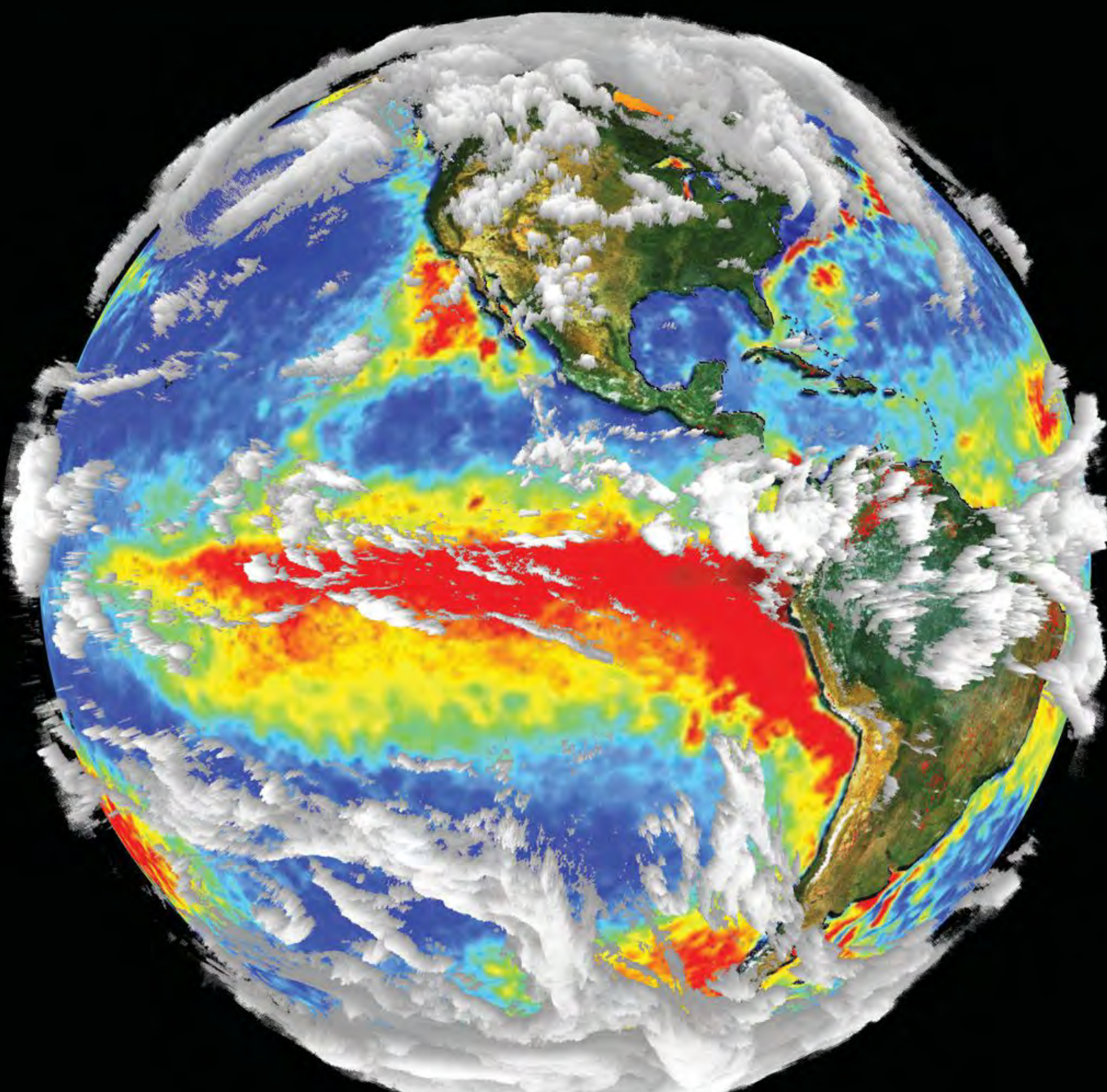
February 2014

AEROSPACE AMERICA

Target: Climate change

Two satellites that could cool the debate



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AEROSPACE AMERICA

February 2014

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The El Niño warming effect is depicted in red in this NASA image compiled from satellite data. Story page 26.

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AIAA
The World's Forum for Aerospace Leadership

Editor's Notebook

Unsettled business

The U.S. will need to decide the way ahead on two expensive aerospace initiatives during deliberations over the 2015 budget.

Consider airborne intelligence. The Air Force as recently as 2011 planned to retire the traditionally piloted U-2s in favor of its unmanned Global Hawks. The service did a major flip-flop in early 2012, saying it actually sees plenty of life left in the U-2s and would prefer to put the core of the Global Hawk fleet into storage. Those are the 18 Block 30 versions equipped with cameras and eavesdropping equipment. Some lawmakers didn't like the storage idea, given the Defense Department's insistence just months earlier that the Global Hawks were vital to national security. Language was drafted barring the Air Force from spending a dime to store the Global Hawks and telling the service to keep flying them at least through 2014.

The Air Force and the Obama administration chose not to push back, which leaves a huge question dangling out there: Is it affordable and necessary to keep both kinds of planes flying, given the detailed view of Iran and North Korea provided by the National Reconnaissance Office's spy satellites? If keeping both is necessary—say, to guarantee 24/7 tactical coverage in the event of war, something satellites are crossing too fast to do—then a modernization and maintenance plan would need to be worked into the budget for each kind of plane. Politics will make it hard to solve that conundrum.

Here's the second dilemma. In the civilian space realm, experts including Lori Garver, a former NASA deputy administrator, have gone public with tough questions about NASA's planned multi-billion-dollar Space Launch System rocket and Orion crew capsule, which would send human explorers into deep space. A few words about SLS uttered by Garver on the Diane Rehm radio show in January went viral: "It's $3 billion a year of NASA's $17 billion. Is that how you would be investing in a space program?"

Why is SLS suddenly on the hot seat? The successes that Orbital Sciences Corp. and SpaceX are having with their privately engineered Antares and Falcon rockets and cargo capsules are making it easier for critics to speak up. Carrying cargo to the space station is not the same as delivering people to the station or eventually to deep space. That's still to come for the private companies. But the successes sure look like steps toward an airline model, in which the FAA and other authorities set regulations and issue certifications, but leave it up to the private sector to engineer safe planes.

NASA deserves praise for nurturing development of these privately developed rockets and capsules through the Commercial Orbital Transportation Services contracts, even if in doing so the agency set itself up for a dilemma: The space transportation market probably won't be big enough to support both kinds of systems—one developed with government engineers in the lead, the other by the private sector [See "Technology alone cannot solve launch costs," page 8].

There are, of course, worse problems to have than too much airborne intelligence and too much space transportation. But these dilemmas need to be solved, because doing so could free up valuable funds for progress in other areas. As Garver told Diane Rehm, "NASA needs to push and do new things."

Ben Iannotta
Editor-in-Chief

Show some optimism

By mentioning "budget battles, test flights and lawsuits" on the cover of the 2013 review [December 2013], AIAA makes one positive item (the flight tests) fight against three negatives. The third negative is Jim Albaugh's cover title ["Preeminence at risk"]. Such a cover could very well deter our future engineering talent from even opening the issue, although its content is very otherwise nice to read and very informative. This runs contrary to our desire to attract young people to our profession.

My suggestion for delivering a better front page material is to let a happy and optimistic mood pervade throughout the team in charge. Just put two of our happiest undergraduate students as part-time interns in your editorial team and that will happen like by magic. In the meantime, [your team] will get a serious education about the realities of our world. I can assure you we would have no lack of candidates to fill such positions. Be assured that we, as educators, engineers and pilots, are also working very hard to project a very positive picture of today's aerospace world from the scientific and economic perspectives. Together, we can make sure the aerospace world's image is positive, although not edulcorated.

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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, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, or by e-mail to: beni@aiaa.org.

Events Calendar

FEB. 2-6
American Meteorological Society Annual Meeting, Atlanta, Ga.
Contact: Claudia Gorski, 617.226.3967; cgorski@ametsoc.org; http://annual.ametsoc.org/2014

MARCH 1-8
IEEE Aerospace Conference, Big Sky, Mont.
Contact: Erik Nilsen, 818.354.4441; erik.n.nilsen@jpl.nasa.gov; www.aeroconf.org

MARCH 12
Congressional Visits Day, Washington, D.C.
Contact: Duane Hyland, duaneh@aiaa.org

MARCH 24-26
Forty-ninth International Symposium of Applied Aerodynamics, Lille, France.
Contact: Anne Venables, 33 1 56 64 12 30; secr.exec@aaaf.asso.fr; www.aaaf.asso.fr

MAY 5-9
SpaceOps 2014, Pasadena, Calif.
Contact: 703/264-7500; www.spaceops2014.org

MAY 26-28
Twenty-first St. Petersburg International Conference on Integrated Navigation Systems, St. Petersburg, Russia.
Contact: 703/264-7500

Prove-it time for space tourism

With Virgin Galactic set to begin suborbital flights for space tourists this year, competitors are readying their own entries for the new market. XCOR's Lynx Mark 1 is scheduled to fly for the first time this year carrying a 120-pound payload. In commercial service, it will take a single passenger 65 kilometers. The Mark 2, due to enter operations a year later, will transport a passenger to 100 kilometers.

Balloon and parafoil concepts could vie for business against Virgin Galactic's SpaceShipTwo. Credit: Virgin Galactic

In March, XCOR announced its firing of a full piston-pump-powered rocket engine, "which is the foundation for fully reusable spacecraft that can fly multiple times per day, every day," said the company.

In January 2013, U.K.-based Unilever Group and the Netherlands' Space Expedition announced a purchase of 22 tickets on the Lynx Mark 2, which has a target in-service date of 2016.

Meanwhile, subscale testing on Paragon Space Development's World View edge-of-space balloon capsule is due to start this month. Flight operations are expected to begin in late 2016, taking six passengers—each paying $75,000—and two crew in a fully pressurized space-certified capsule up to 30 kilometers in a helium-filled balloon, remaining aloft for about two hours before gliding back to Earth with the aid of a parawing. In September the FAA determined that World View's spacecraft and its operations fall under the jurisdiction of the Office of Commercial Space Flight.

"For the initial flight tests, we are using one-tenth-scale full sensor array, and the first flight will be with a parafoil rather than a parawing," says Jane Poynter, chief executive officer of World View. "What we're really testing here are the aerodynamics of the parafoil at that altitude. Parafoils have been flown hundreds of thousands of times, but at lower altitudes. Once we've done these first flights we will have an ongoing program to really map out the entire operational parameters at that altitude."

World View has set up a research and education committee to study the market for offering flights to the science community. The company will be able to carry the scientists with their research "in the same [way] the shuttle would allow for payload specialist flights," according to Poynter. "We haven't researched yet in much detail the lower Earth orbit launch platform concept, but it appears there is the possibility for this as well."

The first commercial flight in Virgin Galactic's suborbital space program is scheduled for later this year, though no definitive date for the launch has yet been released. The hybrid-rocket-powered SpaceShipTwo, carrying up to six passengers and two crew, will take off from the company's terminal in New Mexico slung beneath the WhiteKnightTwo mothership. After being dropped from that ship at 50,000 feet, SpaceShipTwo will fire its hybrid rocket motor and carry its customers and crew to an altitude of 110 kilometers in a suborbital path.

Virgin Galactic has a tough schedule to meet if it is to start operations this year. SpaceShipTwo made just two flights in 2013 to test the hybrid rocket motor. On the second flight, in September, the spacecraft reached 65,000 feet and a speed of Mach 1.6, according to a company statement.

World View Enterprises plans to carry passengers to almost 100,000 feet altitude in a capsule lifted by a balloon. Credit: World View Enterprises.

The price of a ticket is $250,000 per person, and the company says it has already received $80 million in deposits from more than 600 customers.

Poland's Flaris LAR 1 is due to make its inaugural flight, with production to start later in the year. Credit: Flaris LAR 1

Personal jet market re-emerges

Personal jets—small planes that generally weigh 7,000 pounds or less—may be poised for a comeback. The first Cirrus SF50 personal jet built to conform with FAA airworthiness certification is due to fly early this year.

Cirrus is building three of the single-engine planes—C-Zero, C-One and C-Two—on the assembly line that will be used for production aircraft during the test and certification campaign.

"We are expecting the first flight of C-Zero in the first quarter 2014, and certification and first deliveries in late 2015. European Aviation Safety Agency [EASA] certification will follow shortly thereafter," says Gary Black, Great Plains Regional Sales Director for Cirrus. The company, based in Duluth, Minn., says 75 aircraft are likely to be delivered in the first full year of production, rising to 150 a year after that. More than 500 deposits have been taken for the plane.

According to Cirrus, C-Zero will be mainly used for performance verification, flying qualities certification, and production tooling and process development. C-One will be used for aircraft systems development and certification, plus refinement of production components and assembly planning. C-Two will enter flight testing in the late stages of certification and will reflect, as closely as possible, the first production configuration aircraft in equipment as well as manufacturing processes.

The SF50 is not the only personal jet in development. Within the next few weeks, Poland's Flaris LAR 1 is due to make its inaugural flight, with production to start later in the year. FAA and EASA certification are expected in 2015.

The $1.5-million all-composite aircraft has detachable wings and horizontal stabilizers, a nose-mounted ballistic parachute, and a fuselage-mounted fuel tank. The plane will have half the takeoff weight of the SF50, according to Maciej Peikert of the Flaris Team. It will initially be certified as an experimental aircraft under Polish airworthiness regulations with full EASA certification planned for a later stage. Flaris's parent company, Metal Master—a supplier of components to European truck manufacturers—is financing the program, which also received 13 million euros from the European Union's regional development fund between 2007 and 2013.

The first Cirrus SF50 built to conform with FAA airworthiness certification is due to fly early this year. Credit: David Lednicer

A key challenge for personal jet developers in the past has been the escalating costs and the length of time between the first flight and the plane's delivery to customers. According to announcements at the National Business Aviation Association's 2013 convention in Las Vegas, the development costs of the SF50 are $150 million, of which $50 million has been spent and $100 million further committed by Cirrus's parent group, China Aviation Industry General Aircraft.

Development cost increases also were among the main reasons cited by Peter Maurer, president and chief executive of Diamond Aircraft Industries Canada, for the February 2013 suspension of his company's personal jet program, the Diamond D-Jet.

The market for personal and twin-engined VLJs—very light jets—collapsed in the wake of the 2008 financial crisis that engulfed North America and Europe. But the long-term future for these planes is looking more positive, for several reasons: the recent recovery in these markets, the advent of a new generation of more affordable personal jets, and a growing interest in

VLJs from customers and investors outside the U.S.

Although sales of Embraer's Phenom 100 and Cessna's Citation Mustang VLJs have fallen in recent months, new VLJs are entering the market. FAA certification flight testing of the HondaJet VLJ is due to start in early 2014, with type certification expected in early 2015, according to a company news release. The first customer delivery of the Eclipse EA 550 VLJ was in October, and the current production rate is between 1.5 and two aircraft a month, said a company spokesman at the Las Vegas meeting.

Meanwhile, at the annual London Business Aircraft Europe event in September, Richard Koe, managing director of business aviation analysts WingX Advance in Germany, said that between 2008 and 2012, VLJ activity in Europe had increased to 33,000 flying hours from 4,000, and VLJs had increased their market share from 3.6 percent of the market to 33 percent. Planes such as the Embraer Phenom 100 and Cessna Citation Mustang have done well at the expense of the Citation XLS and Hawker 700.

The U.K.-based International Bureau of Aviation's "Business Jet Asset Report 2013" said, "During the period 2005-2010 the VLJ sector saw a period of spectacular growth on products such as the Eclipse EA500, Embraer Phenom 100 and Cessna Citation Mustang. Despite these entry level aircraft faring poorly during the recent economic downturn, IBA's expert opinion predicts this sector will show significant growth by 2025."

Cargo airship gains global partners

In the past few months Worldwide Aeros Corp., known as Aeros, has signed a number of deals with partners aimed at accelerating development of two Aeroscraft dirigible cargo airships: the ML866 and the ML868, which would be able to carry 66-ton and 250-ton cargo payloads, respectively, according to the company.

Worldwide Aeros Corp. is accelerating development of the Aeroscraft ML866 dirigible cargo airship. Credit: Worldwide Aeros Corp.

In December, the Montebello, Calif., company announced a strategic partnership with Luxembourg's cargo airline Cargolux to investigate the potential for new airfreight services in Europe and North Africa based on the ML866 and ML868. The services would exploit the vertical takeoff and landing abilities of these airships for carrying standard intermodal containers as well as heavy and outsized cargos. This announcement followed a November agreement with Icelandair on developing cargo operations to Arctic Circle destinations on multiple continents. This would turn Iceland into a cargo hub for airship operations linking destinations in Greenland, Siberia, Alaska and Northern Canada.

Also in November the company signed an agreement with aviation simulator company CAE on developing simulation and training aids for the new generation of airships.

"Aeroscraft will introduce air cargo options for high-value payloads with a time of delivery and cost per ton-mile in between current airlift and sealift," says the company's chief executive officer, Igor Pasternak. At the same time, he says, the firm will introduce point-to-point delivery to "side-step intermodal transfers and delays [as well as] infrastructure development costs, delivering cargo faster than is now possible by boat, rail and truck."

In September Aeros received an airworthiness certificate from the FAA for research and development flights for its Aeroscraft. This 266-foot-long engineering craft will be operated in designated controlled airspace to test and validate some of the key enabling technologies for the ML866 and ML868.

One of these technologies is a control-of-static-heaviness system—a buoyancy management system that compresses inert helium for in-flight ballasting. Other key technologies include an internal cargo handling system to minimize loading and unloading time, and fly-by-wire systems to connect all flight, engine and utility controls within a single fiber optic network. The proof-of-design demonstration ship for the Aeroscraft established its internal variable buoyancy technology in January 2013, and the advanced prototype demonstrated integration of this technology with other innovative subsystems during flight operations in the last quarter of 2013, according to the company.

Aeros plans to have the first of its initial fleet of 22 Aeroscraft operating in 2016, and current production plans are based on the manufacture of four smaller ML866s and 18 larger ML868s.

"The initial fleet of vehicles will be allocated based on our clients' needs, which include Project Cargo, resupplying offshore oil rigs, moving wind components across the vast landscapes and over borders of Southern Africa, and bringing renewable energy power sources and equipment to rural villages in India," said Pasternak at the 2013 Air Cargo Europe Convention in Munich. "Recognizing that about half the fleet will be located in South America, the Arctic and sub-Saharan Africa, our vehicles have been tested and developed with the goal of global operations in all climates."

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Elias: Technology alone cannot solve launch costs

Antonio Elias of Orbital Sciences Corp. delivered a tough message during SciTech's von Kármán lecture: There is no Moore's Law for rocketry; the only way to lower launch costs significantly would be to spread costs over more launches.

"Chemical rockets are amazing… with power densities [similar] to nuclear explosions;" but "the fundamental technology…is at a dead end," said Elias, Orbital's chief technical officer.

The space shuttle, whose launch rate fell far short of early predictions, was "a great technological achievement," he said, "but certainly from the standpoint of reducing launch cost, it didn't work."

If neither reusability nor chemical rockets will be the answer, "what's left?" He answered his own question: "Rate: To what degree can we increase rate?"

Elias said the importance of launch rates has not been fully appreciated. He pointed to the modernized Delta 4 and Atlas 5 rockets developed in the U.S. under the Evolved Expendable Launch Vehicle program.

Antonio Elias. Photo by Bill Petros

"The U.S. government chose to force Atlas and Delta to co-exist as self competing vehicles in a single market, therefore almost automatically chopping the rates by a factor of two for a given market," he said.

Meanwhile, France's Ariane 5 arose as "one vehicle serving one market." Why does Arianespace have a price edge? "I totally refuse to believe that that's because of some higher competence of… European engineers and managers over the United States."

He struck the same theme in discussing the Space Launch System rocket and Orion crew capsule that NASA and its contractors are building to government specifications, while other contractors are vying to provide commercially designed craft for the NASA market.

"I believe the U.S. government only has enough budget to support one of these approaches, and there has been a political decision to support both, which means the budget required to support these approaches would be insufficient. Therefore, we have doomed both approaches to failure," he said.

The master of ceremonies, David Throckmorton of Northrop Grumman, returned to the microphone: "Well, I don't want to end this conversation on this note," he joked. But he did.

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New design flexibility at stake in X-56A tests

X-56A. Credit: NASA

The X-56A's first flights with flexible wings will be aimed at demonstrating a possible coping mechanism for wing flutter, the aviation world's equivalent of the uncontrolled vibrations that famously destroyed the Tacoma Narrows Bridge in 1940.

The wings of today's planes must be stiff and heavy enough to avoid flutter when an aircraft is flying within its normal altitude and speed envelope. Engineers from the Air Force Research Lab and Lockheed Martin Skunk Works hope to open new design options by demonstrating how a plane can be equipped to detect the start of flutter and actively suppress it with flight controls and wing movements.

"We hope to be flying here in the next couple of weeks," said AFRL's Peter Flick on Jan. 16.

The X-56A Multi-Utility Technol-

2016 could bring breakthrough for small satellites

Soon, small satellite builders could have a new way to launch their spacecraft, other than dispensing them from the space station, as in this photo from 2012, or cramming them on expendable rockets as secondary payloads. Generation Orbit Launch Services, Inc. is developing a rocket called GOLauncher 2 that would be carried into the air under a jet and then be released to blast payloads into space. It's designed specifically for small payloads, which would free builders from the schedule dependency and regulations that constrain them, said Garrett Skrobot, mission manager for the Launch Services Program at Kennedy Space Center. A set of cubesats will be aboard for first flight in 2016.

ogy Test-bed aircraft flew last year with a set of stiff wings as a control for the flexible wing experiments.

If the new tests go well, engineers might be able to design faster, lighter planes for military and civilian applications. The origins of the program are tied to the Air Force's attempts to develop a high-aspect-ratio plane—meaning one with long, thin wings—for high-altitude reconnaissance.

Flick said that the X-56A is not a prototype, nor will the data generated be proprietary: The idea is to advance the state of the art for the industry and provide more data about flutter. The phenomenon is not entirely understood beyond its description as a self-feeding vibration produced by a confluence of external forces. Engineers know it can destroy a plane if it lasts longer than a short time.

The X-56A has to be unmanned because the testing is extremely hazardous. Engineers plan to recover it by parachute, if necessary.

Lockheed has built two center-bodies on the program, each powered by twin 85-pound-thrust JetCat P-400 micro jet engines. The center-bodies can be fitted with a number of different wing sets designed for different test conditions. Lockheed has built one set of stiff wings and three sets of flexible wings. The aircraft and wings are fitted with water tanks to simulate differing fuel weights and different center-of-gravity conditions.

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SciTech 2014

"If you promise your technology will end world hunger, you will not be believed, and if you are believed, you cannot deliver."

Mike Griffin, president, AIAA

"When we're looking to make cuts as if we were trying to lighten the load on an airplane, the idea that the first thing you want to toss out is the engine is not the best approach."

Rep. Chaka Fattah, D-Pa., on cutting "the engine of the U.S. economy," science & technology.

"Stereotypes are hard to shake…. These people said the same thing about small computers."

James Cutler, University of Michigan, on skeptics who question the value of small satellites.

"I can build a very secure system, but it is very, very difficult to generate revenue out of it."

Sam Adhikari, Sysoft Corp.,on balancing revenues and network security.

"Talented engineering will remain the coin of the realm… talent controls the future… [and is] in short supply."

C.D. Mote, National Academy of Engineering

"[While] we have a proud legacy and rich history in space, this is not a substitute for leadership."

Scott Pace, George Washington University

"We celebrate movie stars, we celebrate athletes, but we don't do a great job celebrating people who do great things."

Ray O. Johnson, Lockheed Martin, on communicating aerospace industry achievements.

Hard science

Budgets are tight, but NASA Chief Scientist Ellen Stofan says her agency isn't backing away from bold plans for studying the origins and evolution of life in the universe.

Geologist Ellen Stofan is NASA Administrator Charles Bolden's top advisor in the debates over how best to apply the agency's science dollars. In an era of robotic exploration, Stofan is an unabashed advocate of getting flesh and blood explorers to Mars, and she says she's willing to go up against a robot any time. Her scientific specialties are Venus, Mars and Titan, but Stofan also likes to walk around on volcanoes. She has a Ph.D. in geological sciences from Brown University. Ben Iannotta spoke to Stofan in her office at NASA headquarters.

Photo by Ben Iannotta

NASA plans to extend International Space Station operations to 2024.

As a scientist or a researcher you want to know that a platform is going to be there so you can develop your hypothesis, test it, alter your experiment and keep going. Having that reassurance that the ISS is going to be there is really critical.

The early promise of medical breakthroughs and manufacturing breakthroughs on ISS hasn't panned out.

Well, the bulk of the resources over the past 15 years have gone into construction, and not into the research piece. We had many amazing teasers in the research area. This extension to 2024 allows us to say we're going to take all these nuggets of cool stuff and turn [them] into something.

I hear it said all the time that Mars is better mapped than Earth, and that we study Mars more than Earth. Is that true?

No, it's certainly not true. At NASA, we do the Earth, we do Mars.

Interview by Ben Iannotta

On the Earth, you have all these interacting processes that make our planet so complicated. That's the beauty of why we study the planets—to go to a place like Mars and say, "Okay, there's no biosphere. It's much colder. The atmosphere's thinner. How does a process like climate work?" Venus has this amazing runaway greenhouse [effect]. How can we use all these different planets to help us understand ours better?

So how do you—you, plural—go about deciding the priorities?

We do it through the National Academy [of Sciences] and the National Research Council, where we have these decadal surveys in every area of science. You get the best people together in the community, and you have an open debate, to say, "Where are the real holes in our science? And where is the biggest scientific payoff?" That's a hard thing for scientists to do, because everybody loves their own particular area of research. At NASA, we take those decadal [surveys] and say, "Now let's match them up against the budget realities."

What's your sense of how people on the Hill and at the White House match resources to priorities?

I think everybody's really respectful of the decadal process, because they realize the process the scientists go through, of having to say, "We're going to leave some things behind." Don't we prefer that to a bunch of guys in a smoke-filled room somewhere setting priorities?

Is it possible to make climate predictions for a complicated planet like Earth?

When I started working on the Magellan mission to Venus back in the late 1980s, we knew Venus had a greenhouse atmosphere. You put more CO_2 in an atmosphere and it gets warmer. That's just physics. [See related story: "Target: Climate Change," Page 26.] Back in the 1980s, the models were a little bit all over the place. Over the last 20 to 30 years, the models all converged and started saying the same thing. Are there still areas where we could improve? Yes, and that's why NASA spends a lot of time trying to gather data [about] the role of clouds, precipitation, surface winds. We collect an immense amount of data that allows us to have an awful lot of confidence in those models. That's why 95, 97 percent of papers that come out in the scientific community [say] that there really is a consensus that anthropogenic climate change is what's happening. The bulk of those measurements we make here at NASA on the Earth are all pointing in one pretty unequivocal direction.

"The bulk of those [climate] measurements we make here at NASA on the Earth are all pointing in one pretty unequivocal direction."

Have you had any contacts with your counterpart in China about the research they're doing on the Moon?

No, but we're definitely watching closely and hoping that they send back a lot of cool data.

Is this a fight over lunar resources?

I certainly don't think it's a fight over resources. China has their space program, and they have their goals, and what they're trying to accomplish, and we have ours. In the case of a lunar mission, we don't have a lunar rover right now, but we have assets in orbit around the Moon. So their data has the potential to complement our data. They come to conferences and present their results, and we're anxious to see that. The more players we have the better.

What are some of the technologies that you wish you had?

Oh boy, that's a long list. I always want to go explore the hard places. I've [studied] Venus, where it's 900 degrees Fahrenheit, so where are the high temperature materials and the high temperature systems? I want to see astro-biologists and geologists on the surface of Mars, picking up rocks, cracking them open, trying to find that evidence that life evolved on Mars. There's a huge range of exciting technologies that we need for landing big payloads down on the surface of Mars; sustaining humans for a long period of time; making them autonomous, so that you've got cool things like self healing materials. The president has said he wants to see humans in orbit around Mars by the early 2030s. I'd love to see humans on the surface of Mars as soon as we can after that.

"Don't we prefer [decadal surveys] to a bunch of guys in a smoke-filled room somewhere setting priorities?"

The other area of technology is something that I've been so excited about this year. If you stop and think about it, it just continually blows your mind: Kepler has found 3,500 planets. When I was growing up, we had nine. Then we had eight. Now we've got three thousand five hundred, and that's the tip of the iceberg. I was at a middle school early this week, and

(Continued on page 15)

Laser eye on aircraft ice

Engineers at NASA's Glenn Research Center have figured out how to make three-dimensional digital representations of the ice that can build up on aircraft wings and steal lift. Plans call for turning these digital renderings into resin replicas of ice accretions, so that aircraft designers can attach them to airfoils and assess the effects of ice without having to go to a wind tunnel capable of producing ice. The representations will also be tested in computational fluid dynamics models, which raises the theoretical possibility that wing accretions might someday be modeled entirely on computers, eliminating the need for icing tests in wind tunnels.

NASA cautions that a long list of questions must be addressed before that can happen, including whether the resolution of the laser scanning will be sufficient; whether processing the laser data introduces errors; and whether there's enough computing power to model the complex flow behavior over the ice. Work will progress this year to address these questions.

In the meantime, management is being careful not to over promise. "There have been many people promising [pure CFD] capabilities over the years, which has led to an unwarranted elevation of expectations for CFD and subsequent disappointment with actual capabilities," says mechanical engineer Mark Potapczuk, the airframe icing lead at Glenn. In the nearer term, the 3D digital images can be used to "aid in developing more effective wind tunnel test campaigns and to aid in analysis of wind tunnel test results. That is a much more achievable yet ambitious goal for this research," he says by email.

By mid-2014, the team at NASA Glenn outside Cleveland plans to use laser scanning to see how accurately CFD testing can predict the aerodynamic impact of ice on an airplane wing. To do so, they will scan a 3D digital model of the ice shapes formed in the icing tunnel. They will then enter that model into the CFD software and see how it compares to the results gleaned from testing a physical model in a wind tunnel.

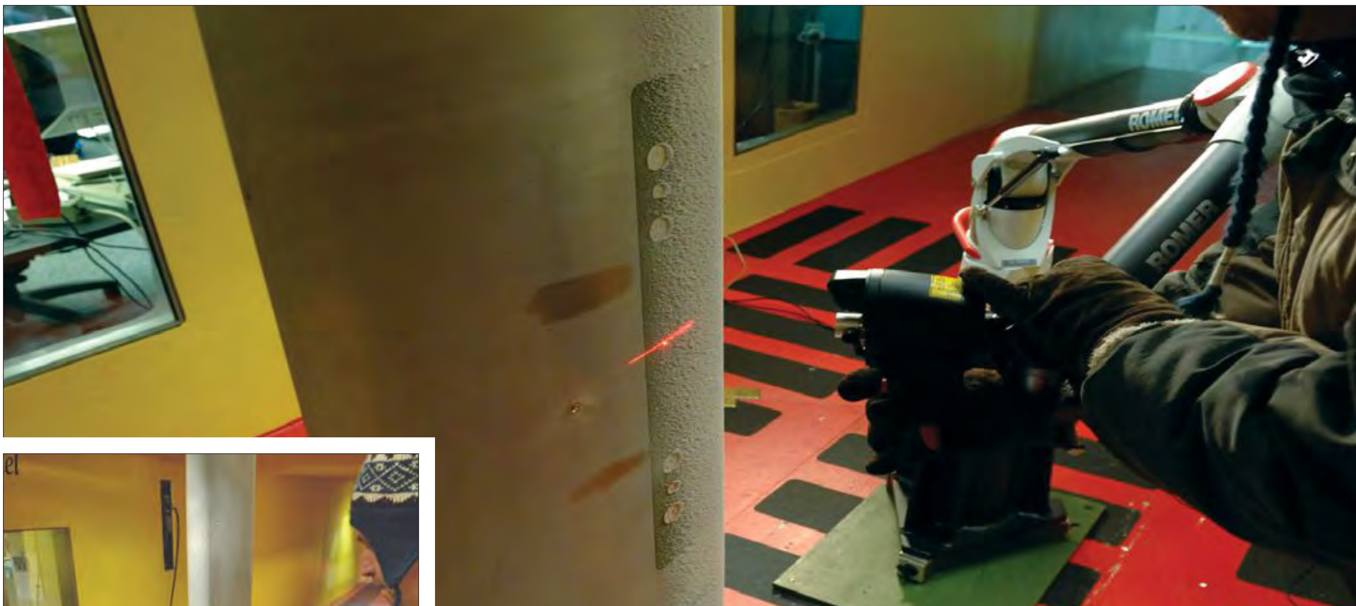
NASA researchers use a laser scanner to collect a 3D model of ice accretion. Credit: NASA

From 2D to 3D

Short of eliminating tunnel testing, the laser technology could let engineers avoid costly and time-consuming modeling techniques, such as casting polyurethane models of ice shapes or using a heated metal plate to bisect the ice, exposing a cross-section. The engineers must trace these cross-sections on a piece of cardboard, which of course means a 2D representation. Those will then be collected for later digitization.

The laser work marks a breakthrough. "This is the first time that we've been able to document [on a computer] an ice shape in a full 3D configuration," says Potapczuk. "In the past it's always been 2D." Laser scanning also allows researchers to do something they could never do with cast models: easily adjust the size of an ice shape. "We can scale it up by a factor of two or three," Potapczuk explains, "or scale [it] down by a factor of two or three," depending on the needs of the testers.

The potential impacts are enormous. Today, the Icing Research Tunnel at NASA Glenn is the first stop in a two-step process for designers who hope to earn FAA certifications for flight in a range of cold weather conditions. Experimenters mount the section vertically and then turn on a powerful fan, generating up to 350-knot winds. At the same time, they set the temperature of the test section to as low as -30 degrees Fahrenheit and turn on a spray to simulate water drops in an icing cloud. Within minutes, the wing is covered in ice.



The laser device scans ice shapes in 10 to 30 minutes. Credit: Hexagon Metrology

Next, the researchers must measure the accreted ice, recreate the shape and see how it affects airflow in an aerodynamic tunnel located elsewhere, one that provides very specific conditions needed for this test and not available at Glenn.

Measuring the ice is a tricky business, and a big motivation for shifting to lasers. Ice does not form evenly on the leading and trailing edges of a wing. Instead, it comes in rough patches and oddly shaped nodules. "We can't just go in and take a tape measure and try to figure out the geometry of the ice shape," says Potapczuk.

Testing the swept wings of large jets is a special challenge, says Michael Bragg, dean of the University of Washington's College of Engineering and the principal investigator on NASA's cooperative agreement supporting the swept wing work. If a researcher tests one section of a straight wing, he has a good idea how ice and air will behave with the rest of it. But swept wings are tapered. "They also have lots of twists, also a changing angle of attack, so they kind of rotate as they go out towards the tip," Bragg says.

To test a swept wing in the Icing Research Tunnel, researchers must use a scaled-down model – a wing that might easily exceed 50 feet cannot fit in a test area that is only 6 feet x 9 feet x 20 feet. Likewise, whatever ice shapes accrete on the mini-wing in the tunnel must be scaled up to match a real wing – something that can now be done easily with a 3D digital model.

Researchers have long recognized laser scanning as a potential answer to these difficulties. In fact, NASA experimented with the technology a little over a decade ago. "They had laser scanners, and they had software, but neither of them were developed enough to provide us with the final outcome that we were looking for at the time, and we kind of let that go for a while," Potapczuk says.

Looking to industry

Two years ago, NASA Glenn revisited laser scanning as part of its swept wing ice accretion characterization and aerodynamics task. The work is carried out in cooperation with Boeing and a few participating universities. Looking for vendors to assist them, the team tapped Hexagon Metrology, a Rhode Island company that produces the Romer Laser Scanner. Described by the firm as a high-accuracy device, the machine is typically used to scan industrial parts so they can be reverse engineered.

At the time, Hexagon Metrology had not yet integrated its Romer Laser Scanner into a freestanding jointed arm, which would eliminate the constant calibration that goes with pairing up two separate pieces. So company officials instead brought a third-party scanner to the NASA demonstration. However, that other laser could not handle rapid changes in temperature. "What they needed was something that…[could go] from a very warm to a very cold environment, and still be able to scan," says Burt Mason, Hexagon's regional sales manager servicing the NASA program.

In a follow-up demonstration, Hexagon Metrology officials brought their new Romer Absolute Arm 7520 SI, an integrated laser scanner system with a 1-meter reach and an accuracy range of 58 microns (about two thousandths of an inch). The carbon fiber construction of the Romer Absolute Arm provided the required thermal stability that the other scanner lacked, so there was no need to wait for the system to adjust to the ambient temperature. Mason describes the second test as a slam dunk: "We walked in and scanned it and walked out and they went, 'Holy smokes!'"

The NASA team purchased a Romer Absolute Arm 7520 SI in March 2012 and a second, longer reach system to measure larger ice shapes in September. That second version can run off a battery and has 802.11g Wifi. One experimenter can scan with it in the icing tunnel while another gets the 3D model on a computer screen in a separate room.

In 2012, NASA purchased a Romer Absolute Arm 7520 SI longer reach system to measure large ice shapes. Credit: Hexagon Metrology

Using the Hegaxon Metrology device, NASA researchers can scan ice shapes in 10 minutes to half an hour, depending on the complexity of the shape and how fine a resolution is sought, says Sam Lee, a Vantage Partners contractor. Lee is working with the team at Glenn and is also principal investigator for the scanning evaluation effort. Before the scan, the ice must be treated with a white, fast-drying titanium oxide paint. "What we would have to do is paint the ice with white paint….We can't scan the ice directly, because it's semi-transparent," Lee explains. "[T]hen we bring in the scanner."

After that, researchers process the scan with specialized software called Geomagic, provided by another company, and that result becomes the basis of the 3D model that can be printed up in resin.

The ultimate objective of the laser research is to bring down the cost of air travel, since a main cost driver is the capital expense of the airplane, which is driven partly by the cost of testing and certification. At the same time, engineers know that safety is sacrosanct. "It's all about being able to provide safe flight at a very fair and reasonable cost," Bragg says.

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(Continued from page 11)

the kids were asking me, "When are we going to get to go visit those planets? How do we understand how much like the Earth they are?" And I'm like, yeah, "Those are the questions we have." We're going to need technology advances, not just in propulsion, but in studying very, very distant objects.

What are some of the interesting things scientists might still be able to do with fewer reaction wheels on Kepler?

The Kepler team has worked really long and hard to see what they could do with a two-wheel mission, and they've come up with some interesting options that are going to have to be folded into the whole view of what we do here in the budget. There are still things you could be doing to study exo-planets, and that's certainly their focus. This has got to go through a senior review, to determine, "Can they keep doing some good science?" And I think there are some indications there that are exciting things that they might be able to do to keep this momentum going on discovering exoplanets. Once we get TESS [the Transiting Exoplanet Survey Satellite] and JWST [the James Webb Space Telescope], they can sort of take over from where Kepler leaves off. So, fingers crossed that something good will come out of it, I'm pretty optimistic.

Why send people to Mars? If you shifted those resources to robotics, maybe robots could crack open the rocks.

You could, and that's a path that we work on. But I just have this incredible bias—I'm a geologist. I still spend part of my year doing field geology. I'm out on a volcano walking around. I would argue that a human can get it done much more quickly and much more efficiently than a robot.

You've seen the statistics about U.S. student math and science scores. How do you feel about the future for science?

That's increasingly worrying as we face things like climate change, which is going to have huge implications for this country, five, 10, 20 years down the road. You want to have a society that is well versed not just in being able to invent that thing that's going to help us, but in understanding the implications of what's happening. We want a STEM-educated public, and we want people going into STEM [science, technology, engineering and math] careers. At NASA, we play a critical role because we provide a lot of inspiration. I was in this middle school and there must have been 150 to 200 kids on the floor of this gym. Those kids were mesmerized. They were excited.

Runway taxiing goes green

What could be one of aviation's biggest environmental advances in 30 years now appears to be a matter of "when" rather than "if." Two companies report they are closing in on electric technologies that would let planes taxi between airport terminals and runway holding areas without using their engines.

One of these firms is a small startup called WheelTug; the other, known as EGTS, is a collaboration by three manufacturing giants. The two companies are pursuing very different technical and business strategies, and WheelTug reckons that its technology could be ready to enter service within two years.

The benefits of taxiing without engine power would be significant, according to Isaiah Cox, chief executive officer of WheelTug, which pioneered the concept of electric taxiing in the early 2000s. Airlines, he says, could save fuel, labor and time by using landing-gear-mounted, battery-powered electric motors to taxi their planes.

New twist on savings

If aircraft could taxi electrically, then pilots could turn on their engines just before moving to the takeoff runway and turn them off just after leaving the landing runway, cutting fuel costs and emissions. The batteries driving each electric motor would be powered by the aircraft's auxiliary power unit, which burns only a small fraction of the fuel the engines would burn while taxiing.

Airbus plans to use the Electric Green Taxiing System on its A320 series. Credit: Airbus

Pilots wouldn't have to ride the brakes as they do during engine-powered taxiing. This would reduce brake wear and replacement costs. Airlines wouldn't have to hire tugs to push back their aircraft, and that task would also require fewer workers, saving labor costs.

Turnaround times between flights also would be reduced. Planes would not have to wait for tugs, or to be coupled to them and then uncoupled. Moreover, a plane's wheel-mounted electric motors would allow it to turn sideways safely in congested ramp areas without causing any jet-blast damage.

This ability—a concept WheelTug has trademarked as the "Twist"—could produce the greatest cost saving of all, says Cox. It could allow planes to disembark and board passengers at two adjacent gates simultaneously, slashing turnaround times by a third.

This could create enough extra utilization time in the day for a short-haul aircraft to operate an additional, revenue-producing sector. Taxiing on battery power generated by the auxiliary power unit would also be much quieter than taxiing even on one engine.

Aiming at single-aisle

WheelTug and its competitor EGTS, Electric Green Taxiing System—a joint venture of Honeywell and Safran's Messier-Bugatti-Dowty unit, respectively the world's biggest producers of airliner auxiliary power units and landing gears—reckon that electric taxiing makes far more sense for single-aisle aircraft than for widebody jets.

Because single-aisle aircraft usually fly far shorter sectors and perform many more takeoffs and landings each day than do widebody jets, they do a lot more taxiing. There are also vastly more single-aisle planes in service: At least 10,000 Boeing 737s and A320 family jets are operating today. Several thousand more single-aisle jets and turboprops also could be fitted with wheel-mounted electric motors.

WheelTug has several industry partners for its electric taxiing system. Credit: WheelTug

The EGTS partners have signed a memorandum of understanding with Airbus to develop and validate their autonomous electric push-back and taxiing system for the A320 family. Although they declined to be interviewed on technological and certification questions, the partners intimate in a Dec. 18 statement that they intend the EGTS system not only to be installed on future-production aircraft but also retrofitted to planes already in service.

EGTS and WheelTug have adopted very different technological approaches, and different business models for marketing their systems. These give each competitor unique certification and commercial challenges.

Creative answers

Although WheelTug doesn't offer system redundancy, it's much simpler and lighter than the EGTS system, which might make it easier to earn airworthiness certifications from the FAA or other authorities around the world. WheelTug uses a nose-landing-gear-mounted electric motor to drive the nosewheel, to taxi and to turn the aircraft. One criticism, from some aircraft analysts and from competitor EGTS, is that its nosewheel location sometimes makes it unable to provide enough traction to push back or taxi a plane when the weather is snowy or icy.

Cox's answer to this is that WheelTug's business model is not to sell the system to airlines, but merely to charge them service fees representing a fraction of the actual savings that customers realize operationally from using it. Only WheelTug would be out of money if bad weather didn't permit its use. To date, WheelTug has garnered commitments from 13 airlines to fit 731 single-aisle planes, mostly Boeing 737s. One, Icelandair, intends to use the system on its future Boeing 737 Max jets, but this is a separate certification challenge, because the nose-landing gear of tomorrow's 737 Max is different from that of today's 737NGs.

As a small company, WheelTug's biggest headache could be that Airbus and Boeing do not sell the design-engineering data for their aircraft cheaply, if at all. This makes it extremely difficult for third parties to perform a full FAA—or equivalent—certification process for aircraft major structural modifications. Instead they usually seek a simpler certification method involving issuance of a supplemental type certificate, which is applicable only to minor structural modifications.

WheelTug tested its system on a Germania Boeing 737-700. Credit: WheelTug

This has been a thorny problem for WheelTug. Cox says the planned late-2014 certification date has slipped to "well into 2015," and that WheelTug has recently simplified its system significantly, mainly to lighten it. WheelTug has done so partly in the hope it can obtain a supplemental type certificate for the system and so avoid the need to buy manufacturers' engineering data for certification. The system is now called V1 and is operated by a pilot rather than ground staff as originally planned. V1's maximum taxi speed is lower than that of the original version.

Cox says the company might still need to buy manufacturer engineering data to achieve certification. But while WheelTug has not yet chosen the aircraft type on which it will first certify the system—the choice depends on having a customer aircraft available for long enough to do so—it has chosen to certify V1 through the FAA rather than through EASA, the European Aviation Safety Agencies.

This is because "EASA relies on Airbus," Cox says. Since Airbus is now allied to EGTS and the A320 family is under the airworthiness oversight of EASA, it appears likely WheelTug will look to certificate V1 first on a Boeing 737. Once the system receives certification for one aircraft type, getting it for other types should be relatively simple.

Harsh challenges for EGTS

The technical and certification challenges for EGTS will be harsher than those for WheelTug, according to Paul Brooker, chief technical manager of IBA Group, a U.K.-based aviation technical services firm. Designed for the A320 family and already demonstrated experimentally, EGTS is a dual system that uses an electric motor mounted on a wheel on each main landing gear unit. Though it offers system redundancy, EGTS is much heavier than V1 and requires air cooling. In addition, its motors are located close to each main landing gear unit's brakes.

EGTS will operate in "an extremely hostile environment," says Brooker. Its motors will be exposed to potential hydraulic leaks, to sizable landing stresses, and—because of the system's proximity to the plane's carbon brakes—to extremely high temperatures and to brake dust. Brooker thinks EGTS may be more likely than WheelTug to experience technical problems in routine operation, particularly after several months in service.

That said, the size, technological expertise and market clout of the EGTS partners should help get their system through EASA certification—this will probably happen later than WheelTug's certification—and into sales contention. The EGTS partners are "already flooding the market" with their sales efforts, says Brooker. He reckons both systems have considerable market potential and should be particularly attractive to airlines serving remote, ill-equipped airports.

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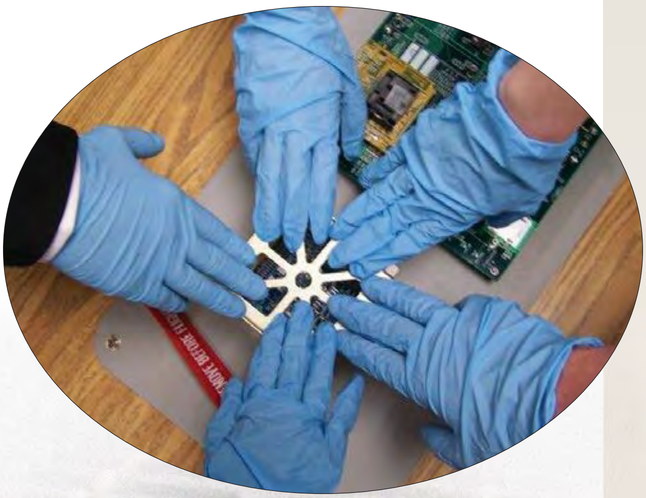
Outreach 101: Listen



Above, students touch the shell of the TJ^{3}Sat. Credit: Orbital Sciences Corp.

Below, the satellite in the thermal vacuum chamber at Orbital Sciences. Credit: Thomas Jefferson High School for Science and Technology

It's not always easy being the intern. You have what you think is a reasonable brainstorm, and the professionals around you just chuckle—most of them anyway. With any luck, someone like systems engineer Carlos Niederstrasser will be around. That's what happened nine years ago at Orbital Sciences Corp. when an intern named Jason Ethier mused that it would be great if his fellow high school students could build a satellite and fly it. Niederstrasser caught wind of the idea raised by Ethier, then a student at Thomas Jefferson High School for Science and Technology, a publicly funded and highly competitive high school in Alexandria, Va. Ethier is now one of Forbes magazine's "30 under 30" for his technology work in the petroleum industry. Niederstrasser took him very seriously. Niederstrasser pushed the idea forward, and the result was years of development work a by a succession of students, culminating in the 10-centimeter-diameter TJ^{3}Sat, pronounced TJ Cubesat. It was launched in November on a Minotaur rocket, with a couple dozen other small payloads.

The TJ^{3}Sat story is not one entirely of high-fives. The plan was for space wonks to visit the project's website and type in short messages that, if approved, would be beamed up from the high school to the satellite, where a voice synthesizer would convert the messages into analog broadcasts for amateur radio listeners. It hasn't worked out that way. Controllers have had no confirmed contacts with TJ^{3}Sat.

Niederstrasser says that's OK. The goal was not perfection, but learning, and lots of that took place over the years. Perhaps most importantly, other high schools have taken inspiration from Thomas Jefferson.

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Career shift >> I started at Orbital in a more traditional systems engineering capacity, working on several programs as I went along—OrbView 3, which was one of the first wave of commercial remote sensing satellites, and the Dawn spacecraft, which is on its way to the asteroid Ceres. As I went along, I started getting involved in recruiting, and that sort of grew to more university relations, and coordinating a lot of the work with the universities.

Orbital Training Academy >> I started an internal training program here at Orbital, where we put together six to eight week courses on various subjects of interest. They're taught by employees, and they're open to any employees, regardless of their job description. I see it as a way to make everyone a little bit more of a generalist and really make sure they understand what goes on in other parts of the company that they may not be exposed to in their day to day work. We started with an introduction to pressure dynamics, which was just talking orbital mechanics, delta V, all that good stuff. We opened it up to whoever wanted

“...no matter how you look at it, they were getting the whole aerospace experience.”

it in the company. So we had electrical engineers who knew their satellites went around in circles but didn’t really understand what that meant. We even had someone from our insurance department come in and take the class just to really get a better grasp of what the subject matter he’s trying to insure is. Another class we have is rocket science for everyone—for folks who are really excited to be working in a space company, but don’t really know what makes it so special, so hard or challenging to put a rocket in space. The course attendance is done on the employee’s own time. You would think that might somewhat reduce interest, but in reality we find that every course we give is overbooked and we sometimes have to turn people away.

Staying sharp >> It’s probably been eight years or so since I worked full time on a specific project, but even today I still do a lot of reviews. I was part of the independent flight readiness review that we did for the Cygnus spacecraft prior to its first launch a few months back. I do a lot of new business support: I either write or review proposals.

Why reach out? >> That was always just something I was very interested in. From high school, I was very involved in going back to elementary school and teaching kids. That interest has kind of remained with me. I’ve done it internally, both with the Orbital Academy, and I’ve done it externally with things like TJ^{3}Sat [pronounced TJ Cubesat]. I’m also a mentor and judge for the AIAA and AFRL University Nanosat competition.

The value of a teacher >> Through elementary school and high school I had some teachers who were very inspiring, and that just got me interested in wanting to share back some of that experience.

TJ^{3}Sat is born >> Back in ’05 we had an intern by the name of Jason Ethier. He mentioned to a couple people, “Hey it would be great if TJ could build a satellite.” The initial reaction was much as you’d expect—giggles, and “That’s not going to happen; a high school cannot build a satellite.” I found out about it, and I was familiar with the evolution of [university] student satellites. I had worked on a student satellite back at Stanford. I knew of this new, crazy concept called cubesats that was just beginning to emerge as a standard platform.

We started talking with the high school a bit more and they agreed to set up a systems engineering class at the school, and Orbital agreed to provide them both with financial support, but more importantly with mentorship and advice to actually put together the program.

Avoid the “gory details” >> At Stanford, I had worked on what was essentially the predecessor or grand-daddy to cubesats, and I knew that the cubesat standard, even as far back as 2006, was beginning to create a commercial marketplace for components that you could just go out and obtain. If there was a significant amount of hardware that we were using as a basis, then there was a high likelihood of them being able to complete it. It was going to be the gory details of hardware design that would trip them up, if they had to do something like design their own flight computer. So being able to have flight computers available already commercially was going to simplify the effort they had to work on.

Wild and crazy >> Originally the students had all sorts of wild and crazy ideas, from the typical camera to having a large gravity gradient boom, to a deorbiting mechanism, all sorts of very complicated payloads. We had mission design reviews, much like you would do in NASA or industry. The students decided they really wanted to focus on outreach. They wanted to inspire other kids to follow in their footsteps. The payload they chose was a voice synthesizer, which also fit into that outreach concept. The voice synthesizer basically would allow them to have anyone in the world type a message into the website.

Carlos Niederstrasser

TJ^{3}Sat fate a mystery >> We had unconfirmed reports from various amateur radio operators hearing the satellite, but we have not been able to reliably command it. They’ve heard the tone at the right frequency, but we couldn’t confirm that it was definitely us. As you’re probably aware, that launch had 27 other cubesats with it, so it’s not 100 percent certain that they heard us. That’s why we say there are unconfirmed reports.

Ultra-realism >> When you look at the course of the project, the experience of the students ended up being much more realistic than we ever could have imagined. Two years into the project there were budget cuts and the system engineering class got cancelled, and so they were left to keep working on the project just with three or four students each year as a senior design project. Even just weeks before the launch, the sequester hit and that delayed the launch a couple months. So they, no matter how you look at it, they were getting the whole aerospace experience.

Disappointed, but upbeat too >> It’s unfortunate in the sense that the students were not able to complete the final accomplishment. But in reality, everyone that went through the project, they feel—and I feel—that it was already fully successful. It inspired a lot of students to go into the space industry. It inspired other schools to follow suit and also try to build cubesats at the primary or high school education level.

Grading "Gravity"

Hollywood got a lot right in the blockbuster "Gravity," which in March will vie for 10 Academy Awards. There are spectacular scenes of Earth, intricate spacesuit details, and lots of can-do attitude. But, alas, it seems as if the film's main character, Dr. Ryan Stone, might have skipped a few classes in astronaut training. Veteran spacewalker Tom Jones explains.

"Gravity," the dazzling space thriller from Golden Globe-winning director Alfonso Cuarón, centers on the fate of a star-crossed astronaut whose mission to repair the Hubble telescope takes what I will call a dramatic turn.

Sandra Bullock as Dr. Ryan Stone and co-star George Clooney as veteran shuttle commander Matt Kowalski gamely hang on for a Mach-25 adventure whose tensions are made even more believable by superb technical execution and eye-popping production values.

The film's photorealistic depiction of space—astronauts, spacecraft, Earth, cosmos—was so well done that one can be forgiven for suspecting the filmmakers shot their story "on location." And despite some shocking plot twists, I was eager to have my wife watch with me, so she could get a better sense of the stunning vistas astronauts experience in orbit. The film digitally imitates the best views from the ISS and shuttle in recreating achingly beautiful impressions of Earth from space.

Although we can't see stars above Earth's daylit hemisphere, and a few orbits could never encompass the array of stunning sights compressed into this film, Clooney's veteran astronaut strikes the right tone of reverent awe when he tells Bullock, "You should see the sunlight on the Ganges." These views alone will have you slapping your money down for a future tourist ticket off the planet.

"Gravity" does deserve to rake in a constellation of production, special effects and sound awards—I went to see it three times. Yet to serve its fast-moving plot, the film doesn't hesitate to finesse some inconvenient realities of spaceflight and physics. We learn early on that Bullock's Dr. Stone got just six months of astronaut training; here are some lessons she missed (*Spoiler alert—plot elements are discussed below.*):

Space junk facts

Kicking off the film's survival challenges is a shuttle crew's deadly encounter with space junk. Astronauts certainly worry about this hazard, which on long missions ranks right up there with launch and landing risks. As we operated the space radar lab on shuttle Endeavour in 1994, we spotted a BB-sized crater in the outer pane of the side hatch window, which was not an uncommon shuttle experience. In 2001, the U.S. Destiny Lab that I helped install at the ISS was armored with Kevlar and metal shielding to break up and absorb hits from micrometeoroids and orbital debris.

Space debris doesn't travel in killer swarms as it does in the movie, and when junk does come, it's closing so fast—several thousand miles per hour—that the human eye would never spot its approach. It would be like trying to catch a glimpse of a rifle bullet coming at you—it either hits you or it doesn't. The good news: Softball-sized and larger pieces are tracked on ground radar, usually giving the ISS time to maneuver away from a worrisome "conjunction."

Although terrifying to watch, the film's anti-satellite-initiated debris shower could never cause the cascading chain of disasters confronting the movie's astronauts. Space is big—and it's achingly empty. Debris might destroy a single spacecraft, but could not plausibly take out both low- and geostationary-Earth-orbit comsats in rapid succession. The dangers of space junk are real, but the film's setup is over the top.

Formula One maneuvering unit

George Clooney's Matt Kowalski flies an Indy 500 version of the 1980s Manned Maneuvering Unit, the MMU. Kowalski is a virtuoso MMU jockey, nonchalantly pirouetting and swooping within a few feet of his orbiter, its robot arm and the Hubble Space Telescope. But he forgot to read the ops limitations, particularly those describing the negative effects of thruster exhaust on the Hubble's delicate optical surfaces and sensors. Clooney earns a ticket for reckless driving.

Photo credits: Warner Bros.

His MMU also has a nearly inexhaustible fuel supply. Kowalski uses the extra juice to capture the tumbling Stone, then chase down the space station (which the writers have conveniently placed in the same orbit as Hubble). The real MMU's total delta-V—its ability to change velocity—was just 80 feet per second, barely enough for sedate fly-arounds of the shuttle. This MMU version is a complete invention, but hey, it's a movie, not a documentary on historic space hardware.

EVA emergencies

To survive, Bullock's Dr. Stone must conduct three separate extravehicular activities, or EVAs. The spacewalk visuals are truly impressive, even to my experienced eye: Tools, tethers and suit exteriors are crisply rendered in nearly every respect. I found myself leaning forward, staring at the screen, trying to wring every last detail out of the 3D EVA scenes so reminiscent of my own experiences. Director Cuarón's team members did their homework well.

Every astronaut I watched the film with was amused, though, at some startling EVA exaggerations. One exuberant spacewalker flings himself, spread-eagled, out to the end of his tether; any real astronaut violating flight rules so blatantly would be enjoying his last EVA. Bullock and Clooney survive some high-impact EVA collisions: with each other, with the shuttle, with ISS structure, and with a disintegrating Chinese space station. Real spacesuits are not nearly so bullet proof, and the first of these EVA smack-downs would likely have ruptured both pressure suits. But that would have made for a much shorter movie.

Perhaps the most laughable latitude taken in the film is the ease with which Bullock's astronaut doffs her spacesuit in the ISS airlock. Near suffocation, she executes a few quick clicks, twists and wriggles, and off come her helmet, gloves, trousers and suit upper torso. A butterfly exiting her cocoon, Bullock is wearing not long-johns, wool socks, and a liquid cooling and ventilation garment—her flattering tank top and skin-tight volleyball shorts could not possibly conceal a spacewalker's diaper. One detail that's spot on target is Bullock's obvious physical fitness, a generous recognition of the high athleticism required of EVA crews.

Flying your fire extinguisher

The movie's special effects excel in depicting the free-fall behavior of shuttle orbiters, EVA tethers and equipment, station hardware, and even astronauts adrift. I'm told the film's creators built Sir Isaac Newton's equations of motion right into the graphics software, predicting the trajectories of any weightless objects in view. But to heighten tension and hurry the survival story along, the filmmakers toggled a figurative ON-OFF switch to shunt that nettlesome Sir Isaac aside when necessary.

Hence we get the Hubble, ISS, and a fictional Chinese space station all cruising the same orbit like so many cosmic beads on a string. We watch Clooney's "Lieutenant Commander" Kowalski (a curiously low pay grade for a shuttle commander) hanging precariously at the end of a taut tether when his surroundings are all in free fall—purely to pump up the drama. And we watch novice astronaut Bullock expertly pilot her Soyuz to a station rendezvous using nothing more than her own eyes and a generous lick of what sharpshooters like to call Kentucky windage. With Sir Isaac's rules operative, she would have blasted herself into a higher, slower orbit, watching helplessly as her Chinese target inexorably pulled away.

Bullock's best MacGyver moment comes when she grips the handle of a salvaged ISS fire extinguisher. Wielding it so it always exhausts on a line between her center of gravity and the Chinese station, she manages a brute-force rendezvous; her tough-as-nails Russian spacesuit survives bone-jarring impacts and collisions with pointy antennas long enough to get her aboard. Even as aerodynamic forces shake and start to shred the reentering station, Stone slips off those draggy forces and secures one last shot at getting home. Bravissima!

Major malfunctions

The film blithely takes another dozen or so technical shortcuts, making for a lively post-screening debrief, best conducted over a beer. Yet despite the exaggerations, the core of the story rings true: space is a hostile, unforgiving environment, and humans must pay extraordinary attention to detail to work and survive there.

All of our shuttle orbit simulations, or sims, had us crewmembers thumbing through our yellow emergency checklists and the well-worn volumes of the "Mal" book, the malfunction response bible for astronauts and Mission Control. "Gravity" easily qualifies as the sim from hell: It assaults its protagonists with every deadly emergency a space traveler could conceivably face: collision, decompression, hypoxia, fire, toxic gases and broken tethers. Not even the most diabolical of our simulator instructors would put together such a no-win scenario; there was little training value in what we called "practicing dying." But such an avalanche of disasters makes for a ripping good survival tale. Bullock hardly gathers her wits from one catastrophe before another rears its head.

Jerked along like a child's balloon behind the unflappable Kowalski, Bullock's character justifiably complains, "I hate space." But she never gives up, never submits to the remorseless power of a cold, indifferent cosmos. Technically implausible at times, "Gravity" is a winning tale, an uplifting lesson for astronaut and Earthling alike.

Tom Jones
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Tom Jones flew on the shuttle four times, led three spacewalks to help build the International Space Station and attended most of his astronaut candidate classes.

Fundamentals of Aircraft and Airship Design

Volume 2—Airship Design and Case Studies

Grant E. Carichner
Leland M. Nicolai

Joseph A. Schetz
Editor-In-Chief

AIAA EDUCATION SERIES

Credit: Eric Long

"MOONWALKING"

I'm sitting on the stage with Buzz Aldrin at the 2,600-seat Robinson Center Music Hall in Little Rock, Arkansas. We're here to tell the packed house about Buzz's latest book, "Mission to Mars: My Vision for Space Exploration," which I helped him write.

During the question-and-answer session, a voice rises from the throng: "What about the guy who said that Apollo 11 was a hoax?"

It's a reference to Buzz's 2002 encounter—captured on video and subsequently gone viral on YouTube—with a man who chased Buzz and challenged him to put his hand on a Bible and swear that he walked on the moon.

The audience falls quiet as Buzz moves forward in his chair. Yup, he says, he punched the man:

"He called me a liar and a cheat. What do you expect me to do?"

The crowd bursts into applause.

At age 84, Buzz has learned to use his Apollo 11 legacy as a springboard to argue for a revitalized American role in space exploration, this time to send humans to Mars.

My job the past year has been to help Buzz present the book's salient points in the form of a stage conversation between Buzz and me, backed by explanatory slides. Keeping our mission on course has not always been easy. Sometimes our high-tech slide clicker refuses to advance to the next image. We try not to get too technical, but some "Buzzwords" are inevitable. It's not easy to boil down the concept Buzz has embraced for using the gravity of Mars and Earth to permanently shuttle spacecraft back and forth. The technique is called spaceship cycling, and it would avoid expending fuel to accelerate and decelerate large spacecraft.

Buzz likes talking about that future, but he's also gracious about discussing the past. Hearing the story of Apollo 11's tense touchdown on the moon from the man who piloted the Eagle lander remains a riveting heart-stopper.

Each audience must know that Neil Armstrong and Buzz do make it onto the moon on July 20, 1969. Yet the crowd seems to be sweating bullets. Will they get down safe and sound?

As Buzz tells it, alarms are going off on the control panel. "We could have looked in a document in the cabin to tell us what those alarms meant…but we were a little busy at the time," he reminds the audience.

With precious fuel nearly gone, the Eagle's shadow stretches out, blanketing the landscape as lunar dust spews outward.

"I call out 'contact light' and 'engine stop,'" Buzz says.

There is a palpable sigh of relief from the crowd, and an ovation. The celebrated landing on the moon has been made one more time.

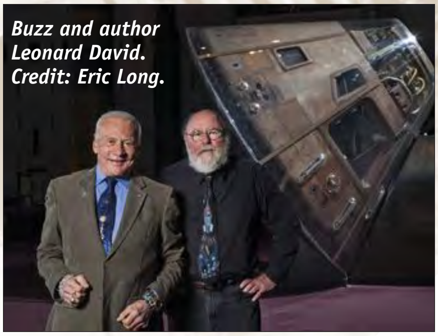
The truth is that Buzz winces a bit at the familiar question, "What was it like to be on the moon?" Even so, his answer still enthralls and often touches on the second-most-famous words uttered from the lunar surface: "beautiful, beautiful; magnificent desolation." Here is Buzz explaining those words to an audience at the National Air and Space Museum in Washington, D.C.:

"In the back of my mind there were Neil's words about his putting a step on the moon, a small but overall big picture step. I felt that one had to acknowledge the great magnificence of humanity getting to the point, from horse and buggy, railroads, airplanes, rockets…and now walking on the moon. That is a testimonial to the progress of the creatures here on Earth."

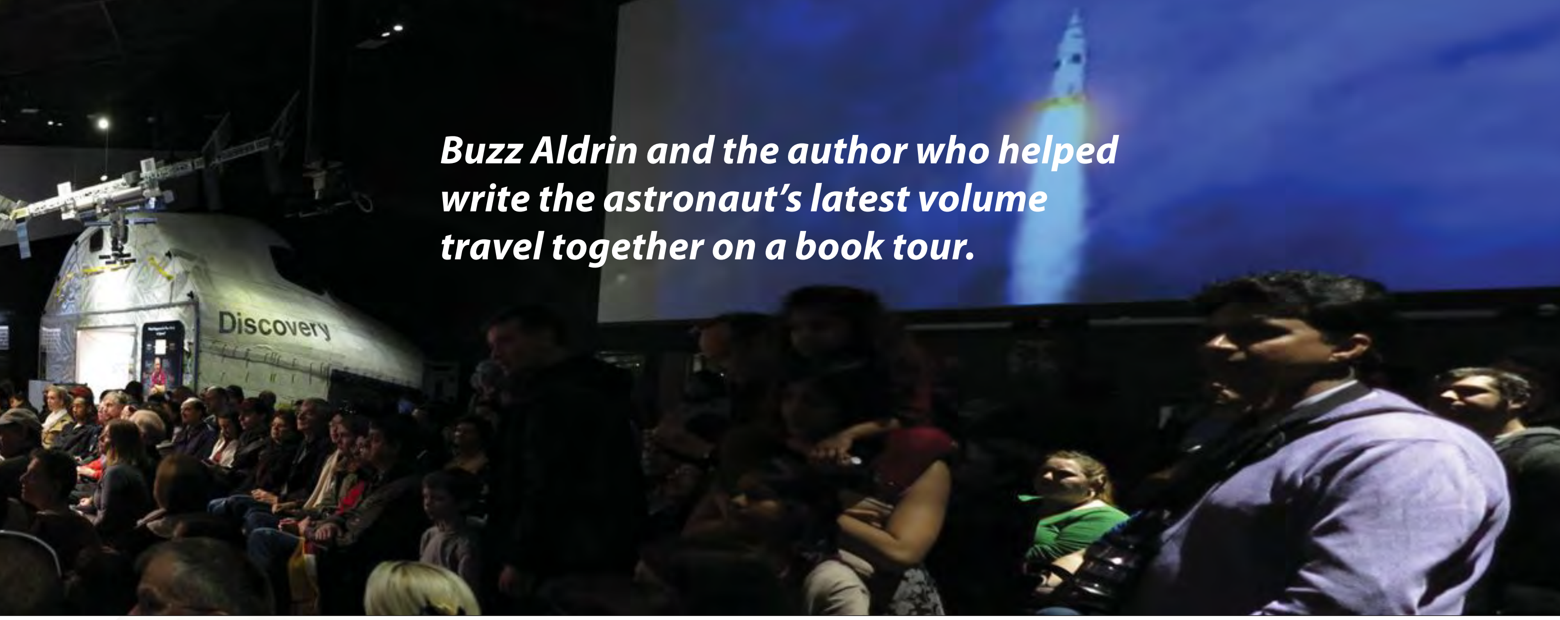
He describes the lunarscape this way:

"In my mind, I knew that it hadn't changed in hundreds of thousands of years. It was just the same scenery. You couldn't find any place like that on Earth. The airlessness…brilliant sunlight illuminates the dust, which was everywhere. And the horizon was so clear because there wasn't any pollution."

As for ambling on the surface, Buzz says "it really was much easier than we had thought it might be." All



Buzz and author Leonard David. Credit: Eric Long.



Buzz Aldrin and the author who helped write the astronaut's latest volume travel together on a book tour.

WITH BUZZ ALDRIN

by Leonard David

those moonwalking simulations here on Earth, "they were hokey," he now admits.

Harkening back to President John F. Kennedy's Apollo commitment, Aldrin is quick to point out a historical fact. "The President didn't say anything about walking around. He said send a man to the moon…bring him back safely. We could have landed, looked out the window, taken a few pictures and come back home."

Two-planet species

So what next? By the book's title, you'd think the volume is all Red Planet proselytizing. That is not the case. The tome spells out Aldrin's stepping-stone vision from Earth, into low Earth orbit and then on to deep space. His "mission" is to eventually plant humans on Mars, and on an everlasting basis. But those critical stepping stones are necessary to help build up the confidence level needed for becoming a two-planet species.

Watching Buzz autograph books has shown me the great public admiration that endures for the risk takers who shot for the moon. People are excited to shake the hand of someone who has been so far away.

Nevertheless, there can be trouble in the book lines.

Given all the eBay fanaticism out there, the desire to have memorabilia signed by notable individuals can look a lot like a gold rush. People have wanted Buzz to sign everything from posters and small lunar replicas to musty-smelling encyclopedias and time-weathered newspapers.

Some want to tell Buzz where they were on the planet when he stepped onto the moon. Others tell him how grateful they are for his service to the country, which Buzz always appreciates. Others tell him a father or other relative designed a switch Buzz threw sometime during the Apollo 11 mission, or tucked in the parachutes that brought him safely back to Earth.

It's the children who tug the heartstrings, often lining up in astronaut apparel with books for Buzz to sign. They are eager to be Mars-bound.

Coast to coast

Buzz signs the autographs, but the big reason he is on tour is to pose a question to audiences around the country: What should America's space program be reaching for now…and why?

Buzz wants what he calls a Unified Space Vision, meaning one in which the U.S. and like-minded nations partner to explore space. To reach beyond low Earth orbit, he sees a progressive suite of missions that are the vital underpinnings—a foundation—for the vision.

Buzz's case to the American public is that Apollo was a "get-there-in-a-hurry, straightforward space race strategy." The thinking was, don't waste time developing re-usability. "That chapter in the space exploration history books is closed," Buzz says.

A second race to the moon is a dead end, Buzz tells audiences. The effort "would be a waste of precious resources, a cup that holds neither national glory nor a uniquely American payoff," he says. Let nations such as China and India tie into the International Space Station family of countries. "The risk is low and the value on the political and collaborative front is high."

Today, the call should be for a unified international effort to explore and utilize the moon, a partnership that involves commercial enterprise and other nations building on Apollo. "For the United States, other finish lines await," he says.

At Mars, humankind has been given a set of moons—two different choices, Phobos and Deimos—from which hardware and personnel can be pre-positioned prior to occupying Mars with increasing numbers of people…not just one select group of individuals. "To succeed at Mars, you cannot stop with a one-shot foray to the surface," he tells audiences.

Buzz knows he needs to reach young people to do all this. We have added a surprise video prior to questions and answers: "The making of Buzz Aldrin's 'Rocket Experience,'" Buzz's pro-space rap.

This video shows rapper Snoop Dogg (now Snoop Lion), lauding Buzz, with Talib Kweli, Soulja Boy and master music-maker Quincy Jones.

As Buzz explains in the video: "I have only two passions: space exploration and hip hop."

Who would have thought?

But then again, he did hop across the moon.

TARGET:

In the next two years, NASA, in collaboration with other agencies, will launch satellites to study the concentration of carbon dioxide in the atmosphere with unprecedented detail and ensure there is no break in two decades of precise ocean level measurements from space. The question is whether these satellites can cool the political debate and set the stage for a verifiable carbon treaty.

The first Orbiting Carbon Observatory, shown on the launch pad, crashed into the Pacific Ocean after launch. Credit: NASA

CLIMATE CHANGE

February 24, 2009, was a big day for David Crisp, the principal investigator for the Orbiting Carbon Observatory mission at NASA's Jet Propulsion Laboratory in Pasadena, California. Nine years of hard work and millions of dollars spent on research and top-notch engineering were about to pay off with the launch of a satellite that was meant to revolutionize the way climate scientists measure the concentration of carbon dioxide in the atmosphere and calculate its effects on the Earth's climate. At 4:55 a.m. Eastern Standard Time, the Taurus XL rocket carrying the satellite blasted off at Vandenberg Air Force Base in California; about 3 minutes 40 seconds into the flight, Crisp and others in the control room realized there was something seriously wrong: the launch vehicle's ascent was 1 kilometer per second too slow. Crisp remembers putting his hands over his head in frustration and turning to the launch director who said simply, "I'm sorry, we failed."

"It took me a while to fully understand what it meant," says Crisp.

Seven minutes later the $273-million piece of NASA equipment re-entered and burned up in the Earth's atmosphere. "A handful of titanium parts may have made it to the surface, but that's now in the Indian Ocean or the South Pacific," Crisp says. The satellite's protective shell—the fairing—failed to separate as planned, weighing down the rocket and slowing the acceleration. "That was not my best day, to put it very mildly," says Crisp.

But even before the sun rose, Crisp's boss at the time, Earth Science Division Director Michael Freilich, told him that the mission was so important it should be replicated. The challenge would be convincing the powers that be to fund it. Crisp imagined the scenario through the eyes of those holding the purse strings: "This kid, who you knew just dropped a quarter of a billion dollars into the Pacific Ocean, walks up to you, a policy maker, and says 'Sir can I have some more?"

...OCO-2 will shed light on the mystery of why and how the Earth's ecosystem and oceans have been consistently able to absorb half of the steadily increasing amount of carbon emitted by human activities.

After nine months of frustration and nearly giving up, in December of 2009 Crisp got an excited 2 a.m. phone call from a White House official at the Copenhagen climate summit informing him that the mission was back on. This time his team had only three years to build the satellite. In July 2014, just four years after the fiery crash at the OCO launch, NASA is poised to launch OCO-2, the original's exact replica.

OCO-2's predecessor, OCO, lifted off on a Taurus booster in February 2009. Credit: Orbital Sciences

Illusion vs. facts

Crisp is under no illusions that a success this time would usher in an era of vast, new climate-focused space investments. "We understand that we live in a finite world and there are always resource limitations. This is not the Apollo days," he says. "We need

by Natalia Mironova

The two large segments of OCO-2's fairing, or outer shell. Credit: NASA

to move forward on this, just to keep up with the changes that we're seeing in our climate system."

So, in the next two years, NASA plans to target two key factors that will figure prominently in the political debate over whether and how to combat climate change. Assuming all goes well this time, OCO-2 will map the distribution of carbon dioxide more completely than today's ground sensors can. That ability could help the U.S. verify a future carbon emissions treaty. Another satellite, called Jason-3, will bounce radar signals off the ocean to ensure scientists can measure sea surface height accurately for years to come. It's scheduled for launch in March 2015.

There's a chance the missions could help cool the political debate that has frustrated those scientists who argue that the scientific debate is largely over. "Global warming is real, it's caused by people, and you have to be pretty wacky to think otherwise," says Josh Willis, a climate scientist at NASA's Jet Propulsion Laboratory and project scientist on the Jason-3 project, an international effort to monitor ocean levels. Crisp says people who aren't scientists have the luxury of believing in "Santa Claus" if they want to, but that scientists must reach conclusions based on data. "From our measurements and our models and everything that we've been able to derive from our planet, [scientists are convinced] that CO_2 traps heat from the sun and causes the Earth to warm up a little bit."

Mysterious processes

Mostly, scientists see the role of OCO-2, in particular, as one of untangling the mystery of why Earth isn't warming even faster, given the explosion of carbon emissions in the industrial era. From an array of 150 ground sensors, scientists have a good idea of how much CO_2 is in the atmosphere. What the scientists don't know is where it all comes from, where it goes, and what

OCO-2 is designed to make global CO_2 measurements of atmospheric carbon dioxide. Credit: Orbital Sciences processes control it. They hope the precise, global measurements from OCO-2 will shed light on the mystery of why and how the Earth's ecosystem and oceans have been consistently able to absorb half of the steadily increasing amount of carbon emitted by human activities.

"Wouldn't it be nice to know what processes are kicking into gear to do this, and maybe ask a question: Can we exploit some of those processes to pull some of the carbon dioxide out of the system? That would solve some of our problems," says Crisp.

There are some scientists who question the causes of climate change, but even they agree that the climate is changing, and that the efforts to study climate are valid and valuable. Roy Spencer, a vocal skeptic on the issue of man-made causes of global warming, serves as science team leader for one of the instruments flying on NASA's Aqua satellite, the mission dedicated to studying the Earth's water cycle. "I think our Earth observational satellites are indispensable for understanding the climate system, partly because only satellites can provide truly global coverage. The data collected in the last 10 to 30 years will be providing new research insights for decades to come," says Spencer.

According to the 2013 report by the Intergovernmental Panel on Climate Change, "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased."

Advantage of satellites

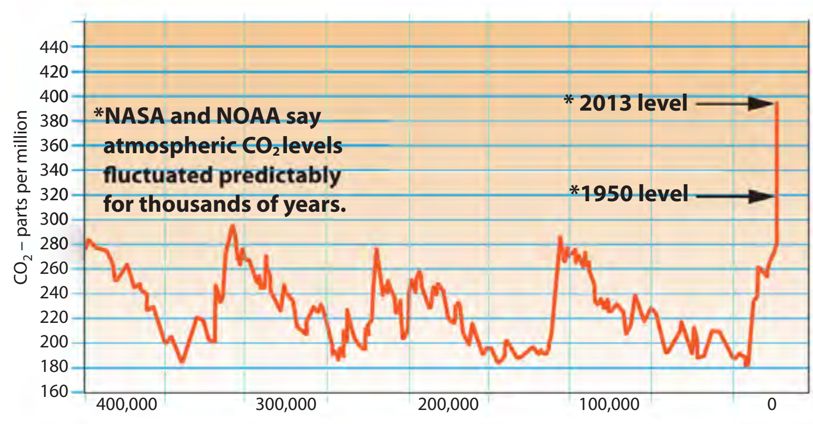
Satellite remote sensing technology is becoming the go-to tool for scientists in tracking climate change indicators such as greenhouse gases, ocean levels, ice and aerosols, by allowing the scientists not only to look at the Earth as a whole, but also to take extremely accurate readings from parts of the globe previously too inaccessible to measure. As a recent paper in the scientific journal Nature concludes, satellite remote sensing "has provided major advances in understanding the climate system and its changes" by enabling more accurate readings and better coverage than conventional observation and computer models.

Crisp says trying to measure CO_2 without satellite technology would be like relying exclusively on the ground stations of the 19th century to forecast the weather. "We need space-based measurements of carbon dioxide that are accurate enough that we can understand what processes on the surface of the Earth are emitting carbon dioxide. That includes human processes and natural processes, and what natural processes on the surface of the Earth are absorbing carbon dioxide. We need to know what, where, how, why and for how much longer these processes will operate," says Crisp.

That's the reason to go to space; and when you look at the Earth from space, you see mostly water. The ocean covers 71 percent of the Earth's surface, and it's the "best yardstick" for measuring the planet's health, according to NASA's Willis. Ninety percent of carbon released into the atmosphere gets absorbed into the ocean, warming it up and increasing its acidity, threatening some sea life. The predicted 3-foot to 5-foot level rise over the next 100 years would have huge economic impacts on communities within close proximity to the shoreline. It would be "way cheaper" to ad-

"…OCO and OCO-2 and maybe its follow-on may be critical for verifying any future carbon dioxide treaty that our country signs."

SOUNDING THE ALARM



Source: NASA/NOAA

Scientists use ice core samples to estimate CO_2 content in the ancient atmosphere, and 150 ground-based atmospheric stations to chronicle modern CO_2 levels. The Orbiting Climate Observatory satellite will fill gaps in this ground-based data by collecting CO_2 measurements at fine spatial resolutions over the globe.

Technicians prep the OCO-2 instrument for shipping. Credit: NASA/JPL-Caltech

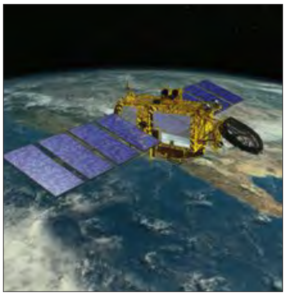
dress climate change now than "to rebuild all our infrastructure and pull back from the sea as it advances," says Willis.

Jason and GOSAT

NASA has been using remote satellite sensors to observe the oceans since 1992. The original purpose of the mission called Topex Poseidon was ocean topography—to map the surface of the ocean and to study its currents. Two satellites followed the Topex Poseidon mission—Jason-1 and Jason-2. As scientists began to look at sea level rise as an indicator of climate change, the Jason team began to shift focus to monitoring sea level and temperature.

Jason-3 is the newest incarnation of this mission. It's an international mission led by NOAA and EUMETSAT (the European Union's equivalent of NOAA's satellite program) in collaboration with NASA and the French Space Agency CNES. The agencies are working closely together: NASA's Jet Propulsion Laboratory is providing some of the sensors that will be placed on the satellite frame or bus being built by the French; the French are also building the primary instrument, the altimeter. The technology behind the mission is surprisingly simple, according to Willis. To measure the distance between the satellite and the ocean's surface, Jason-3 and its predecessors carry altimeters that bounce radar waves off the surface and measure how long it takes the reflected signals to come back. Another instrument on board, called a radiometer, measures the concentration of water vapor to correct the measurement. A three-part location-finding system pinpoints the satellite's position at any given time. "And the difference is how tall the ocean is. It's pretty simple, really," says Willis.

Jason-3 measures the height of the ocean surface. Credit: NASA/JPL-Caltech



The three NASA-built instruments—the microwave radiometer and two location-finding instruments—the GPS and the laser-reflector, along with associated ground support equipment, were shipped to France in May. They will be installed on the Jason-3 satellite along with the altimeter and the "reverse GPS"—another positioning sensor. They'll be tested before being dispatched back to Vandenberg Air Force Base in California for the 2015 launch on a SpaceX Falcon 9.

Close international collaboration is required for space-based climate monitoring. According to John Bates, chief of the remote sensing division at NOAA's National Climatic Data Center, countries have been working together and sharing resources since the early days of weather satellites. "If all our assets are down, we can count on our international satellites. There is great international collaboration in Earth conservation right now," says Bates.

In fact, when the OCO mission crashed during launch in 2009, the Japanese scientists who just a month earlier launched GOSAT—their version of a CO_2 monitoring satellite—reached out to NASA's Crisp and his team and suggested they work together. "We didn't want to be the man with two watches who didn't know what time it was, so we started working together in 2004," says Crisp. "My Japanese colleagues said, don't waste all this effort you put into this as a science experiment, your science team is some of the best people in the world, come work with us, and we'll make use of this great progress we made together." The GOSAT team provided the NASA scientists on the OCO team with measurements they could use to continue their research as they worked to put their own satellite into orbit. Crisp is grateful for GOSAT's contribution. Still, he is excited to improve on its technology—the OCO-2 will take 100 times as many usable measurements daily as GOSAT.

Treaty monitoring

Crisp is convinced that President Obama's trip to the Climate Summit in Copenhagen in December of 2009 was the catalyst to reviving the OCO mission. Having an accurate CO_2 monitoring satellite in space would potentially give the United States the data it needs to work with other countries on reducing carbon emissions and to have the background for a carbon treaty it will sign in the future. Crisp points out that the OCO-2 was not designed for carbon treaty monitoring, but its innovative approach has the potential to measure CO_2 emissions in the now poorly measured developing world, expanding the treaty to include more nations.

"It gave us the opportunity to monitor a possible CO_2 treaty from space and to verify the results of ground-based work that otherwise could not be verified. And that's one of the sticking points that came out of Copenhagen: Nobody wanted on-site inspections. And so things like OCO and OCO-2 and maybe its follow-on may be critical for verifying any future carbon dioxide treaty that our country signs. In fact, having those measurements in place and understanding what we can learn from them may be a precursor to any greenhouse gas treaty the U.S. wants to sign. Because why sign a treaty if you can't verify it?" says Crisp.

When OCO-2 is launched this year, it will carry aboard the technologies that were originally developed for ground-based astronomy and studying other planets. JPL scientists then modified these components to measure clouds in Earth's atmosphere and the concentration of carbon dioxide.

The OCO-2 instrument is a three-channel spectrometer that divides the sunlight into a rainbow of colors and isolates three "absorption bands" in the near infrared, just beyond what the eye can see, where CO_2 molecules and oxygen molecules are most visible and the scientists are able to count them. "We make that measurement very precisely, to three-tenths of 1 percent. This is an incredibly difficult measurement to make using remote sensing," says Crisp. He explains that the same basic technology is used by other agencies around the world that are employing or planning to launch their own CO_2 monitoring satellites. "All will launch the same basic technique that we pioneered in 2000. Different instruments, but we pioneered that track, we told them how to do it," Crisp says.

All these satellites will eventually work together to provide the most accurate global picture of CO_2 distribution, its sources and sinks.

The main culprit

So what makes CO_2 monitoring so critical that the U.S. Congress, the current administration and many governments around the world, including China, Japan and the European Union, are investing resources into research and continuing monitoring from space? Carbon dioxide is not the only heat-trapping greenhouse gas, but it's notable because its concentration has increased dramatically since the dawn of the industrial age – from an average of 270 parts per million to nearly 400 parts per million. According to NASA's Crisp, it's a "big change." Climate scientists zero in on carbon dioxide because they believe it's the main culprit responsible for global warming, but also because there is still so much to learn about the natural processes on Earth that control the balance of CO_2 production and emission. The oceans and the land's biosphere naturally "breathe out" CO_2, but they are actually absorbing more than they are emitting each year. "We now know that the natural processes are absorbing half of all the carbon dioxide that's being emitted by human processes, such as burning fossil fuels and land use practices. What processes are responsible for absorbing half of our carbon dioxide emissions? We don't know," Crisp says.

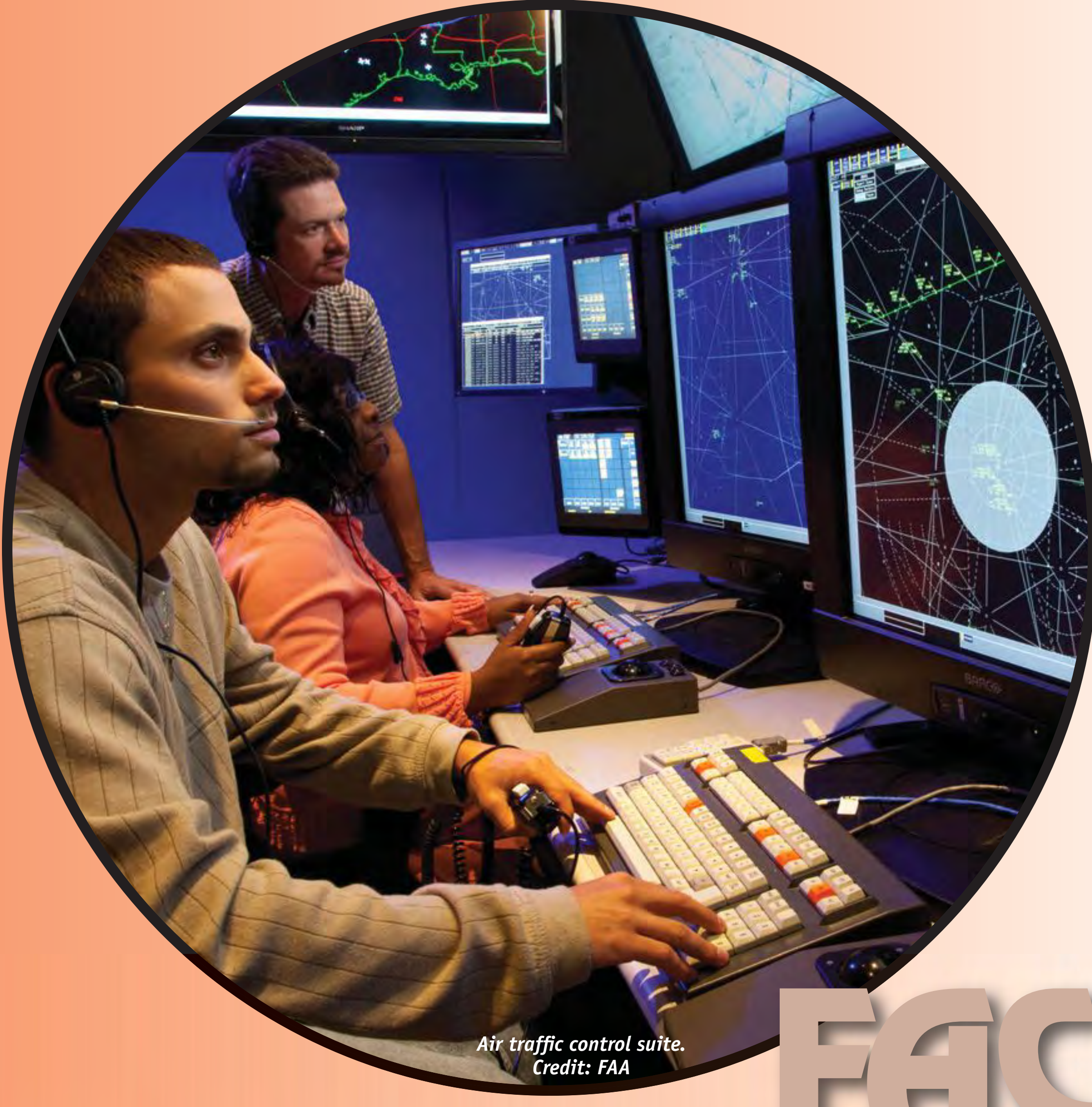
Crisp and his OCO-2 team hope to shed light on some of these mysteries once they begin delivering data to the scientific community at the end of 2014, and he views his mission as critical to the planet's well-being: "Earth scientists, whether we're working on the ground, in aircraft or on satellites, are diagnostic physicians trying to understand the health of the system we live in. It's crucially important."

OCO-2 is scheduled for launch in July. Credit: NASA/JPL

"...Earth observational satellites are indispensable for understanding the climate system, partly because only satellites can provide truly global coverage."

Roy Spencer, climatologist

AIR TRAFFIC CONTROLLERS FACE AUTOMATION



Air traffic control suite.
Credit: FAA

by Philip Butterworth-Hayes

Modernization of air traffic management is already under way. The new systems envisioned in Europe and the U.S. would begin automating a pilot's tasks even before submission of a flight plan. From a hotel room, hours before a flight, the pilot could plug an electronic flight planner into a tablet computer, automatically linking to the plane's flight management system and the FAA air traffic network center. He could choose one of several routes, from the fastest to the least expensive. He would receive weather information, including the wind's speed and direction. Within seconds, an optimal route would be calculated and a touchdown time determined, accurate to within two seconds.

Two out of three flights would be flown automatically: A plane's own systems, linked to the airline's operations and FAA computers, would operate the aircraft, from the closing to the opening of the passenger cabin doors. Schedule disruptions caused by late passengers or sudden changes in weather would be managed by the networked computer systems, with the pilot alerted to the changes. Very rarely would a pilot have to intervene during an automatic flight, and usually only because the network offers faster or more fuel-efficient routing.

That, broadly, is the end-state planned in the two current multi-billion-dollar programs for modernizing air traffic management: the U.S. Next-Generation Air Transportation System—NextGen—and SESAR, the Single European Sky Air Traffic Management Research system. Under way in parallel is the FANS—future air navigation system—communications, navigation, and surveillance management system being pioneered globally by ICAO, the International Civil Aviation Organization.

At the heart of all these is an evolution from today's tactical, manually based air traffic control system to one in which tactical control of aircraft will be managed automatically by the planes' own computers, connected by data-link to the network management system. In this new scenario, known as trajectory-based operations, the controller's job will be to manage a defined sector of airspace, rather than to control every flight.

The promised revolution in air traffic management will bring automation on a grand scale. Introducing the changes is posing challenges that go beyond technology, especially for those who see their roles diminishing.

While the required technologies and the concepts of operation have been researched to the finest detail, it is only now, with the implementation phase of NextGen and SESAR, that the true scale of the challenges is becoming evident. These fall into two broad categories: those where there are clear solutions and those where there are not.

It is more or less clear what the key enabling technologies and procedures will be, how much they will cost to introduce and what benefits they will bring. What is less clear is how the global network will be able to operate when parts of it are degraded, how soon all aircraft operators will adopt compliant technologies, how controllers will accept their changing roles, and how a global net-centric traffic management system will be regulated and certified.

NextGen is transforming the national airspace system to meet future demand. Credit: MITRE

Resistance to change

According to ATC consultant Ann Heinke of Overlook Consulting in Loveland, Colo., ”Avionics equipment is so sophisticated and capable that not even half of the capability is being used on today's aircraft. But there is a huge cultural resistance to change of any kind.”

For controllers, the main sticking point is the degree to which their jobs will be automated. Until now, ATC automation tools —such as software to predict potential conflicts—have been based on enhancing the controller's capability to handle an increasing number of flights within the current management architecture, where the controller remains at the heart of the system. Now, however, the technologies being tested will instead put the aircraft operators' requirements at the heart of the network, while the traffic management system configures itself around their needs.

A milestone in implementing this major ATC change was reached in September, when the FAA and the SESAR Joint Undertaking agreed on the broad outline for a single standard for data-link to transfer data automatically between the air and the ground. This will allow the ATC computer and the aircraft's flight management system to exchange data directly and automatically, without the need for pilots and controllers to talk to each other.

That key development followed others that occurred over the past two years: February 2012 had brought the first I-4D—initial four-dimensional—trajectory management flight trial, where an aircraft's management system was data-linked into the ATC ground computer to automatically fly a precise trajectory that guaranteed the plane would reach specific waypoints within 10 seconds of its flight plan. Then, in January 2013, another milestone was reached with the first operational revenue flight supported by the FAA's FANS Departure Clearance trials: Pre-departure clearance of the flight plan negotiated by the pilot, the aircraft operator and the FAA was automatically loaded into the aircraft's management system.

Boeing aircraft use ground-gased augmentation system data.

Credit: George Bush Intercontinental Airport

Roadmap for landings

Trials have started on GBAS, ground-based augmentation systems, which would provide automatic precision approaches and landings using GPS signals. GBAS augments the signals by performing local area corrections for all satellites in view, broadcasting corrections and approach path information via VHF data link.

The FAA has agreements with United Airlines, the Port Authority of New York and New Jersey, the Houston Airport System and Boeing to gain operational experience with the existing GBAS. Currently, 2016 is the target date set by the FAA for being able conduct landings when there is virtually zero visibility. These landings, known as Category 3, consist of three subcategories, a, b and c. In a Category 3a approach, the plane's autopilot receives lateral and vertical signals from a ground station and flies the plane to a decision height lower than 100 feet (30 meters) above the runway touchdown zone. In a Category 3b approach and landing, the autopilot lands the aircraft on the runway; the FAA says there are 85 runways around the world with instrument landing systems to enable this. A Category 3c approach, which would allow automatic taxiing, is not yet implemented anywhere in the world.

Effects on controllers

It is still early, and the new systems will probably not be complete for another 10 years, according to technology and air navigation service provider experts. But initial indications are that increasing automation will change the skills required of controllers rather than reducing their numbers. Ensuring that an automated network can still function when parts of the system are degraded will inevitably require skilled personnel to fill the gaps.

“We've already seen how this might work in oceanic areas with FANS data communications [conveying] ATC messages with aircraft beyond line of sight,” says Heinke. “It works great until it stops working. The system should then revert to voice messages; but when you are beyond line of sight, you can't use VHF [very high frequency] communications. You have to use HF, which is scratchy, hard to understand, but managed by a third-party operator, so the waves are incredibly long. As you've reduced separations and have aircraft tightly spaced, when you suddenly lose data-com it's a big deal.

ADS-B air traffic network. Credit: Excelis

"The airspace planners in the North Atlantic have been doing an outstanding job in contingency planning," says Heinke, "so that even if you lose data-com because your satcom links have failed, these aircraft can still talk VHF to each other. We're also putting in place ADS-B [automatic dependence surveillance-broadcast] so they can see each other. The backup planning is becoming a self-managed operation, and that's where the aircraft operators want to go."

It may be where the aircraft operators want to go, but controllers sound skeptical. The IFATCA—International Federation of Air Traffic Controllers' Associations—acknowledges the benefits of improved communications on oceanic routes but is concerned about some aspects of the plan to remove humans from the key role of managing tactical ATC operations.

"The rapid developments in technology have heightened IFATCA's concern that the influence of the systems' designers and engineers is overshadowing the requirements and demands of the front-end users such as controllers and pilots for the…future systems," says a recent IFATCA policy paper on automation. "The transition from the current ATC system is universally recognized as an evolutionary process. However, the emphasis on the use of technology is nothing short of revolutionary."

Ensuring a safe revolution

The need to introduce this automation revolution safely is a growing concern worldwide. "At what point does the controller stop using the automation to provide information [and] advice and become reliant on the automation to make decisions?" asks Neil May, head of human factors at the U.K.'s air navigation service provider, NATS, which is undertaking a major study of the issue. "When this happens, who is then really in control, is it the controller or is it the automation?" Do controllers "really understand what the automation is doing, and can they step in when necessary to take over the automated functions? What happens when the automation fails or is no longer available? Above all, how do we gain assurance that the air traffic management system continues to be safe in this future world of increased automation?"

One clear message from the work so far is that introducing automation will require great emphasis on training. At the end of 2011, NATS introduced an automated predictive tool called iFACTS, based on trajectory prediction and medium-term conflict detection. The tool highlights potential aircraft conflicts and enables controllers to look at the airspace traffic picture up to 18 minutes into the future. According to NATS it has delivered, on average, a 15 percent increase in airspace capacity in the U.K. Some airspace sectors have grown as much as 40 percent without any increase in the number of operational staff or redesign of the air routes, says NATS.

"We're not getting so many potential conflicts now we have introduced iFACTS—they are being planned out in advance."

Single European Sky ATM Research will drive modernization of air traffic management. Credit: Honeywell

But in cases where controllers must be asked to step in to take avoiding action, "they haven't practiced as much as before," says May. So we're providing a lot more training now," especially for unusual circumstances," he says, adding, "There's a belief that if you introduce more automation you can reduce training. That's definitely not true."


Gulfstream planes offer Future Air Navigation System equipment. Credit: NOAA

Time line

According to the SESAR and NextGen roadmaps, by 2020 the building blocks will be in place for automation not just to enhance controller tactical control, but to replace it. Most aircraft will have data-link systems, and there will be a global system-wide information management network. Air navigation service providers hope that by then new controllers will have been recruited and the current generation retrained to deal with their new roles.

"In terms of technology, we're well on our way," May says. "The bigger issues are about the political need, and the people issues. The controllers of the future will need very different skills from the controllers we have today. What skills will they need…? And can we make sure the controllers [we have] today can transition to the new arrangements?

"We have a roadmap for the automation, and we're now putting together a roadmap for the people—looking at various tasks and deciding whether people or automation are best placed to do them and how they should work together," according to May.

Four contractor teams are vying to convince the U.S. Army that their approach to a new multi-role helicopter is best. Only two competitors will survive to address the Pentagon's long -term goal of advancing rotorcraft technology beyond the V-22 tilt-rotor, whose technological roots can be traced to the Vietnam era.

face

by J.R. Wilson

The U.S. military has been pushing the envelope of vertical lift since rotor wing aviation began at the start of the 20th century. The past four decades have brought three new forms of VTOL—vertical takeoff and landing—and vertical short takeoff and landing: the AV-8B Harrier jump-jet, the MV-22 Osprey tilt-rotor and the F-35B fifth-generation Joint Strike Fighter.

Of those, only the Osprey is a replacement for traditional helicopters. And according to Jim Hayes, director of military programs and requirements at Piasecki Aircraft, all of the rotorcraft technologies now in service or being considered for the Defense Department's "next-generation" development efforts date back to the 1960s.

"We need technological advancement. We've been living with those Vietnam-era capabilities and performance in vertical lift for a long time—and those no longer meet our requirements," says Hayes. "The Army and others decided the helicopter was a mature technology, so the 1960s

Future Vertical Lift designs

A Marine Corps MV-22 Osprey lifts off from Naval Air Station Patuxent River. Credit: U.S. Navy

was considered the end of the great era of pursuing new capabilities in vertical lift." In their view, helicopters "only needed to go short distances and carry heavy loads," he says.

The Lockheed AH-56 was the last significant advance in vertical lift, Hayes claims, and its cancellation in 1972 ended all but the incremental improvements made since then. It was a compound design, with a four-blade rigid-rotor system for vertical lift and a tail-mounted propeller and low-mounted wings for forward flight.

The dollars invested since then in R&D for fixed-wing aircraft are funds that vertical lift did not get, says Hayes. "The world today is a smaller place, but those Vietnam platforms can't deliver today's required response time, speed and troop support over a lot greater distances. So range is important, but is only practical if you have speed…and [are] able to sustain that force."

off

Contract awards

The Pentagon's current plan to develop a more capable vertical-lift, fast-flight aircraft moved forward in October with the award of four seven-month technology investment agreements of $6.5 million each to AVX Aircraft, Bell Helicopter Textron, Karem Aircraft and Sikorsky Aircraft. Leading this Joint Multi-Role Technology Demonstration effort is the Army Aviation and Missile Research, Development and Engineering Center. The organization will downselect two proposed designs in the second half of this year for three-year technology development contracts, concluding with a prototype fly-off.

Cancelled in 1972, the Lockheed AH-56 Cheyenne was a major advance in vertical lift. Credit: U.S. Army

The two selected will be part of the demonstration's first phase. The Army plans to invest $217 million in Phase 1 to investigate the technical risks associated with developing a next-generation medium-class Future Vertical Lift aircraft to replace most of the military's current helicopter fleet in the 2030s. Phase 1 is to run through fiscal year 2019 and will include all prototype flight tests and data collection. Phase 2 will follow up with an assessment of mission systems, leading to competitive bids for research, development, test and evaluation on the aircraft.

An F-35B test aircraft takes off from the USS Wasp. Credit: Lockheed Martin.

"We must continue to push implementation of the FVL [Future Vertical Lift] strategic plan, which will positively impact vertical lift aviation operations for the next 50-plus years," William Lewis, director of the center's Aviation Development Directorate, said when the contracts were awarded.

The target for a production Future Vertical Lift aircraft is 2030. Goals include major increases over the current fleet—in speed, range, payload, endurance, survivability, reliability, situational awareness and sustainability.

Designs would be based on an open architecture enabling common systems across a family of light, medium and heavy aircraft able to operate on ships. With internal payloads ranging from 1,850 pounds to 10,000 pounds and six to 24 warfighters, the helicopter would have a mission radius of at least 424 kilometers.

The AV-8B Harrier II. Credit: U.S. Marines.

Achieving this will require several key technologies. These include multi-engine and multi-speed transmission designs to drive the rotors over a wide range of speeds and to optimize hover and cruise efficiency, increase range and improve maintainability. Also needed will be lightweight rotorcraft structures with durability and damage tolerance. Creating these will require an integrated design, development and test methodology; more accurate load determination; a more mature stress-life methodology; refined damage tolerance analysis; and integrated elements with testing.

The development process and timeline will require "virtual, linked design, analysis and qualification of materials, structures and subsystems—Boeing calls it 'atoms to airplanes,'" said Lewis in a November 14 presentation to the Georgia Tech Vertical Lift Research Center of Excellence. All this will demand "an unprecedented degree of human/system integration," he added. "The Army, as the lead service for rotary-wing vehicle technology, must maintain core competence across all focus areas," said Lewis.

Achieving the desired range, speed and payloads will require configurations other than edge-wise rotors, said Lewis. This will necessitate research on variable-speed rotors, drives, and engines, and on low-drag fuselage design. Increased digitization also will require integration of complex cyber-physical systems, he said.

Candidate designs

The Sikorsky-Boeing team describes its Joint Multi-Role demonstrator, the SB-1 Defiant, as a significantly up-sized version of Sikorsky's 8,000-pound X2, a coaxial rigid-rotor technology demonstrator. In 2010 the X2 exceeded 250 knots—nearly 10 percent faster than required. The Defiant, with its

AgustaWestland continues to tweak its AW609. Credit: AgustaWestland

stacked counter-rotating blades for vertical flight, would transition in forward flight to two small tail wings and a pusher propeller. Sikorsky already plans to fly an 11,400-pound version, the S-97 Raider light tactical helicopter prototype, this year. Their challenge is to prove the X2 technology can handle a much larger aircraft—30,000 pounds, according to preliminary specifications.

AVX also is pursuing a coaxial compound design. It has two counter-rotating rotors mounted one above the other on concentric shafts for vertical takeoff and landing. It also has a combination of two stubby wings mounted above the cockpit and two side-mounted ducted propellers near the tail for forward flight. The AVX proposal is based on a design the company developed under an earlier Joint Multi-Role-related contract on "configuration trades and analysis." For the Phase 1 prototype, which is one-third larger than the earlier design, AVX has teamed with AdamWorks, a company that manufactures lightweight, high-strength composite structures.

The V-280 Valor, says Bell, is a tilt-rotor, with large three-blade rotors on the ends of extended wings attached to the center top of the fuselage. Because of early problems experienced by the Bell-Boeing V-22, whose engines and rotors both rotate, the Valor's GE engines are fixed, with only the rotors rotating. According to Bell, the Valor has a predicted combat range of up to 800 nautical miles, 280-knot cruise speed and a useful payload of more than 6 tons (including a crew of four and 11 troops). The aircraft also has a triple redundant fly-by-wire flight control system and two 6-foot-wide side doors, says the company. In addition, it has what Bell calls "enhanced situational awareness and sensing technologies." The design's three variants are for attack, utility and medevac operations.

California-based Karem was a latecomer to the Phase 1 competition and a surprise final four selection from the nine proposals the Army received. Former Israeli Air Force aviation designer Abraham Karem, who was involved in developing the Gnat 750 (which evolved into the MQ-1 Predator) and A180 Hummingbird unmanned aircraft, founded the company in 2000 to advance tilt-rotor technology development.

Karem's multi-role demonstrator proposal is based on the company's TR36TD design, including its optimum speed tilt-ro-

The X-49A SpeedHawk undergoing flight test. Credit: Piasecki Aircraft

The Bell V-280 in low-level flight. Credit: Bell Helicopter

tor. Twin 36-foot variable-speed rotors are mounted at the center of extended, high-center fuselage wings. The tiny company (with fewer than three-dozen employees) claims its aircraft will be capable of cruise speeds up to 360 knots (414 mph), significantly faster than the Bell design or the 230 knots predicted by both AVX and Sikorsky/Boeing.

Nearer term projects

Other rotor-wing manufacturers are moving forward with their own designs. Some are purely company financed, others are related to various U.S. and foreign programs, a few of which are seen as more near-term than the Future Vertical Lift. EADS, for example, reportedly withdrew its Eurocopter X^3 from the Joint Multi-Role competition for just that reason.

With five-blade rotors, the compound X^3 can take off and land vertically like a helicopter; propellers on the ends of its short-span wings take over for forward flight. During its flight test program, the X^3 reportedly reached a level flight speed of more than 230 knots, using less than 80 percent of its available power, according to the company.

Eurocopter hopes to put the X^3 into service in the 2020s and already has begun preliminary research and development on a generation-after-next X^4.

AgustaWestland continues to tweak its AW609, which has tilt-rotors at the ends of its high center-mounted wings and a tall T-tail. During flight tests in July at its Cascina Costa flight test facility in Italy, AW609 program manager Clive Scott said Prototype 2 has had some significant upgrades.

"New avionics, [a] new cockpit display system and a large number of other improvements will together give the aircraft greater performance and mission capabilities," he says. It will also have "much higher cruise speed, high-altitude cruise capability and longer range, when compared to existing helicopters or other proposed high-speed rotorcraft," says Scott.

According to AgustaWestland, the modified AW609 has a maximum cruising speed of 275 knots—and bursts of up to 333 knots—as well as a range of 700 nautical miles. The aircraft represents the company's re-baselining of its tilt-rotor program, an approach that is helping to reduce customer acquisition and operating costs while still delivering performance and technology improvements, Scott says.

Piasecki, one of the oldest helicopter manufacturers in the U.S., has opted not to follow the tilt-rotor path now embraced to one extent or another by most major rotorcraft manufacturers. However, Hayes says future military and commercial requirements are enough to warrant further development on a wide range of vertical lift technologies.

"There is no one perfect technology to solve all requirements. You usually compromise when you try to make a platform that is all things, rather than meeting a specific mission set. As a result, the problems we have are designed into the platform," the former Marine helicopter pilot tells Aerospace America. "There were obvious benefits with the V-22, but it could have had longer rotor blades and a different box design if it did not have to fit on a carrier deck."

Piasecki's next-generation designs focus on compound technology. An example is the X-49A Vectored Thrust Ducted Propeller compound helicopter demonstrator, which the company is offering as a retrofit package for legacy craft, claiming it will increase speed while reducing vibration, thus extending the useful lives of those aircraft.

Often confused with the X-49A is Piasecki's proposed "clean sheet" next-generation compound helicopter, the SpeedHawk, which would incorporate X-49 propeller and other advances in an original design. The result, according to Hayes, would be a fast, scalable aircraft that, compared to current helicopters, will also have a significantly longer life cycle.

Eurocopter hopes to put the X^3 into service in the 2020s. Credit: Eurocopter

"Another technology we're working on is adaptive flight controls, which is a huge capability. We have redundant controls, both fixed-wing and helicopter [modes]," he adds. "If a round goes through one of those control systems, what might be a catastrophic failure on a conventional helicopter becomes a fly-home ability as the other control system automatically adapts to take over. We're introducing that on the X-49A demonstrator, but it is still in the lab."

While Joint Multi-Role is a centerpiece for military technologies leading to an eventual Future Vertical Lift, the variety of other programs—both within and outside the Defense Department—also are expected to contribute to next-generation vertical aircraft in the 2020s and beyond.

As Lewis notes, "We are looking to bring transformational vertical lift capabilities across the spectrum of operations."

Out of the

25 Years Ago, February 1989

Feb. 10 The Soviet Union launches six Cosmos satellites from a single Cyclone rocket. One of the satellites is placed into a near polar orbit to take photographs of previously unexplored regions of central Antarctica. NASA, Astronautics and Aeronautics, 1986-1990, Page 205.

Feb. 14 In the first use of the new Delta 2 booster, the Air Force launches NAVSTAR, the first in a series of 21 GPS navigation satellites, into an 11,000-mile-high circular orbit. NASA, Astronautics and Aeronautics, 1986-1990, Page 205.

Feb. 21 The Soviet Union's Phobos 2 probe, on its way toward the Martian moon Phobos to land two robotic rovers there, is now sending photos of its surface, according to Soviet news agency Tass. NASA, Astronautics and Aeronautics, 1986-1990, Page 206.

50 Years Ago, February 1964

Feb. 1 The Boeing tri-jet 727 airliner enters passenger service with Eastern Airlines on the Miami-Washington, D.C., route. The first of a dozen 727s to be delivered to Lufthansa German Airlines is also scheduled to make its inaugural flight by the end of the month. The 727 will be produced in large numbers, with the last one completed in 1984. Know Aviation, Page 63; Aviation Week, Feb. 17, 1964, Page 45; Flight International, March 3, 1964, Page 354.

Feb. 2 The U.S. Ranger 6 spacecraft, launched on Jan. 30, hits the surface of the moon but fails to transmit any pictures of the lunar surface as planned. Aviation Week, Feb. 10, 1964, Pages 22-25.

Feb. 4 Valentina Tereshkova, the first woman in space, arrives in London and on the following day receives the Gold Medal of the British Interplanetary Society from its president, Leslie R. Shepherd. She is also presented to Queen Elizabeth. Tereshkova made a 72-hour 48-orbit flight in the Soviet Vostok spacecraft in June of 1963. Flight International, Feb. 13, 1964, Page 258.

Feb. 5 French pilot Hrissa Pélissier crosses the South Atlantic in her single-engine Wassmer WA 40 Super IV aircraft, named Sancy. She covers the 5,600-mile distance from Issoire, France, to Rio de Janeiro in 12 hours and 40 minutes, becoming the third woman to accomplish a transatlantic flight. The last such crossing was made by Maryse Bastié in 1936. Flight International, Feb. 13, 1964, Page 256.

Feb. 10 Austrian rocketry pioneer Eugen Sänger dies at age 58 in West Berlin. As a student in the early 1930s, Sänger conducted some of the world's first scientific rocket motor experiments and in 1933 produced the book "Rocket Flight Engineering," viewed as one of the best technical works on the subject. He also published articles on rocket-powered flight and in 1936 obtained support from the German government for himself and his team to conduct a rocket research program toward development of a suborbital long-range rocket-propelled bomber. Called the Silbervogel or Silverbird, and later the Antipodal Bomber, it prefigured the space shuttle but never became operational. Following World War II, Sänger became a prominent promoter of spaceflight. New York Times, Feb. 11, 1964, Page 39.

Feb. 10 France launches the fourth test of its Sud-Aviation two-stage solid-propellant Dragon research rocket from its Sahara Desert test range at Hammaguir, Algeria. The rocket attains an altitude of 470 kilometers. France therefore announces that the rocket is available for sending up scientific payloads and can lift 30 kilograms to a height of 600 kilometers, or 200 kilograms to 250 kilometers. Flight International, March 5, 1964, Page 376.

Feb. 10 The first Athena four-stage solid-propellant sounding rocket launch takes place at Green River Bend, Utah, with dummy third and fourth stages. After a flight of about 200 miles, however, a malfunction causes the rocket to veer off course and crash near Durango, Colo. Aviation Week, Feb. 17, 1964, Pages 30-31.

Feb. 25 Maurice Farman, the British-born French aviation pioneer, dies in Paris at age 96. Farman started his career in automobile racing and in 1908 bought a Voisin Model 4 biplane, setting world endurance and speed records in 1909. He soon began to manufacture airplanes and in 1912 merged his own company with that of his brothers Henri and Richard, as the Farman Aviation Works. The firm produced many aircraft, including the Farman MF.7 Longhorn and MF.11 Shorthorn biplane bombers and the F.30 and F.40 fighters, all of World War I vintage; the F.51 maritime reconnaissance flying boat and F.60 Goliath airliner, a forerunner of later passenger planes; and other aircraft used during and after World War II. New York Times, Feb. 28, 1964, Page 29.

Past

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

Feb. 27 The USSR launches the 25th of its Cosmos series of satellites. Although usually called scientific, many of these are widely believed in the West to be military satellites, and probably reconnaissance types. Over the years, the Soviet Union launches hundreds of them. Flight International, March 5, 1964, Page 370.

Feb. 27 The tube-launched, optically tracked wire-command-link anti-tank guided missile is publicly introduced by its developer, Hughes Aircraft. The weapon, known as the TOW, will become one of the most widely used anti-tank guided missiles in the world. Flight International, March 12, 1964, Page 403.

Feb. 29 President Lyndon Johnson discloses the existence of the Lockheed A-11, a 2,000-mph, high-altitude reconnaissance aircraft. The A-11 soon leads to an even more advanced reconnaissance plane, the A-12, and is the precursor of the SR-71 Blackbird. Flight International, March 12, 1964, Pages 377-379.

75 Years Ago, February 1939

Feb. 4-6 The Boeing XB-15 bomber prototype, which made its inaugural flight on October 15, 1937, flies a mercy mission to Chile, carrying 2,250 pounds of medical supplies for earthquake victims. This is a nonstop flight of 29 hours 53 minutes from Langley Field, Va., to Santiago, Chile. The pilot, Maj. Caleb V. Haynes, is later presented with the Distinguished Flying Cross. Aircraft Year Book, 1940, Page 431.

Feb. 14-28 Lufthansa places a Dornier Do 26 four-engined flying boat, the Seefalka, into experimental use on the South Atlantic for the first time. It carries 1,300 pounds of medicines for the relief of earthquake victims in Chile. Interavia, March 3, 1939, Pages 7-8.

Feb. 22 The first Fokker T.8-W begins flying trials in Amsterdam, the Dutch Navy having ordered several of the twin-engined torpedo aircraft. Interavia, Feb. 24, 1939, Page 5.

Feb. 24 Boeing's Model 314 flying boat is officially handed over to Pan American Airways for U.S.-European service. An agreement has already been reached with the French government for U.S. air transports to carry passengers, mail and goods across the Atlantic and into and out of French terminals. Aircraft Year Book, 1940, Page 431; Aero Digest, Feb. 1939, Page 17.

And During February 1939

—During a blizzard, Northwest Airlines operates the only airplane service out of Chicago, using a single-engine Hamilton equipped with skis for flying mail and express baggage between Chicago and Milwaukee. Aero Digest, March 1939, Page 32.

—Germany's Junkers aircraft firm signs an agreement with the Mexican government on trading Mexican oil for German planes. Interavia, Feb. 21, 1939, Page 7.

100 Years Ago, February 1914

Feb. 3 German pilot Bruno Langer sets a new duration record by flying his Roland biplane for 14 hours 7 minutes. A. van Hoorebeeck, La Conquete de L'Air, Page 103.

Feb. 11 French pilot Agénor Parmelin flies his Deperdussin monoplane over Mont Blanc, the highest peak in the Alps. A. van Hoorebeeck, La Conquete de L'Air, Page 103.

And During February 1914

—Marc Pourpe of France completes the first flight from the Red Sea to the Mediterranean by flying his aircraft above the length of the Suez Canal. A. van Hoorebeeck, La Conquete de L'Air, Page 103.

—At Marblehead, Mass., trial flights begin for the Burgess-Dunne hydroplane, the world's first sweptback seaplane. Made by the Burgess company and Curtiss, the craft is a modification of the Dunne sweptback landplane designed by Lt. John W. Dunne of England. A 100-horsepower Curtiss O-X engine powers the 46-foot-span seaplane. Flight, June 19, 1914, Pages 644-647.

Georgia Institute of Technology

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The Daniel Guggenheim School of Aerospace Engineering at Georgia Institute of Technology, in Atlanta, GA, invites nominations and applications for tenure-track faculty positions in autonomy, space systems and fluid mechanics & automation. Appointments are expected to be at the Assistant Professor level, however appointments to the Associate or Full Professor level will be considered for exceptional candidates having demonstrated a superior research and teaching record with a strong commitment to aerospace applications. **Visit ae.gatech.edu/careers to view complete position announcements and application instructions for specific position postings.**

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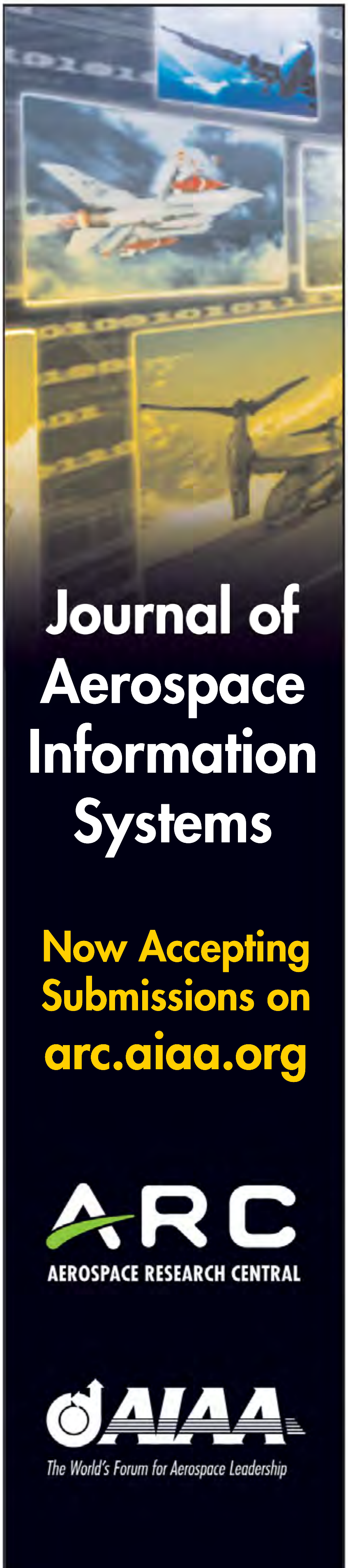

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Candidates must submit applications electronically to Prof. Ghatu Subhash, Search Committee Chair, at maesearch@mae.ufl.edu. Applications should include: 1) a cover letter mentioning the specific area, and briefly outlining the candidate's qualifications, research and educational interests; 2) 3-5 year research plan, potential collaborative activities and statement of teaching philosophy; 3) a complete CV; and 4) the names and full contact information for at least four references. The search committee will begin screening of applicants immediately and will continue to accept applications until all positions are filled. University of Florida counts among its greatest strengths — and a major component of its excellence – that it values broad diversity in its faculty, students, and staff and creates a robust, inclusive and welcoming climate for learning, research and other work. UF is committed to equal educational and employment opportunity and access and seeks individuals of all races, ethnicities, genders and other attributes who, among their many exceptional qualifications, have a record of including a broad diversity of individuals in work and learning activities. The selection process will be conducted in accord with the provisions of Florida's 'Government in the Sunshine' and Public Records Laws. The University of Florida is an Equal Opportunity Employer.

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AIAA

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AIAA Bulletin

At the 2014 AIAA Science and Technology Forum and Exposition (AIAA SciTech 2014), AIAA's President-Elect Jim Albaugh moderated a panel on "AIAA's Role in Defining the Future of Aerospace" with panelists Ray Johnson, Senior VP, CTO, Lockheed Martin; David Hills, Director, Research and Technology, Airbus Americas; Michael Ryschkewitsch, Head of the Space Sector of Johns Hopkins University, Applied Physics Lab; and John Tracy, CTO and SVP of Engineering, Operations, and Technology, Boeing. The panel generated discussion on two tracks: 1) what is the future of the industry and how can that future be shaped, and 2) what role can AIAA play in that shaping. See a video of the panel at http://www.livestream.com/aiaa/video?clipId=pla_b42290ca-fa77-499c-a86c-d5fb8403471a&utm_source=lslibrary&utm_medium=ui-thumb.

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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
2014			
Feb–June	Advanced Computational Fluid Dynamics	Home Study	
Feb–June	Computational Fluid Turbulence	Home Study	
Feb–June	Introduction to Computational Fluid Dynamics	Home Study	
Feb–June	Missile Design and System Engineering	Home Study	
Feb–June	Spacecraft Design and Systems Engineering	Home Study	
2–6 Feb†	American Meteorological Society Annual Meeting	Atlanta, GA (Contact: Claudia Gorski, 617.226.3967, cgorski@ametsoc.org, http://annual.ametsoc.org/2014/)	
1–8 Mar†	2014 IEEE Aerospace Conference	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
24–26 Mar†	49th International Symposium of Applied Aerodynamics	Lille, France (Contact: Anne Venables, 33 1 56 64 12 30, secr.exec@aaaf.asso.fr, www.3af-aerodynamics2014.com)	
15–16 Apr	NASA MaterialsLAB Workshop	Arlington, VA (Contact: Dennis Griffin, dennis.e.griffin@nasa.gov, 256.544.2493, http://www.cvent.com/events/nasa-materials-lab-workshop/event-summary-f0ee4d29123a453b94c511ab660b81fa.aspx	
30 Apr	2014 Aerospace Spotlight Awards Gala	Washington, DC	
5–9 May	SpaceOps 2014: 13th International Conference on Space Operations	Pasadena, CA	**5 Aug 13**
26–28 May	21st St. Petersburg International Conference on Integrated Navigation Systems	St. Petersburg, Russia (Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru)	
26–29 May†	6th International Conference on Research in Air Transportation (ICRAT 2014)	Istanbul, Turkey (Contact: Andres Zellweger, 301.330.5514, dres.z@comcast.net, http://www.icrat.org/	
5 Jun	Aerospace Today ... and Tomorrow: An Executive Symposium	Williamsburg, VA	
14–15 Jun	Third AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III)	Atlanta, GA	
16–20 Jun	AIAA AVIATION 2014 (AIAA Aviation and Aeronautics Forum and Exposition) Featuring: 20th AIAA/CEAS Aeroacoustics Conference 30th AIAA Aerodynamic Measurement Technology and Ground Testing Conference AIAA/3AF Aircraft Noise and Emissions Reduction Symposium 32nd AIAA Applied Aerodynamics Conference AIAA Atmospheric Flight Mechanics Conference 6th AIAA Atmospheric and Space Environments Conference 14th AIAA Aviation Technology, Integration, and Operations Conference AIAA Balloon Systems Conference AIAA Flight Testing Conference 7th AIAA Flow Control Conference 44th AIAA Fluid Dynamics Conference 20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference 11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference 21st AIAA Lighter-Than-Air Systems Technology Conference 15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference AIAA Modeling and Simulation Technologies Conference 45th AIAA Plasmadynamics and Lasers Conference 7th AIAA Theoretical Fluid Mechanics Conference	Atlanta, GA	**14 Nov 13**
22–27 Jun†	12th International Probabilistic Safety Assessment and Management Conference	Honolulu, HI (Contact: Todd Paulos, 949.809.8283, secretariat@psam12.org, www.psam12.org)	
13–17 Jul†	International Conference on Environmental Systems	Tucson, AZ (Contact: Andrew Jackson, 806.742.2801 x230, Andrew.jackson@ttu.edu, http://www.depts.ttu.edu/ceweb/ices/)	
15–18 Jul†	ICNPAA 2014 – Mathematical Problems in Engineering, Aerospace and Sciences	Narvik University, Norway (Contact: Seenith Sivasundaram, 386.761.9829, seenithi@aol.com, www.icnpaa.com)	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
28–30 Jul	**Propulsion and Energy 2014** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference** **12th International Energy Conversion Engineering Conference**	Cleveland, OH	**14 Jan 14**
31 Jul–1 Aug	**2nd AIAA Propulsion Aerodynamics Workshop**	Cleveland, OH	
2–10 Aug†	**40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events**	Moscow, Russia http://cospar2014moscow.com/	**14 Feb 14**
4–7 Aug	**SPACE 2014** **(AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA/AAS Astrodynamics Specialist Conference** **AIAA Complex Aerospace Systems Exchange** **32nd AIAA International Communications Satellite Systems Conference** **AIAA SPACE Conference**	San Diego, CA	**21 Jan 14**
7–12 Sept†	**29th Congress of the International Council of the Aeronautical Sciences (ICAS)**	St. Petersburg, Russia (Contact: www.icas2014.com)	**15 Jul 13**
29 Sep–3 Oct†	**65th International Astronautical Congress**	Toronto, Canada (Contact: http://www.iac2014.org/)	
2015			
5–9 Jan	**AIAA SciTech 2015** **(AIAA Science and Technology Forum and Exposition 2015)** **Featuring:** **23rd AIAA/ASME/AHS Adaptive Structures Conference** **53rd AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Spacecraft Structures Conference (formerly the AIAA Gossamer Systems Forum)** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **11th AIAA Multidisciplinary Design Optimization Specialist Conference** **17th AIAA Non-Deterministic Approaches Conference** **56th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **8th Symposium on Space Resource Utilization** **33rd ASME Wind Energy Symposium** **AIAA Infotech@Aerospace Conference**	Kissimmee, FL	
7–14 Mar†	**2015 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
25–27 Mar†	**3rd Int. Conference on Buckling and Postbuckling Behaviour of Composite Laminated Shell Structures with DESICOS Workshop**	Braunschweig, Germany (Contact: Richard Degenhardt, +49 531 295 3059, Richard.degenhardt@dlr.de, www.desicos.eu	
25–27 May†	**22nd St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia, (Contact: Prof. V. G. Peshekhonov, 7 812 238 8210, icins@eprib.ru, www. Elektropribor.spb.ru)	
22–26 Jun	**AIAA AVIATION 2015** **(AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **21st AIAA/CEAS Aeroacoustics Conference** **31st AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **33rd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **7th AIAA Atmospheric and Space Environments Conference** **15th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference** **45th AIAA Fluid Dynamics Conference**	Dallas, TX	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
	21st AIAA International Space Planes and Hypersonic Systems and Technologies Conference 13th AIAA/ASME Joint Thermophysics and Heat Transfer Conference 22nd AIAA Lighter-Than-Air Systems Technology Conference 16th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference AIAA Modeling and Simulation Technologies Conference 46th AIAA Plasmadynamics and Lasers Conference 8th AIAA Theoretical Fluid Mechanics Conference		
27–29 Jul	**Propulsion and Energy 2015** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** 51st AIAA/ASME/SAE/ASEE Joint Propulsion Conference 13th International Energy Conversion Engineering Conference	Orlando, FL	
18–20 Aug	**SPACE 2015** **(AIAA Space and Astronautics Forum and Exposition)** **Featuring:** AIAA SPACE Conference	Pasadena, CA	

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

AIAA REMAINS ENGAGED: A PUBLIC ACCESS STATUS REPORT

Sandy H. Magnus, Executive Director

Although this column is being published in the February 2014 issue, I am writing it at the cusp of the New Year, a natural time of reflection and anticipation. In the last several months you've read articles by me and others on policy issues that affected the aerospace technical community in 2013. There have also been developments on a number of issues that affect AIAA as a business—in particular government travel restrictions for technical conferences and public access to federally funded research, particularly research that results in peer-reviewed journal articles. Public access is not a particularly new issue and the debate was not sparked by irresponsible behavior by a single or a few agencies. Open and public access to scholarly research articles is an issue that has been around at least 10 years. The desire for Open Access to such research is tied to beliefs strongly held by some that progress and innovation is driven by the broad sharing of new ideas and that barriers such as paywalls and usage restrictions should be reduced or eliminated. Public Access calls for the free, open distribution of federally funded research.

Public Access Publishing Mandates

Twelve months ago, STM (scientific, technical, and medical) publishers like AIAA—both commercial and not-for-profit—were operating in a wait-and-see mode under the provisions of America COMPETES 2010. This approach had been received favorably by AIAA and its peers because it recognized the inherent variability among scientific and technical disciplines and the nature of their respective research, etc.; called for input and recommendations from and collaboration with non-federal stakeholders including publishers; and considered the role that scientific publishers play in the peer-review process, ensuring the integrity of the record of scientific research, including the investments and added value that they make to the overall process. A change of direction was prompted by OSTP Director John Holdren's 22 February 2013 memorandum to executive department and agency heads setting expectations and an 22 August 2013 deadline for the drafting of plans "to support increased public access to the results of research funded by the Federal Government" including any results published in peer-reviewed scholarly publications and related digital data. The articles were to be made freely available to the public after a 12-month embargo period, which is intended to allow publishers time to recoup their investment in the publishing process.

While this triggered some initial hand-wringing, the OSTP memo was fully consistent with and referenced the provisions of America COMPETES 2010 and soon elicited a positive and collaborative reaction from most STM publishers. AIAA, already a member of the Association of American Publishers Professional and Scholarly Publishing (AAP/PSP), became involved in AAP/PSP's Government Affairs Task Force (GATF) and organized an informational and listening session of GATF publisher representatives with NASA's internal public access working group. This meeting in May included representatives from both commercial and fellow society publishers (Elsevier, Wiley-Blackwell, American Physical Society, and American Institute of Physics). Throughout the summer there were a number of similar briefings across technical disciplines made to federal agencies as well as briefings on compliance solutions recommended to the Interagency Public Access Committee.

Publisher Initiatives

STM publishers took action early on. Seven publishers and four research funders—National Science Foundation, Department of Energy, NASA, and the Wellcome Trust—have worked toward a means to facilitate compliance with public access mandates. As a result, in May 2013, FundRef was launched to help address tracking the publications resulting from federal-funded research, one of the primary goals of the OSTP directive. FundRef enables a standard way to report funding sources for published scholarly research. Using this asset, publishers can deposit funding information from articles using a standard taxonomy of funder names. This funding data is then made publicly available through CrossRef's search interfaces and APIs. [CrossRef is the association of scholarly publishers that develops shared infrastructure to support effective scholarly communications. Its citation-linking network (based on the ISO standard ISO 26324:2012 for digital object identifiers or DOIs) covers over 64 million journal articles and other content items.]

With FundRef moving from the pilot to the operational stage, publishers were able to pursue additional initiatives to support compliance with the OSTP directive, resulting in the Clearinghouse for the Open Research of the United States (CHORUS). CHORUS is a not-for-profit, public-private partnership designed to increase public access to peer-reviewed publications that report on federally funded research. CHORUS, of which AIAA was an early signatory, currently comprises 86 international publishers and 7 publishing service and support providers. CHORUS, however, is not a repository of peer-reviewed articles originating from federally funded research. It merely provides a discovery service through an end-user website and API that links to the article version of record that is freely available on the publisher's website; one of several independent archiving and preservation platforms; or government repositories if the publisher's site is inaccessible or no longer maintained. Furthermore, CHORUS requires no investment from the government—a key requirement of the OSTP directive—and will allow for international scalability, which is fully anticipated given the numerous open/public access studies and policies under development around the world. CHORUS is anticipated to use a membership funding model supported by publishers much like that of CrossRef. While this will represent an additional expense for AIAA as a participant, it represents a manageable one in the grand scheme of challenges stemming from public access.

Legislative Efforts

Taken together, the provisions of America COMPETES 2010, reinforced by the OSTP directive and complemented by the voluntary efforts of STM publishers, help chart a reasonable future course; although there remains some uncertainty when it comes to embargo periods. In parallel to the action of the executive branch and the ongoing dialogue with the STM publishing community, two bills were introduced in the 113th Congress—"Fair Access to Science and Technology Research Act" or FASTR (H.R. 708 and S. 350) and "The Public Access to Public Science Act" or PAPS (H.R. 3157)—solely focused on public access. The PAPS legislation introduced on 20 September 2013 is limited to only NASA, the National Science Foundation (NSF), the National Institute of Standards and Technology (NIST), and the National Weather Service (NWS), and calls for a 12-month embargo period and allows for the petition to increase (or decrease) the embargo period by up to 6 months (by discipline or field). On the other hand, FASTR, introduced in February 2013, is the most recent incarnation of the "Federal Research Public Access Act" (FRPAA), which has been introduced in each Congress since 2006. FASTR's provisions call for a one-size-fits-all, 6-month embargo period with no provision for exceptions for different disciplines. As we begin 2014, a discussion draft of "Frontiers in

Innovative Research, Science, and Technology Act" (FIRST) is being circulated. FIRST, which has a scope that encompasses more than public access, would provide for investment in innovation through scientific research and development to improve the competitiveness of the United States. The current draft includes language that calls for the use of existing information technology infrastructure and that of the private sector to facilitate public access to covered material. Additionally, FIRST echoes the America COMPETES and OSTP directive's call for input from public and private sector stakeholders including publishers; provides for longer embargo periods for peer-reviewed research articles (not later than 24 months after publication); and allows for an extension of the embargo period by 6 to 12 months if the agency, in consultation with the stakeholders, determines that the scientific field and stakeholders would be uniquely harmed without such an extension. Other provisions of FIRST may ultimately cause concerns for groups advocating on behalf of science and technology policy; however, the commonsense approach to public access mandates reflects a recognition that data-driven solutions and stakeholder involvement would lessen the overall risk to the research enterprise.

The passage of the "Consolidated Appropriations Act of 2014" (H.R. 3547) in mid-January, included additional public access mandates in Sect. 527, which covers the federal agencies under the jurisdiction of the Labor, Health, and Human Services, Education and Related Agencies (LHHS) Committee. The language in general is similar that of the OSTP directive and seems to allow for a nongovernment solution like CHORUS. However the language stipulates a fixed 12-month embargo, with no mention of exceptions or modifications based on stakeholder input. While the legislation only impacts the agencies under LHHS oversight, it introduces an additional level of complexity for researchers and their publishers.

STM publishers are working toward evidence-based, data-driven recommendations on article embargo periods. In mid-December the first attempt at this was described in a study released by the AAP that demonstrates that for most scholarly disciplines, usage (as defined by article downloads, not citations) peaks somewhere between 36–48 months following publication; much longer than any of the 6–12 embargo periods being advocated. In fact only 3% of all disciplines have a usage half-life of less than 12 months. Engineering follows the overall trend of 36–48 months. AIAA did not contribute data to this study but is considering replicating this study using its own data or collaborating with other engineering publishers on an engineering-specific usage study.

Public Access to Federally Funded Research Data

In addition to public access mandates for peer-reviewed articles based upon federally funded research, the preservation and public accessibility of the underlying data in digital form are also called for in America COMPETES 2010, OSTP directives, and the discussion draft of FIRST. Scholarly publishers like AIAA have long seen the value of providing access to supplemental material, including datasets not easily communicated in the framework of the written article in either print or digital formats. There are still concerns associated with standards of format, attribution and citation, persistent linking, long-term storage of large amounts of data, and interoperability. These issues also beg the questions: As a scholarly publisher, is AIAA prepared to offer data (and eventually code/software) repositories to its federally funded authors as an adjunct to publication? Is the provision or maintenance of a discipline-specific digital data repository an evolution of the role of a learned society such as AIAA? Does it fit within the AIAA strategic plan?

As the federal research agencies' public access policies develop; legislation moves, evolves, or stalls; and AIAA refines its mission, vision, and strategies, these fundamental questions will need to be answered.

While there are positive signs on the research landscape, H.R. 3547 having restored some of the automatic cuts established by sequestration, complex challenges persist. As an organization that serves a research and development, technically focused membership, AIAA must remain focused on finding new and agile means to meet these challenges. This will entail enhancing our products and services for existing and emerging technical communities, examining our publishing business models to ensure the continued viability of our publications, and advocating broadly for common-sense policies affecting the research enterprise (i.e., for consistent research funding, lifting of conference travel restrictions, and flexible usage- and discipline-based public access embargoes to name a few). Despite a challenging environment now or in the future, robust technical content has been and will remain the core value that AIAA provides.

AIAA ANNOUNCES 2014 FELLOWS AND HONORARY FELLOWS

AIAA is pleased to announce the 2014 AIAA Fellows and Honorary Fellows. Presentation of the new Fellows and Honorary Fellows will take place at the AIAA Aerospace Spotlight Awards Gala, Wednesday, 30 April 2014, at the Ronald Reagan Building and International Trade Center, in Washington, DC.

The title of *Honorary Fellow*, the highest distinction conferred by AIAA, is granted to preeminent individuals who have long and highly contributory careers in aerospace, and who embody the highest possible standards in aeronautics and astronautics. The 2014 Honorary Fellows are:

Edward Greitzer, Massachusetts Institute of Technology
Paul Kaminski, Technovation, Inc., Hughes Research Labs, Exostar, General Dynamics
George Muellner, U.S. Air Force, Boeing Defense Systems, University of Illinois

The distinction of *Fellow* is conferred upon those members of the Institute who have made notable and valuable contributions to the arts, sciences, or technology of aeronautics or astronautics. The 2014 AIAA Fellows are:

Joao Luiz Azevedo, Instituto de Aeronáutica e Espaço
Neal Barlow, U.S. Air Force Academy
Steven Battel, Battel Engineering
John Blanton, GE Power & Water
John Brophy, Jet Propulsion Laboratory
Tom Crouch, Smithsonian National Air and Space Museum
Michael Delaney, The Boeing Company
Eugene Dionne, Lockheed Martin Corporation
Song Fu, Tsinghua University
John Kim, University of California Los Angeles
David King, Dynetics, Inc.
Roger Krone, The Boeing Company
Dimitris Lagoudas, Texas A&M University
Deborah Levin, Pennsylvania State University
Meng-Sing Liou, NASA Glenn Research Center
Robert Lucht, Purdue University
Jeffery Puschell, Raytheon Space & Airborne Systems
David Riley, The Boeing Company
Zamik Rosenwaks, Ben-Gurion University of the Negev
Daniel Scheeres, University of Colorado Boulder
Bob Schutz, University of Texas at Austin
Sergey Surzhikov, Russian Academy of Sciences – Institute for Problems in Mechanics
James Voss, University of Colorado Boulder
Richard Wahls, NASA Langley Research Center
Andres Zellweger, Aviation Consultant

"The title of AIAA Fellow is among the highest honors that one can earn in the aerospace community. It represents the acknowledgement of peers that one's work is truly outstanding, and that you have made lasting contributions to significantly advancing the state-of-the art of aerospace science and technology," said AIAA President Mike Griffin. "Beyond that, the title of Honorary Fellow honors those whose work and contributions have placed each at the pinnacle of our profession. This year's selection committee has done an outstanding job of identifying those who meet these standards. I congratulate each member of this year's class of Fellows and Honorary Fellows."

In 1933, Orville Wright became AIAA's first Honorary Fellow. Today, AIAA Honorary Fellows and AIAA Fellows are the most respected names in the aerospace industry. For more information about AIAA's Fellows and Honorary Fellows program, contact Patricia A. Carr at triciac@aiaa.org or 703.264.7523.

CALL FOR PAPERS FOR *JOURNAL OF AEROSPACE INFORMATION SYSTEMS*

Special Issue on Aerospace Human–Automation Interaction

The *Journal of Aerospace Information Systems* is devoted to the applied science and engineering of aerospace computing, information, and communication. Original archival research papers are sought that include significant scientific and technical knowledge and concepts. In particular, articles are sought that demonstrate the application of recent research in human–automation interaction to a wide range of practical aerospace problems in the analysis and design of vehicles, on-board avionics, ground-based processing and control systems, flight simulation, and air transportation systems.

Information about the organizers of this special issue as well as guidelines for preparing your manuscript can be found in the full Call of Papers under Featured Content in Aerospace Research Central; arc.aiaa.org. The journal website is **http://arc.aia.org/loi/jais**.

Key research areas included in the special issue are:

- *Metrics and Measures*, including real-time measures or techniques to measure mission effectiveness, function allocation, observability, mental models, and situation awareness.
- *Personification issues of advanced automation*. Should intelligent systems behave as agents with a personality and autonomy, or should advanced automation be built and used as a tool?
- *Novel analysis techniques for verification of automation, human, vehicle/device, and environment interaction*: including formal modeling, simulation, and the use of virtual environments. Certification of systems with human operators and advanced intelligent automation.
- *Design Methods*, including methods for the inclusion of etiquette into automation design, automation awareness of its own boundaries and limitations, and interfaces for static and adaptive automation
- *Human interaction aspects of future developments in automation for ATC and aircraft*, including monitoring systems, delegation of authority, and certification issues with advanced and adaptive automation.
- *Roles and effects of automation in all aspects of training*, including on skill development, college curricula, and certification of designers and engineers working on human–automation interaction as well as certification of operators and personnel working with advanced automation.
- *Joint Cognitive Systems*, collaboration and joint decisions taken by humans and automation, compatibility of automation, and human decisions and actions.

These areas are only indicative. Also, the special issue is open to manuscripts that are relevant to the applied science and engineering of aerospace computing, information, and communication in systems with human–machine interaction but do not fit neatly into any of the above areas. We do envisage, however, that successful manuscripts will include experimental results, sophisticated simulations of aerospace systems, or (in the case of a paper in the areas of education or policy) well-researched and thorough arguments for policies and their implementations.

Deadline: Submissions are due by **15 May 2014**.
Anticipated Publication Date: **September 2014**.
Contact Email: Karen Feigh, Karen.feigh@gatech.edu or René van Paassen M.M.vanPaassen@TUDelft.nl

CALL FOR NOMINATIONS—WALTER J. AND ANGELINE H. CRICHLOW TRUST PRIZE

AIAA invites you to nominate candidates for the Walter J. and Angeline H. Crichlow Trust Prize. The Prize is presented by AIAA every four years for excellence in aerospace materials, structural design, structural analysis, or structural dynamics.

Nominations should include any one or more of the following: environment and loads definition, utilization of advanced materials and fabrication processes, innovative structural configurations, determination of structural integrity by analysis and test, advanced mathematics and/or computer programming of general and advanced usage, weight-reliability-life cycle considerations, or adaptive structures. The Prize consists of a certificate of citation, an engraved medal, and an honorarium of $100,000.

The recipient will be invited to receive the Prize at the 2015 AIAA Science and Technology Forum and Exposition (SciTech 2015).

Don't delay! Nominations for the 2015 award must be postmarked by 15 March 2014. To download regulations/procedures or a nomination form, please visit **www.aiaa.org/Secondary.aspx?id=20414**.

ROCKY MOUNTAIN SECTION SECOND ATS—BIGGER, BOLDER, BETTER—SETS THE BAR FOR THE FUTURE

The Rocky Mountain Section (RMS) held its 2nd Annual Technical Symposium (ATS), chaired by Dr. Taylor Lilly, RMS Southern Vice Chair, on 25 October at the University of Colorado Colorado Springs (UCCS). This ATS built on the success of 2012's ATS, with improvements to every aspect of the agenda, including a more extensive and diverse program, almost twice the attendees, and visibility in the technical and political communities. There were ten corporate sponsors led by primary sponsor Lockheed Martin Space Systems Company (LMSSC); and four major supporting organizations—UCCS, USAFA, Space Foundation, and CSBR, who provided support including promotion and volunteers and committee members.

After a welcome by UCCS Chancellor Pamela S. Shockley-Zalabak, the three-track program with over 40 technical presentations began. Presentations ranged from deeply technical academic and research topics to industry innovations and new directions to educational enhancement, such as initiatives to encourage and support STEM achievements. Approximately half of the presentations were student presentations—demonstrating the scope and reach of this event!

There were also four panel sessions on topics important to the industry and populated with an elite set of panelists. Panel 1 (Job Market /Career Advancement in Colorado) was moderated by RMS YP Chair Heather MacKay and included panelists from Colorado academic institutions and leaders in the local aerospace industry. Panel 2 (Direction of the Industry) was moderated by RMS Chair Roger McNamara and included Colorado Lt. Governor Joseph Garcia as well as leaders from industry, academia, and advocacy associations such as the Colorado Space Business Roundtable (CEO Edgar Johansson). Panel 3 (STEM Education and Outreach) was moderated by RMS Education Chair John Eiler, with panelists representing diverse interests from industry and academia. Finally, Panel 4, moderated by RMS PPC Jason Kuchera, concerned Cross-Sector Collaboration. This panel was headlined by Monisha Merchant from U.S. Senator Michael Bennet's (D-CO) office and included representatives from academic, corporate, and local governmental agencies interested in promoting the acceleration of technology development and integration.

The lunchtime keynote speech was on "The History of Hypersonics," presented by AIAA Distinguished Lecturer Dr. Richard P. Hallion. The speech was followed by remarks from the Colorado Lt. Governor and a presentation by Lockheed Martin Space Systems entitled "Innovation without Boundaries," addressing the opportunities and environmental factors surrounding and influencing the growth and direction of the industry.

The day finished up with an after-event social with "in-kind" support from Bristol Brewery, continuing a tradition from the first ATS. The RMS has begun to plan for next year's 2014 ATS. The ATS' full proceedings and program are on the RMS Home page at **http://www.aiaa-rm.org/ATS**.

Lt. Governor of Colorado addressing the ATS

Attendees talk with sponsors and exhibitors in the main hall

CALL FOR NOMINATIONS

Recognize the achievements of your colleagues by nominating them for an award! Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 July**. Awards are presented annually, unless otherwise indicated. However AIAA accepts nominations year-round and applies them to the appropriate year.

Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines to view nominee eligibility, page limits, and letters of endorsement instructions. All nominations, whether submitted online or in hard copy, must comply with the limit of 7 pages for the nomination package; see details on the webpage (**https://www.aiaa.org/secondary.aspx?id=230**).

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 recognizes outstanding technical and/or management contributions to aeronautical or astronautical software engineering. (Presented odd years)

Children's Literature Award is 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 for 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.

Dr. John Ruth Digital Avionics Award

Presented to recognize outstanding achievement in technical management and/or implementation of digital avionics in space or aeronautical systems, including system analysis, design, development, or application. (Presented odd years)

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)

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

Gardner-Lasser History Literature Award is 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 is presented for the best historical manuscript dealing with the science, technology, and/or impact or aeronautics and astronautics on society.

Information Systems Award is 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 is 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 **December 31** of the year preceding the presentation.

Mechanics and Control of Flight Award is 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 is presented for an outstanding contribution or contributions to aeronautical and astronautical literature in the relatively recent past.

Structures, Structural Dynamics and Materials Award is 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.

For further information on AIAA's awards program, please contact Carol Stewart, Manager, AIAA Honors and Awards at carols@aiaa.org or 703.264.7623.

OBITUARIES

AIAA Fellow Sackheim Died in December

Robert L. Sackheim, age 76, died on 22 December 2013.

Mr. Sackheim earned his bachelor's degree in chemical engineering from the University of Virginia in Charlottesville, and his master's degree in chemical engineering from Columbia University in New York. He completed his doctoral coursework in chemical engineering at the University of California in Los Angeles, where for nine years he taught a professional-level engineering course on spacecraft design and propulsion. Also, from 1960 to 1964, he served in the U.S. Air Force as propulsion chief for the Titan II Development Launch Crew, responsible for development, testing, and launch of the Titan II missile system.

In 1964, he began a 35-year career with TRW where he worked in several technical management positions. From 1990 to 1999, Mr. Sackheim was the manager of the propulsion systems center at TRW's Space and Technology Division in Redondo Beach, CA, where he was responsible for design, development, and testing of high energy chemical lasers, materials technologies, and combustion and fluid system products. He had previously served as project manager for TRW's Orbital Maneuvering Vehicle project, an effort intended to develop a short-range space cargo vehicle to ferry payloads to and from the International Space Station.

In 1999, Sackheim became assistant center director and chief engineer for space propulsion at NASA's Marshall Space Flight Center in Huntsville, AL. He supervised all NASA space propulsion research and development activities—from Space Shuttle propulsion elements and conventional rockets, to innovative kerosene and liquid oxygen engines intended to launch next-generation spacecraft to orbit, to alternative propulsion technologies meant to carry them deep into the solar system and beyond. Mr. Sackheim was also on the Marshall Center Director's Executive Staff providing technical review in space propulsion and transportation matters. After retiring in 2006, he worked as a consultant to several aerospace contractor and government organizations.

Mr. Sackheim wrote over 250 technical papers, contributed to four books on space propulsion, and held nine patents in spacecraft propulsion, launch vehicles and missiles, and control systems technology. He was honored with numerous awards and honors throughout his career, among them the AIAA Wyld Propulsion Award (1992), a NASA Outstanding Leadership Medal (2001), the AIAA Alabama-Mississippi Section 2002–2003 Holger Toftoy Award, and an AIAA Sustained Service Award for his work as a section chair and technical committee chair (2000).

AIAA Honorary Fellow Jones Died in January

Thomas V. Jones, age 93, died on 7 January 2014.

Mr. Jones joined Northrop in 1953, and became its chairman and chief executive officer in 1960, serving for over 30 years in those roles before retiring in 1990. His leadership was instrumental to Northrop's growth as one of the world's leading providers of military aircraft. Notable aircraft designed and produced by Northrop under Jones' leadership included the F-5 "Freedom Fighter," and F/A-18 "Super Hornet" jet fighters, B-2 "Stealth" bomber, and the "Global Hawk" unmanned aerial vehicle.

Before his tenure at Northrop, Jones studied aerospace engineering at Stanford University and held positions with Douglas Aircraft Corp. during World War II, and later worked for the Brazilian government setting up that nation's civil aviation system.

Jones received the 1985 AIAA Reed Aeronautics Award, as well as the National Aeronautics Association's 1989 Wright Brothers Memorial Trophy.

AIAA Aviation and Aeronautics Forum and Exposition

Aviation's Global Promise—Challenges & Opportunities

16–20 June 2014
Hyatt Regency Atlanta
Atlanta, Georgia

Featuring:
20th AIAA/CEAS Aeroacoustics Conference
30th AIAA Aerodynamic Measurement Technology and Ground Testing Conference
AIAA/3AF Aircraft Noise and Emissions Reduction Symposium
32nd AIAA Applied Aerodynamics Conference
AIAA Atmospheric Flight Mechanics Conference
6th AIAA Atmospheric and Space Environments Conference
14th AIAA Aviation Technology, Integration, and Operations Conference
AIAA Balloon Systems Conference
AIAA Flight Testing Conference
7th AIAA Flow Control Conference
44th AIAA Fluid Dynamics Conference
20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference
11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference
21st AIAA Lighter-Than-Air Systems Technology Conference
15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference
AIAA Modeling and Simulation Technologies Conference
45th AIAA Plasmadynamics and Lasers Conference
7th AIAA Theoretical Fluid Mechanics Conference

Sponsors

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Executive Steering Committee (2014–2015)

Juan Alonso, Associate Professor, Department of Aeronautics and Astronautics, Stanford University

Jennifer Byrne, Vice President, Technical Operations, Lockheed Martin Aeronautics

Victoria Cox, Former Assistant Administrator for NextGen, Federal Aviation Administration (retired)

David R. Maroney (Forum General Chair), Principal Systems Engineer, The MITRE Corporation

John O'Leary, Vice President, Engineering, Airbus Americas

AIAA Programs

Welcome Letter

It is with pleasure that we invite you to participate in an event that will address the challenges and opportunities of aviation's global promise. An essential driver of economic growth and stability, the aviation enterprise is in a phase of evolving business models, increased efficiency demands, emerging manufacturing methods, and constantly evolving technology integration. These trends offer unprecedented opportunities and challenges for new capabilities that could transform the way we utilize this critical asset.

The AIAA Aviation and Aeronautics Forum and Exposition (AVIATION 2014) will feature a full program of detailed technical discussions that will underpin high-level conversations that provide a wide-ranging overview of the state of the art in our industry. In addition to cutting-edge technical research presentations, we are including keynote presentations and panel discussions that focus on addressing some of the pressing issues associated with the implementing new air traffic management capabilities, a rethinking of our traditional commercial aviation operational models, and the integration and utilization of unmanned platforms to enhance our existing fleets, as well as an evolving financial landscape for both commercial and military aviation system acquisition, increasingly connected and networked aviation platforms, and the implications of policy decisions on how we define, design, and field new operational systems.

Take a few minutes to look over the AVIATION 2013 Recap report to learn more about this annual forum (**http://www.aiaa.org/aviation2013recap**). We look forward to having you join us in Atlanta, Georgia, 16–20 June 2014.

Technical Program

A strong technical program—featuring more than 18 technical conferences and ITAR-compliant sessions—address the broad spectrum of applied science and aviation technologies. More than 1600 abstracts have been submitted for consideration on more than 125 specialized topics focused on:

- Environmental Impact of Aerospace Systems
- Measuring, Testing, and Validation of Aerospace Systems
- Aerodynamic, Fluids, and Thermal Sciences
- Design and Optimization of Aerospace Vehicles
- Aerospace Systems, Operations, and Life Cycle

Coming Soon—Browse, search, and create a personalized agenda for AVIATION 2014. Sign up for email alerts at **aiaa-aviation.org**.

Speakers

Speakers for AVIATION 2014 will be announced soon. Take a look at the AVIATION 2013 Recap (**http://www.aiaa.org/aviation-2013recap**) to get a sense of who you can expect to see at this year's forum.

Recognition

Join us as AIAA bestows more than 18 awards, recognizing the very best in our industry: those individuals and teams who have taken aerospace technology to the next level…who have advanced the quality and depth of the aerospace profession…who have leveraged their aerospace knowledge for the benefit of society. Their achievements have inspired us to dream and to explore new frontiers.

Continuing Education

Stay at the top of your game with the 3rd AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III).

Networking

AIAA AVIATION 2014 is expected to draw more than 2500 participants, from across all facets of the aviation enterprise, who are shaping the future of flight. Whether it's breakfast or lunch in the exhibit hall, evening receptions, B2B matchmaking, awards ceremonies, lectureships, or simply talking with the person next to you at a technical paper presentation, you'll find many opportunities to meet new colleagues and build new relationships.

Business-to-Business (B2B) Speed Networking

Want to find out how to do business with commercial, governmental, and aerospace research entities like the small business programs offices of DARPA, NASA, Lockheed Martin, Boeing, and SPAWAR? Find out how your capabilities match with the needs of major government R&D agencies and aerospace corporations.

Sponsorship and Exposition

Commercial aviation is the only industry on the planet that actually grew during the worst recession since WWII. Airlines will need more than 35,000 new airplanes in the next 20 years.—Richard Aboulafia, Vice President, Analysis, The Teal Group

In today's dynamic business environment, effective outreach and customer interface are vital to successfully capturing new partnership opportunities. AIAA's sponsorship and exhibits programs can help you achieve your objectives. Contact Merrie Scott, merries@aiaa.org to secure your sponsorship, and Christopher Grady at chrisg@aiaa.org to book your exhibit space today.

Hotel Information

Hyatt Regency Atlanta, 265 Peachtree Street NE, Atlanta, Georgia, USA 30303, Tel: +1.404.577.1234 Fax: +1.404.588.4137

AIAA has made arrangements for a block of rooms at the Hyatt Regency Atlanta. The hotel is just 11 miles from the Hartsfield-Jackson International Airport (ATL). These rooms will be held for AIAA until **23 May 2014**. Room rates are $139 for single or double occupancy plus applicable taxes. To call to make a reservation, dial 1.888.421.1442 and mention AIAA AVIATION 2014. To book a reservation online go to: **https://resweb.passkey.com/go/2014AERO**. *Government Employees*: A limited number of rooms are available at the prevailing government per diem at the time of the conference. Proper government ID is required. To book a reservation online go to: **https://resweb.passkey.com/go/AERG2014**.

Registration

Registration will open soon. Sign up for email alerts at **aiaa-aviation.org**.

Upcoming AIAA Continuing Education Courses

February–June 2014
Home Study Courses
www.aiaa.org/homestudy

Introduction to Computational Fluid Dynamics

Instructor: Klaus Hoffmann

This introductory course is the first of the three-part series of courses that will prepare you for a career in the rapidly expanding field of computational fluid dynamics. Completion of these three courses will give you the equivalent of one semester of undergraduate and two semesters of graduate work. The courses are supported extensively with textbooks, computer programs, and user manuals.

Key Topics
- Classification of partial differential equations (PDEs)
- Finite-difference equations
- Parabolic equations
- Stability analysis
- Elliptic partial differential equations
- Hyperbolic partial differential equations
- Scalar representation of the Navier-Stokes equations
- Incompressible Navier-Stokes equations

Advanced Computational Fluid Dynamics

Instructor: Klaus Hoffmann

This advanced course is the second of the three-part series of courses that will prepare you for a career in the rapidly expanding field of computational fluid dynamics. Completion of these three courses will give you the equivalent of one semester of undergraduate and two semesters of graduate work. The courses are supported extensively with textbooks, computer programs, and user manuals.

Key Topics
- Grid-generation-structured grids
- Transformation of the equations of fluid motion from physical space to computational space
- Euler equations
- Parabolized Navier-Stokes equations
- Navier-Stokes equations
- Grid-generation-unstructured grids incompressible Navier-Stokes equations
- Finite volume schemes

Computational Fluid Turbulence

Instructor: Klaus Hoffmann

This advanced course is the third of the three-part series of courses that will prepare you for a career in the rapidly expanding field of computational fluid dynamics with emphasis in fluid turbulence. Completion of these three courses will give you the equivalent of one semester of undergraduate and two semesters of graduate work. The courses are supported extensively with textbooks, computer programs, and user manuals.

Key Topics
- Introduction to turbulence and turbulent flows
- Reynolds average Navier-Stokes equations
- Parabolic equations
- Turbulence models
- Compact finite difference formulations
- Boundary conditions
- Large eddy simulation
- Direct numerical simulation

Missile Design and System Engineering

Instructor: Gene Fleeman

This course provides the fundamentals of missile design, development, and system engineering. A system-level, integrated method is provided for missile configuration design and analysis. It addresses the broad range of alternatives in satisfying missile performance, cost, and risk requirements.

Key Topics
- Key drivers in the missile design process
- Critical trade-offs, methods, and technologies in aerodynamic, propulsion, structure, seeker, warhead, and subsystems sizing to meet flight performance and other requirements
- Launch platform-missile integration
- Robustness, lethality, guidance, navigation & control, accuracy, observables, survivability, reliability, and cost considerations
- Missile sizing examples for missile systems and missile technologies
- Missile system and technology development process

Spacecraft Design and Systems Engineering

Instructor: Don Edberg

This course presents an overview of factors that affect spacecraft design and operation.

Key Topics
- History
- Design drivers
- Orbital mechanics and trajectories
- Systems engineering
- Design considerations
- Estimation, testing, and failure prevention

To register for any of these Home Study courses, visit www.aiaa.org/homestudy and select "Register Now".

14–15 June 2014
Workshop at AIAA Aviation and Aeronautics Forum and Exposition 2014 (AIAA AVIATION 2014)
www.aiaa-aviation.org

Third AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III)

The major emphasis of this workshop will be coordinated computational, modeling, and measurement efforts based on collaborative definition of a hierarchical set of benchmark configurations representing major sources of airframe noise; joint development of datasets that would eventually achieve benchmark quality.

31 July–1 August 2014
Workshop at AIAA Propulsion and Energy Forum and Exposition 2014 (AIAA Propulsion and Energy 2014)
www.aiaa-propulsionenergy.org

2nd AIAA Propulsion Aerodynamics Workshop

This workshop is being held so that various groups from industry and academia can look at a given set of Propulsion Aerodynamic problems and come up with an agreed set of solutions to the problems.

2014 Aerospace Spotlight Awards Gala

Wednesday, 30 April 2014

Ronald Reagan Building and International Trade Center
1300 Pennsylvania Ave NW, Washington, DC

Reception begins at 1830 hrs in the Oculus
Dinner and Awards begin at 1930 hrs in the Atrium

Attire is Black Tie or Military Equivalent

AIAA ignites and celebrates ingenuity and collaboration and ensures aerospace professionals are recognized for their contributions to making the world safer, more connected, more prosperous—from the major missions that reinvent our national uses of air and space, to the inventive new applications that enhance everyday living.

Join us as we honor the recipients of the following awards:

- Newly Elected Fellows and Honorary Fellows
- Goddard Astronautics Award
- Reed Aeronautics Award
- AIAA Foundation Award for Excellence
- International Cooperation Award
- Public Service Award
- Distinguished Service Award
- Daniel Guggeheim Medal

Host a young professional at your table. AIAA has formed a partnership with the Future Space Leaders Foundation (FSLF) the Society of Satellite Professionals International (SSPI) and the Achievement Rewards for College Scientists (ARCS®) Foundation, as we all share a common interest in encouraging and facilitating young professionals to pursue aerospace-related careers.

Also, we are pleased to coordinate with Women in Aerospace (WIA) as they host Aerospace 2014, a day-long conference on issues of importance to women and men in the aerospace industry worldwide. For more information, please visit: www.womeninaerospace.org.

For reservations, please visit **www.aiaa.org/gala2014** or contact Merrie Scott at **703.264.7530** or **merries@aiaa.org**

This event is organized according to government directives. Government guest selection, invitation, and seating will be administered solely by AIAA in accordance with government policy.

AIAA

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