Tyler Sanders; team member Androw Yany; team adviser Gonzalo Mendoza of Textron Aviation and San Jose State University. Front, from left: team members Roshan Patel, John Paul de la Cruz, Kevin Surban, and Chris Dickason.

Read more at **http://www.aiaa-aviation.org/DBF2016/**.

MAY 2016

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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			
16–20 May†	SpaceOps 2016: 14th International Conference on Space Operations	Daejeon, Korea (www.spaceops2016.org)	**30 Jul 15**
24–26 May†	The Fifth International Conference on Tethers in Space	Ann Arbor, MI (http://tethersinspace2016.com/)	
30 May–1 Jun†	22nd AIAA/CEAS Aeroacoustics Conference	Lyon, France (www.aeroacoustics2016.com)	
30 May–1 Jun†	23rd Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (Contact: Ms. M. V. Grishina, +7 812 499 8181, icins@eprib.ru, www.elektropribor.spb.ru)	
11–12 Jun	Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-On Training Using CIFER®	Washington, DC	
11–12 Jun	Concept in the Modern Design of Experiments	Washington, DC	
11–12 Jun	Optimal Design in Multidisciplinary Systems	Washington, DC	
13–17 Jun	AIAA AVIATION 2016 (AIAA Aviation and Aeronautics Forum and Exposition) **Featuring:** 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference 34th AIAA Applied Aerodynamics Conference AIAA Atmospheric Flight Mechanics Conference 8th AIAA Atmospheric and Space Environments Conference 16th AIAA Aviation Technology, Integration, and Operations Conference AIAA Flight Testing Conference 8th AIAA Flow Control Conference 46th AIAA Fluid Dynamics Conference 17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference AIAA Modeling and Simulation Technologies Conference 47th AIAA Plasmadynamics and Lasers Conference 46th AIAA Thermophysics Conference	Washington, DC	**5 Nov 15**
15 Jun	Aerospace Spotlight Awards Gala	Washington, DC	
16–17 Jun	6th AIAA CFD Drag Prediction Workshop	Washington, DC	
5–8 Jul†	ICNPAA 2016 Mathematical Problems in Engineering, Aerospace and Sciences	University of La Rochelle, France (Contact: Prof. Seenith Sivasundaram, 386.761.9829, seenithi@gmail.com, www.icnpaa.com)	
23–24 Jul	3rd Propulsion Aerodynamics Workshop	Salt Lake City, UT	
23–24 Jul	Advanced High-Speed Air-Breathing Propulsion Technology	Salt Lake City, UT	
23–24 Jul	Electric Propulsion for Space Systems	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 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)	
11–12 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**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
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)	
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** **AIAA Information Systems — Infotech@Aerospace Conference** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **19th AIAA Non-Deterministic Approaches Conference** **58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **10th Symposium on Space Resource Utilization** **4th AIAA Spacecraft Structures Conference** **35th Wind Energy Symposium**	Grapevine, TX	**6 Jun 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	
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)	
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 (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	

continued on page **B4**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
10–12 Jul	**AIAA Propulsion and Energy 2017 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **53rd AIAA/SAE/ASEE Joint Propulsion Conference** **15th International Energy Conversion Engineering Conference**	Atlanta, GA	
12–14 Sep	**AIAA SPACE 2017 (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

AEROSPACE ADVOCATES: AIAA'S PUBLIC POLICY EFFORTS

Sandy H. Magnus, Executive Director

While much attention has recently been placed on the Institute's governance changes, there has been a great deal of activity in our public policy efforts as well. Just last month AIAA held its 19th Annual Congressional Visits Day (CVD). CVD is an exciting and eye-opening event that brings members from all over the country to Washington, DC, for a day of advocacy on Capitol Hill. Participants have an opportunity to meet with their elected officials to help promote the Institute's key issues and raise awareness of the long-term value that science, engineering, and technology bring to the nation.

This year nearly 90 participants from 22 states took part in the CVD program. A large majority of the participants were student members representing the University of Central Florida, University of Cincinnati, Cleveland State University, Embry-Riddle Aeronautical University, Iowa State University, University of Michigan, Ohio State University, and Stanford University. Student engagement is essential to our outreach efforts, and I'm sure their contributions in the meetings resonated with many of the congressional staffs. I hope even more students and young professionals are able to attend next year's event.

We also have been quite active at the state level. For the fifth straight year AIAA has helped plan and host the California Aerospace Days event, which took place in Sacramento on 29 February and 1 March. The event, sponsored by Aerojet Rocketdyne, The Aerospace Corporation, The Boeing Company, and Northrop Grumman Corporation, provided a platform for state lawmakers and their staff to hear from the California aerospace community about the importance of the aerospace industry to the state's economy, education system, manufacturing base, and workforce.

The event was multifaceted and comprehensive. A panel of female aerospace executives spoke before a joint hearing that explored the challenges and opportunities for women in STEM fields. Separately, lawmakers, staff members, and the public were able to visit exhibits from the three California-based NASA centers, large aerospace companies, and suppliers. The exhibit really helped illustrate the ways in which the aerospace community impacts the lives of Californians every day. The event also featured briefings on how small businesses are transforming the state's aerospace sector, the challenges faced by aerospace suppliers statewide, some ideas about how unmanned aerial vehicles could be integrated into the National Airspace System, and the release of an aerospace economic impact study encompassing eight Southern California counties.

Similar aerospace-related events were held over the last few months in other states across the country. The sixth annual Georgia Aerospace Legislative Breakfast, held 9 February, brought together leaders from government and industry to discuss issues of importance to the continued growth of this key industry to the state. This was AIAA's fourth year as the primary sponsor and officers from the Atlanta and Savannah Sections participated.

Florida held its annual Space Day on 3 February. Industry leaders and aerospace supporters met with state officials to highlight the positive impact of the space industry on the state economy and to determine the best strategies for leveraging economic development policies to attract private sector investment and jobs. This was my first time participating in the event, and I thoroughly enjoyed speaking with lawmakers about our community. AIAA continues to be a bronze-level supporter of the event.

On the same day, AIAA members from the Hampton Roads and National Capital Sections joined other aerospace stakeholders to discuss the many benefits the aerospace industry is bringing to the Commonwealth of Virginia. AIAA was a silver-level sponsor and an exhibitor at the Virginia Aviation Business Association's Legislative Reception, which provided an opportunity to network with industry partners, state legislators, and state agency officials.

At the national level the Institute has received a great deal of media attention surrounding the 4 March release of a joint white paper, "Ensuring U.S. Leadership in Space," at a National Press Club Newsmakers press conference in Washington, DC. Five organizations, AIAA, AIA, SF, CSF, and AAS, formed a coalition to produce the paper and then invited other organizations to sign on, with a total of twelve engaging. The paper highlights and addresses the challenges facing continued U.S. exploration and use of space, and the need for the next administration and Congress to make space policy a priority. It also offers sensible policy solutions to the four most common challenges that continued space exploration and use efforts face – unpredictable budgeting, foreign competition, the hostile space environment, and workforce trends.

We also recently collaborated with the Aerospace Industries Association to develop a white paper to support NASA's Aeronautics Research Mission Directorate (ARMD) priorities. The President has requested $790 million for ARMD for Fiscal Year 2017, $150 million (or 23 percent) above its Fiscal Year 2016 appropriation. This increase supports a 10-year, $10.6 billion plan that includes the accelerated development of several experimental X-planes to demonstrate and validate the ability to fly at supersonic speed over land and new environmentally friendly technologies that dramatically reduce fuel consumption, emissions, and noise.

In the months to come we will continue to address the important issues facing our community. Even with a strong presence and a successful day of outreach during CVD and the state events, we still have to do more. It is imperative for our members to be everyday advocates of aerospace and to reach out to local, state, and national leaders to communicate the importance of the aerospace community to our economy, national security, and as an inspiration to the future STEM workforce.

I would strongly encourage those of you who may be interested in our public policy efforts to consider joining one or more of the Public Policy Committee's six working groups. From key issue development to our annual Congressional Visits Day Program to fostering forum topics, advocating at the state level, and selecting deserving recipients of our honors and awards, your contributions would be relevant and important. At the very least, please continue to be vocal aerospace advocates and champions.

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

California Aerospace Days was held 29 February–1 March. A joint select committee hearing, networking reception, exhibition, and several educational briefings brought together state lawmakers and their staffs with members of the California aerospace community to learn more about the importance of the aerospace industry to the state's economy, education system, manufacturing base, and workforce. The State Assembly and the State Senate passed a joint resolution recognizing the event. Below are a few photos from the event.

AIAA held its 19th Annual Congressional Visits Day (CVD) on 16 March. CVD is an exciting and eye-opening event that brings members from all over the country to Washington, DC, for a day of advocacy on Capitol Hill. Participants meet with their elected officials to help promote the Institute's key issues and raise awareness of the long-term value that science, engineering, and technology bring to the nation. This year, nearly 90 participants from 22 states took part in the CVD program. A large majority of the participants were student members.

The Public Policy Committee has many opportunities for you to get involved, including six outcome-based working groups focused on Key Issue Development, the CVD Program, Forum Integration, States Advocacy, Engagement Activities, and Honors & Awards. For information, contact Steve Sidorek at steves@aiaa.org.

OPEN ACCESS OPTION FOR AIAA'S JOURNALS

This year all of AIAA's scholarly journals are transitioning to a hybrid open access model, with the institution of a $1500 article processing charge (APC). The voluntary APC reflects the value of the free access to the article, and authors who want their final, published articles to be openly accessible immediately upon publication now have the opportunity to make this happen. For several years, AIAA has permitted authors to post their accepted manuscripts on their personal websites and in university or institutional repositories, so long as the content is not for sale. This new opportunity for author funding of open access through AIAA ensures that the most up-to-date version of the article in Aerospace Research Central (ARC) is freely available and easily discoverable online. Publishing with AIAA supports all authors by providing infrastructure, tools, and features in ARC to display, preserve, and protect scholarly content, and to ensure that the most up-to-date versions of our journal articles are discoverable by the research community.

ANNUAL BUSINESS MEETING NOTICE

Notice is hereby given that the Annual Business Meeting of the American Institute of Aeronautics and Astronautics will be held at the Washington Hilton Hotel, Washington, DC, on Thursday, 16 June 2016, at 10:20 AM.

William Seymore, AIAA Corporate Secretary/Treasurer

The 2016 AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award was presented to **Peter Scherrer**, Airport Manager (left) on behalf of the Westchester County Airport Environmental Management System Technical Committee, which was recognized for substantial improvement to its relationship with neighboring communities. With Scherrer is Dirk Speas (right).

All AIAA Fellows and Honorary Fellows are cordially invited to the

AIAA *Fellows Dinner*

Tuesday, 14 June 2016, at the Washington Hilton, Washington, D.C.

Please help us celebrate the Class of 2016 AIAA Fellows and Honorary Fellows!

Honorary Fellow is the highest distinction conferred by AIAA, and recognizes preeminent individuals who have had long and highly contributory careers in aerospace and who embody the highest possible standards in aeronautics and astronautics. The 2016 Honorary Fellows are:

Dennis Bushnell, *NASA Langley Research Center*

Mark Lewis, *Institute for Defense Analyses*

John Tracy, *The Boeing Company*

AIAA confers the distinction of **Fellow** upon individuals in recognition of their notable and valuable contributions to the arts, sciences or technology of aeronautics and astronautics. The 2016 Fellows are:

Richard Ambrose, *Lockheed Martin Corporation*

Brian Argrow, *University of Colorado Boulder*

Daniel Baker, *University of Colorado Boulder*

Kyung Choi, *The University of Iowa*

John-Paul Clarke, *Georgia Institute of Technology*

Steve Cook, *Dynetics, Inc.*

James Crocker, *Lockheed Martin Corporation*

Mary Cummings, *Duke University*

Russell M. Cummings, *U.S. Air Force Academy*

Jean-Jacques Dordain, *European Space Agency (retired)*

James Gord, *U.S. Air Force Research Laboratory*

Je-Chin Han, *Texas A&M University*

Jonathan How, *Massachusetts Institute of Technology*

C. Russell Joyner, *Aerojet Rocketdyne*

Konstantinos Kontis, *University of Glasgow*

Ping Lu, *Iowa State University*

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

T. Kent Pugmire, *Standex Engineering Technology*

Ganesh Raman, *Illinois Institute of Technology*

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

Brian Smith, *Lockheed Martin Corporation*

Marilyn Smith, *Georgia Institute of Technology*

Robert Strain, *Ball Aerospace and Technologies Corporation*

Mark Whorton, *Teledyne Brown Engineering*

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AIAA/Fellows Dinner
12700 Sunrise Valley Dr. Suite 200
Reston, VA 20191

16-1018

AIAA HOUSTON SECTION WORKSHOP ON MULTIPLE ASPECTS OF INNOVATION HELD IN JANUARY

Throughout human history, innovation has been the engine that drives progress. Every aspect of our modern lifestyle, which we take for granted, started out as a revolutionary new idea. The human species is where it is today because countless individuals sought creative, "outside of the box" solutions to problems that they faced. Innovation ecosystems have evolved in many nations through funding and programs that are being made available by federal and state governments. In addition, incentives including tax reliefs and low-interest loans have been instituted to accelerate the pace of innovation.

Resonating with the invigorating pace of innovation throughout the world, AIAA Houston Section organized an Innovation Workshop at the Lead NASA Center for Human Space Exploration. The AIAA Houston Section Workshop on Multiple Aspects of Innovation was held at Gilruth Recreation Center, on 29 January 2016 with the theme: Yesterday and Tomorrow. The workshop was aimed at facilitating dialogue among various NASA Johnson Space Center (JSC) entities regarding recent accomplishments and with potential implications and plans for the future of innovation at and around JSC. The speakers were Dr. Jeff Davis, JSC Human Health and Performance Director; Dr. Stan Love, NASA astronaut; Joel Walker, JSC Center Operations Director; Dr. Kumar Krishen, JSC; Steve Rader, JSC; Larry Toups, JSC; Bob Prochnow, Technology Collaboration Center of Houston; James Brown, JSC; Jeffrey Osterlund, Boeing; Dr. Kritina L. Holden, Lockheed Martin; David Whitlock, Jacobs; James W. Hughes, PAE; and Kiley Wren, Wyle.

The presentations covered multiple aspects of innovations at JSC. For example, Dr. Love reviewed the orbital mechanics of a Mars mission, the limitations of present-day rocket technology, and the considerations for keeping a Mars crew healthy and productive on a space mission lasting up to three years. Mr. Walker discussed how the built environment, both formal and informal, supports workplace productivity and the lessons he takes from human spaceflight to apply to workspace design at JSC. Dr. Davis presented the development and use of open innovation (crowdsourcing) at NASA, results of challenge competitions, the addition of new problem-solving capabilities, and the development of an innovation strategy for the future.

We believe the presentations can be of great benefit to AIAA community. They have been linked to the event page: http://www.aiaahouston.org/event/aiaa-houston-innovation-workshop.

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).

AIAA Northwest Florida Section Teams with STEM-ED

The Northwest Florida (NWF) Section has teamed with a local nonprofit, STEM-ED, to provide scientists and engineers for classroom visits (show-and-tell, lectures, lessons) and STEM-related field trips. One of the most successful partnerships is with Paxton School (K–12) in Walton County, FL. This relationship has developed through significant interaction with AIAA Educator Associate and Paxton School teacher Heather Stewart, who has spread the opportunities of collaboration with AIAA to the elementary, middle, and high school levels at Paxton. Paxton School is located in a rural area, but through extensive partnerships with AIAA, Embry-Riddle Aeronautical University, and others, the students enjoy world-class instruction in the aerospace field.

Within the last several months, the NWF Section has teamed with Paxton School to provide:

1) Engineers to co-present the lesson "Lunar Lander" with Paxton teacher and AIAA Educator Associate Heather Stewart at the Florida Association of Science Teachers Conference. AIAA Senior Member Anton VanderWyst and Saumya VanderWyst guided the teachers through the lesson and provided take-home packets of the lesson materials.

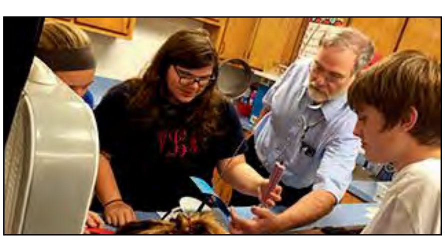
2) Judges for the district science fair, which serves eight local schools at the elementary, middle, and high school level.

3) Hands-on presentation of Bernoulli's Principle from AIAA Associate Fellow Dr. John Fay to students in Paxton High's Gaetz Aerospace Institute at Embry-Riddle Aeronautical University. The lesson materials (and others) are available on the NWF AIAA SharePoint site (NWF Section, Education Outreach, EFA Lessons).

4) Career briefings via Skype to Paxton Elementary School students from Cory Ocker, Christopher Martin, and Maj. Michael Hyland (from Qatar!). Students learned what an engineer is and what local (and deployed) engineers do. Students were also able to ask questions and interact directly with the engineers.

5) Career briefings to Paxton Elementary and High School students from Anton VanderWyst and Saumya VanderWyst, who traveled to the school to interact face-to-face with the students.

6) Field trip to Eglin Air Force Base to visit the 40th Flight Test Squadron (logistical and financial support by NWF Section). Paxton High School students in the Gaetz Aerospace Institute were able to tour the flight line and mission operations led by Maj. David Levene, and the day ended with an engineer's tour of the Air Force Armament Museum by Dr. John Fay.



Above: AIAA Senior Member Anton VanderWyst presents the Lunar Lander lesson at the Florida Associate of Science Teachers conference with Paxton High School teacher and AIAA Educator Associate Heather Stewart. Left: AIAA Associate Fellow Dr. John Fay teaches the Paxton High School students Bernoulli's Principle using airfoils and a simple fan setup.

Skype presentations with Christopher Martin and Maj. Michael Hyland.

Paxton High School students on the Eglin AFB flight line with Maj. David Levene.

Paxton High School students at the Air Force Armament Museum with AIAA Associate Fellow Dr. John Fay.

OBITUARIES

AIAA Associate Fellow Wilcox Died in February

Dr. David C. Wilcox , 72, died on 24 February 2016.

In 1966, Dr. Wilcox received his bachelor's degree from the Massachusetts Institute of Technology. He then graduated from Caltech in 1970 with a Ph.D. in Aeronautics and Astronautics.

After a stint in the aerospace industry, Dr. Wilcox formed DCW Industries, Inc. in 1973. He was instrumental in the development of computational research methods for some of the most important projects of his time. Working with various government agencies including the Army, Navy, Air Force and even NASA, Dr. Wilcox had a hand in shaping the future of aerospace for the next four decades.

Dr. Wilcox wrote a number of textbooks that became the basis for courses at universities including the University of Southern California and University of California, Los Angeles, where he taught for over 30 years. Some of his works were *Turbulence Modeling for CFD*, *Basic Fluid Mechanics*, *Perturbation Methods in the Computer Age*, *Elements of Fluid Mechanics*, and *Dynamics*. He was involved with AIAA as a professional development instructor and as a member of the Publications Committee and the Professional Member Education Committee.

AIAA Associate Fellow Klockzien Died in March

Vernon G. Klockzien, 94, died on 6 March 2016.

During World War II, Mr. Klockzien joined the the Army Air Corps. His exemplary service in aircraft maintenance gained him a field commission as Flight Lieutenant onboard the new B29 Super Fortress. After the war, his attraction for anything aviation led him to the University of Illinois, where he received his bachelor's degree. Mr. Klockzien received his Masters of Science in Aeronautical Engineering from Purdue University.

In the early 1950s, he had the opportunity to join The Boeing Company. He later joined the aerospace division of Lockheed Martin, where he led projects until his retirement in 1986.

AIAA Senior Member Juarez Died in March

Dominick J. Juarez, 84, passed away on 23 March 2016.

Mr. Juarez received a BS degree from The American Television Institute of Technology. Working at Westinghouse Air Arm Division in Baltimore, MD, he helped develop bomber defense systems. During the Korean War, he entered the Army and was an instructor and member of the Staff and Faculty of the Army AAA and Guided Missile School.

He joined ITT as a design engineer in 1956. During his 31 years at ITT he worked on many projects and was promoted to Director of Electro Optics. Working in the area of Electro Optics, he lead the capture and development of spaceborne instruments such as SCMR, AVHRR, and HIRS for the TIROS and GOES satellites. Marking the 25th anniversary of weather satellites in 1985, the National Oceanic and Atmospheric Administration awarded him the Space Science Pioneer Medal. He retired from ITT in 1987.

AIAA Associate Fellow Macdonald Died in March

William Macdonald, a 60-year AIAA member, passed away on 30 March 2016.

He had a long and exciting career in aerospace: he was one of the first Americans to hear Sputnik's signal, and was involved in America's earliest rocket test flights following World War II.

Mr. Macdonald was originally a member of the American Rocket Society prior to its merger with the Institute of the Aeronautical Sciences, which created AIAA in 1963). Over the years he held virtually every executive position within the AIAA Cape Canaveral Section, most recently serving as Section Treasurer. In 1992, he received the AIAA Distinguished Service Award "For 35 years of continuous member participation, particularly in guiding young members into progressive leadership roles, adopting unique methods to stimulate member and Section recognition, and actively serving in every office within the New Mexico, West Texas, Los Angeles, and Cape Canaveral Sections."

CALL FOR NOMINATIONS

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

Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines carefully. AIAA members may submit nominations online after logging into **www.aiaa.org** with their user name and password. You will be guided 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.

Nomination Deadline 1 June 2016

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

Nomination Deadline 1 July 2016

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Summerfield Book Award is presented to the author of the best book recently published by AIAA. Criteria for the selection include quality and professional acceptance as evidenced by impact on the field, citations, classroom adoptions and sales.

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

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

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

AIAA Aviation and Aeronautics Forum and Exposition

Concepts to Reality: Driving The Next Century of Flight Innovation

13–17 June 2016
Washington Hilton
Washington, D.C.
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34th AIAA Applied Aerodynamics Conference
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8th AIAA Atmospheric and Space Environments Conference
16th AIAA Aviation Technology, Integration, and Operations Conference
AIAA Flight Testing Conference
8th AIAA Flow Control Conference
46th AIAA Fluid Dynamics Conference
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AIAA Programs

Keynote Speakers and Plenary Sessions

Get the big picture on aviation from the thought leaders in the field during these high-level discussions and presentations. Sessions and speakers include:

Leadership: The Technology Time Clock — Michael Delaney, Vice President, Engineering, Boeing Commercial Airplanes, The Boeing Company
Balancing Innovation and Inspiration — The HondaJet — Michimasa Fujino, President & CEO, Honda Aircraft Company
NASA Aeronautics — Charles F. Bolden Jr., Administrator, NASA
Cybersecurity — Richard A. Clarke, Chairman & CEO, Good Harbor Security Risk Management, LLC
UAS Developments — John S. Langford, Chairman and Chief Executive Officer, Aurora Flight Sciences Corporation

Forum 360

These conversations will cover a spectrum of timely topics including programs, systems, policy, operations, applications, platforms, and more! Session titles include:

- Commercial Aviation: Solving the Disruption Challenge
- The Future of Education
- NASA Roadmaps: Guiding Direction for Aeronautics Research
- Investments
- Cybersecurity Table Top War Gaming Exercise
- TTX Hot Wash and Cybersecurity Interactive Training Session
- Restoring the Foundation of Aviation
- Future of Flight Test
- Hypersonic Flight Testing: X-15 to Space Shuttle and Beyond

Technical Program

The technical program contains more than 1,500 technical papers from about 600 government, academic, and private institutions in 34 countries reporting on the latest in aviation and aerodynamic research, and offering scores of opportunities for collaboration and discussion on high-impact topics. Search, browse, and create your own personal agenda at Detailed Agenda on the AVIATION website.

New! DEMAND for UNMANNED: Catalyst for the Machine Intelligence Revolution

Held 15–16 June, this new symposium—open to all AIAA AVIATION 2016 registrants--will focus on UAS-related research and development topics to address user needs. Participants will discover how UAS are catalysts for autonomy, robotics, and machine intelligence; and are changing the nature of civil and military aviation.

Courses and Workshops —Now offering student registration rates

- Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-on Training using CIFER® (11–12 June)
- Concepts in the Modern Design of Experiments (11–12 June)
- Optimal Design in Multidisciplinary Systems (11–12 June)
- AIAA CFD Drag Prediction Workshop (16–17 June)

Special Sessions and Networking Events

- Rising Leaders in Aerospace
- AIAA Student Reception
- Forum Welcome Reception
- Recognition Events

Additional AIAA events in Washington, D.C. this week:

- Aerospace Spotlight Awards Gala (15 June)
- Regional Leadership Conference (16–17 June)

Exposition

The Exposition Hall is the hub of activity during this event—from seeing exhibitor displays to enjoying networking breaks and other functions. All the major networking events are held in the Exposition Hall to give attendees and exhibitors an opportunity to connect with partners, industry thought leaders, and collaborators who can help move your business forward.

Lodging

AIAA has arranged a block of rooms at:

Washington Hilton
1919 Connecticut Ave., NW
Washington, D.C. 20009
USA TEL: +1-202-483-3000 • FAX: +1-202-232-0438

The regular attendee rate is $239 and the government rate is $229 per night plus taxes for both single and double occupancy. The block rates will be available until **20 May 2016**, or until the block is full.

Registration

Early Member Rate registration is in effect until **23 May 2016**. Rates are:

- Full Conference - $840
- Full-Time Undergraduate Students - $65
- Full-Time Graduate or PhD Students - $170

Additional rates can be found at www.aiaa-aviation.org/register

Discover More: www.aiaa-aviation.org

Upcoming AIAA Continuing Education Courses

Courses at AIAA Aviation and Aeronautics Forum 2016 (AIAA AVIATION 2016)
www.aiaa-aviation.org/CoursesWorkshops
11–12 June 2016

Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-on Training Using CIFER® (Instructor: Dr. Mark B. Tischler)

The objectives of this two-day short course is to 1) review the fundamental methods of aircraft and rotorcraft system identification and illustrate the benefits of their broad application throughout the flight vehicle development process and 2) provide the attendees with an intensive hands-on training of the CIFER® system identification, using flight test data and 10 extensive lab exercises. Students work on comprehensive laboratory assignments using a student version of software provided to course participants (requires student to bring a PC laptop running Windows 7 (preferred) or above, or a Mac laptop capable of dual-booting to Windows OS or running Windows virtual machine using VMware Fusion or Parallels Desktop). The many examples from recent aircraft programs illustrate the effectiveness of this technology for rapidly solving difficult integration problems. The course will review key methods and computational tools, but will not be overly mathematical in content. The course is highly recommended for graduate students, practicing engineers and managers. Course includes the AIAA book, *Aircraft and Rotorcraft System Identification*.

Concepts in the Modern Design of Experiments (Instructor: Dick DeLoach)

Aerospace researchers with considerable subject-matter expertise who have had relatively little formal training in the design of experiments are often unaware that research quality and productivity can be substantially improved through the specific design of an experiment. Reductions in cycle time by factors of two or more, with quality improvements of that same order, have occurred when the fundamental precepts of experiment design covered in this course have been applied in real-world aerospace research. Examples drawn from specific studies will quantitatively illustrate resource savings, quality improvements, and enhanced insights that well-designed experiments have delivered in various aerospace applications. As a bonus, each student will be able to download an evaluation copy of experiment design software that simplifies many aspects of experiment design.

Optimal Design in Multidisciplinary Systems (Instructors: Joaquim R. R. A. Martins and Jaroslaw Sobieski)

When you are designing or evaluating a complicated engineering system such as an aircraft or a launch vehicle, can you effectively reconcile the multitude of conflicting requirements, interactions, and objectives? This course discusses the underlying challenges in such an environment, and introduces you to methods and tools that have been developed over the years. The course includes a review of the state-of-the-art methods for disciplinary optimization that exploit the modern computer technology for applications with large numbers of variables, design limitations, and many objectives. Students will learn how to evaluate sensitivity of the design to variables, initial requirements, and constraints, and how to select the best approach from many currently available.

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.

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
11–12 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.


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