February 2016

AEROSPACE AMERICA

CURBING CONTRAILS

Eliminating them could make a dent in global warming

Meet the researchers who study contrails in midair

Page 20

Flight Safety's Beatty on airliner tracking, congestion/10

Seeing shockwaves/14

An atomic clock in space/40

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

AEROSPACE AMERICA

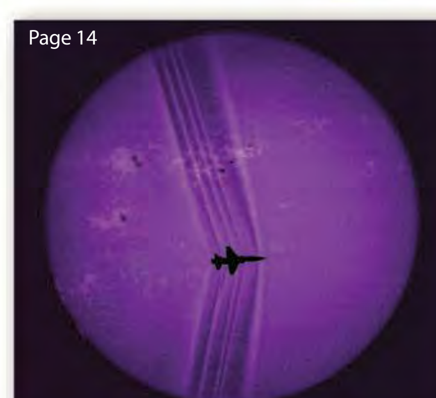
February 2016


Page 4


Page 28


Page 40


Page 34


Page 14

DEPARTMENTS

FEATURES

BULLETIN

ON THE COVER
NASA's DC-8 flying laboratory in this photo was taken from an HU-25 Falcon.
Image credit: NASA

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

40,000 copies of this issue printed. This is Volume 54, No. 2.

AEROSPACE AMERICA®

is a publication of the American Institute of Aeronautics and Astronautics

Ben Iannotta
Editor-in-Chief
Kyung M. Song
Associate Editor
Greg Wilson
Production Editor
Jerry Grey
Editor-at-Large
Christine Williams
Editor AIAA Bulletin

Contributing Writers
Keith Button, Warren Ferster, Lawrence Garrett, Michael Peck, Marc Selinger, Hannah Thoreson, Robert van der Linden, Debra Werner, Frank H. Winter, Anatoly Zak

Jane Fitzgerald
Art Direction and Design

James F. Albaugh, *President*
James "Jim" Maser, *President-Elect*
Sandra H. Magnus, *Publisher*
Craig Byl, *Manufacturing and Distribution*

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

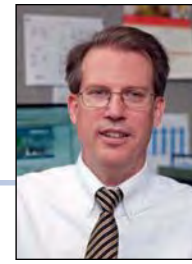
QUESTIONS AND ADDRESS CHANGES
custserv@aiaa.org

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

February 2016, Vol. 54, No. 2

AIAA
Shaping the Future of Aerospace

Editor's Notebook



Contrails and climate science

Our cover story this month on efforts to predict the size and duration of contrail cirrus clouds strikes me as a microcosm of the overall climate-change topic.

For one thing, the impact of jet flight on the atmosphere is complex. The correct policy prescriptions are not always arrived at by following one's common sense.

Consider airliner flight routes. Before I read our story, common sense would have told me that a longer route burns more fuel and emits more carbon dioxide and would be worse for the climate than a shorter route. That's not always the case, as the graphic on page 23 shows. A longer route can be preferable if a jet flies at an altitude and in weather conditions that produce smaller or shorter-lived contrails. These human-made cirrus clouds hold in heat like insulation, and if they can be reduced significantly enough, the effect can more than offset the extra CO_2 from flying farther. This means that a policy prescription that only looks at carbon would not be the right answer.

That complexity reminds me a little of the years after the Toyota Prius hybrid sedan hit the market. Scientists and economists soon counseled us that calculating a product's climate change footprint requires taking into account manufacturing, not just the emissions of the end product. That didn't mean that hybrid cars were bad for the environment. It meant that automakers should also clean up their production processes. Today, in fact, the Toyota website has a graphic showing how it seeks to reduce carbon emissions throughout its chain, from the factory floors to its dealerships and the performance of its vehicles.

Another similarity to the broader issue has to do with the temptation to say: "My sector isn't a big part of the climate problem." It's true that aviation produces just 11 percent of the overall U.S. transportation greenhouse-gas emissions, according to the Environmental Protection Agency. But as our story points out, matters are not so simple. If a predictive capability can be achieved for contrails, action to reduce contrails could produce faster climate results than in the energy sector, for example, where action to reduce CO_2 emissions will pay off more slowly because of how CO_2 remains in the atmosphere.

I also see similarities with the climate issue in the scientific culture. Our cover story shows scientists who are working hard to stay in their lanes as simply producers of scientific explanations, perhaps to avoid getting bogged down in the policy debates over what to do about climate change. If researchers can define the fuels, routes, designs and weather conditions that produce the biggest or longest-lived contrails, other experts can step forward and decide whether or how to reduce them. Even so, the sense of urgency among the scientists shines through in the article.

Ben Iannotta
Editor-in-Chief

Events Calendar

14 - 18 February 2016
26th AAS/AIAA Space Flight Mechanics Meeting
Napa, California

5 - 12 March 2016
2016 IEEE Aerospace Conference
Big Sky, Montana

8 - 10 March 2016
AIAA Defense and Security Forum (AIAA DEFENSE 2016)
AIAA National Forum on Weapon System Effectiveness
AIAA Strategic and Tactical Missile Systems Conference
Missile Sciences Conference
Laurel, Maryland

16 March 2016
Congressional Visits Day 2016
Washington, D.C.

19-21 April 2016
16th Integrated Communications and Surveillance Conference
Herndon, Virginia

Missed significance

The January 2016 issue overlooked a piece of historical aviation trivia. The item dated Jan. 18, 1941 [Out of the Past, page 43] shows a China National Aviation aircraft. The aircraft illustrated was actually nicknamed the DC-2½. The story goes that a DC-3 had its right wing shot up in a strafing attack, but a DC-2 right wing was available. So, this wing was installed and the aircraft flew safely out.

Carl Ehrlich
Calabasas, California
AIAA Associate Fellow
ehrliccf@ix.netcom.com

Correction

The year-in-review article, "Expandable space habitats ready for launch," (December, page 63) omitted the byline of one of the authors, Mark Kerr.

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

DARPA's giant Legos in space

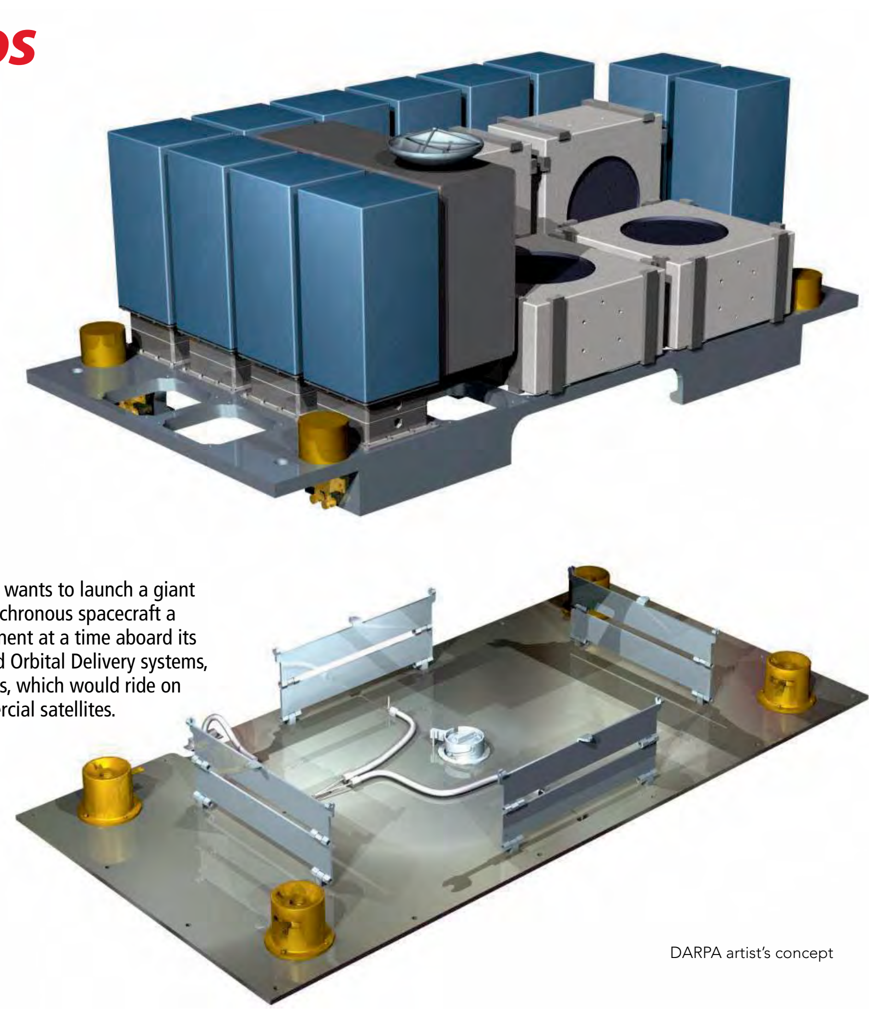
Launching satellites today is like reinventing the wheel. In the factory, each set of cameras or communications antennas must be fitted to a satellite bus that provides power and navigation. DARPA has a better idea: Instead of expending mass on a satellite bus for each mission, why not position permanent satellite support platforms in geosynchronous orbit, and then simply send the payloads to them?

This is the concept behind DARPA's Persistent Platform in Geosynchronous Earth Orbit project. The goal is ambitious: create orbital platforms in geosynchronous orbit that could eventually be larger than the International Space Station. Small payloads would be lofted into GEO and then robotically added to the sustaining structure.

Each of these platforms would be "designed to last decades, perhaps even longer than the ISS. Systems that permit a large number of secondary payloads would ferry these payloads to GEO on a regular basis," says Jeremy Palmer, a program manager in DARPA's Tactical Technology office. "Robotic systems on this platform would have the ability to swap out the new arrivals for the old ones."

The impetus for the project is sheer economics. GEO satellites are elaborate, long-term projects. By the time the payload is inserted into orbit, the electronics might already be obsolete. A platform could include supporting infrastructure, which ages more gracefully, while upgraded payloads and their high-value electronics could be attached as technology improves.

Palmer says construction of small GEO platforms could be accomplished within the next 10 to 15 years, though larger, kilometers-wide structures might take far longer. For now, DARPA's goals are more modest. The industry is competing to be included in the first phase of a Small Business Innovative Research project that could begin in September. DARPA has specified that the individual units comprising the platform must each fit within DARPA's Payload Orbital Delivery launch system, which is scheduled for a test launch in 2017. POD aims to cheaply loft payloads into orbit by piggybacking them aboard commercial satellite launches. However, POD payloads must be only 90 to 130 kilograms and less than a cubic meter in volume.



DARPA wants to launch a giant geosynchronous spacecraft a component at a time aboard its Payload Orbital Delivery systems, or PODs, which would ride on commercial satellites.

DARPA artist's concept

While the concept of on-orbit assembly isn't new, Palmer sees DARPA as spurring commercial use of GEO by creating what could be described as essentially a satellite office park in space. "The platform operator would be akin to a building manager that is leasing apartment space."

The technology to build a GEO platform is almost ready, Palmer says. There will need to be advances in assembling structures and fabricating structural members in space. Also, the platform will require cellular components that can be assembled into whatever support nodes, such as communications, are needed.

"Instead of exquisite and unique bus components launched to this platform, imagine instead a collection of Lego bricks," Palmer says.

Commercial firms must also be willing to invest the necessary capital. And therein lies the thorniest problem of a GEO platform: If the platform is international and services everyone's satellites, who owns the platform?

"There are a lot of regulatory and policy issues that have to be addressed with the presence of robotic — especially robotic servicing technology — in GEO," Palmer notes. "The law has to catch up with the technology first."

Michael Peck
michael.peck1@gmail.com
@Mipeck1

Powering airliners with hydrogen

Airliners might one day draw electric power from rods or pellets of solid hydrogen. A small London company, Cella Energy, has been working on the technology and hopes to fully develop it under a five-year contract that could be signed by April with Herakles, a subsidiary of Safran based in Paris. The solid hydrogen would supply hydrogen to fuel cells for the auxiliary power units on airliners.

Cella began working on the technology with Herakles in December 2014, and now plans to extend the work. The first power plants developed under this initial arrangement — 2.5-kilowatt generators — were tested by Safran in its Paris laboratories, says Stephen Bennington, Cella Energy's managing director, who also heads technology efforts. The new contract would extend the exclusive arrangement for five more years to develop 2- to 20-kilowatt power plants and methods for loading solid hydrogen onto aircraft.

For small power plants, Cella uses dry hydrogen in the form of rods measuring 20 centimeters long by 2.5 centimers wide, each with a hole down the center. These rods are packed into an insulated bed, and then heated one by one to 120 to 150 degrees Celsius to create a chemical reaction that releases the hydrogen, which is then run through a purifying filter and into a fuel cell to convert the hydrogen to energy. The power system — including the fuel rods, gas generator and the fuel cell — weighs one-third as much as comparable-power lithium ion batteries, Bennington says.

For larger, 100-kilowatt fuel cells, which would provide auxiliary power, the hydrogen rods won't work, because hundreds of kilograms of the material would have to be loaded into the hydrogen generator. So Cella is developing a form of solid fuel that can be pumped like a liquid fuel, but in 1-millimeter solid pellets. The pellets could be pumped pneumatically, just as pellets are pumped in pharmaceutical and mining industries.

According to Bennington, Cella is the only commercial dry-hydrogen generator under development for conventionally piloted airplanes.

Cella Energy was spun out of the Science and Technology Facilities Council, a U.K. government research institute, to develop ways to safely store hydrogen without high pressures or low temperatures. The company branched out into developing power supplies for small unmanned aircraft, which today is about half of Cella's business. Cella is working with Israel Aerospace Industries on a solid-hydrogen-powered fuel cell to power IAI's BirdEye mini drone.

Bennington says the company anticipates growing demand for its power plants because aircraft are "now more and more electric, a lot of the [manufacturers] are looking at alternative power supplies," he says. "They're looking at: Can they take that electrical power not from systems that attach to the main engines or auxiliary power systems that ultimately all use jet fuel?"

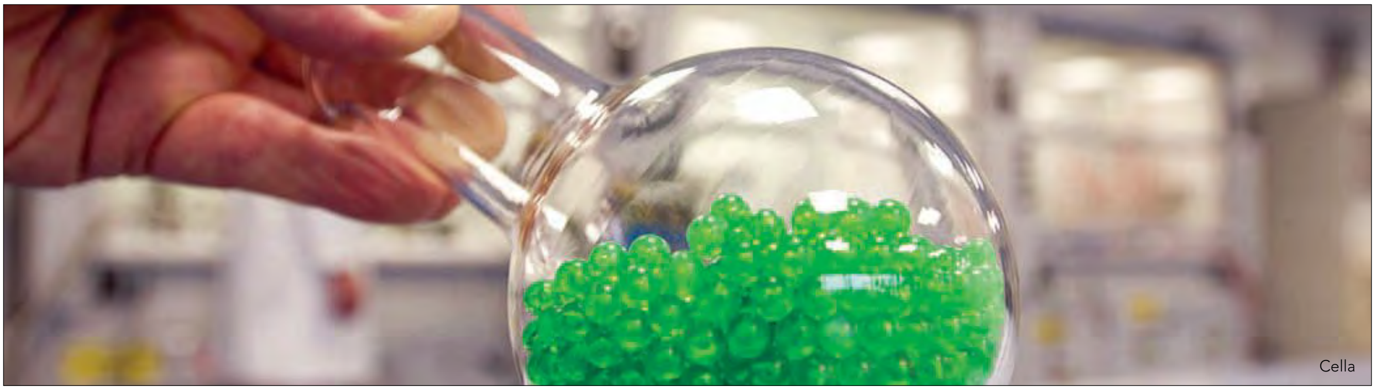
The main drawback for batteries is their weight. Some experts also question their safety, citing overheating lithium-battery incidents aboard Boeing 787 Dreamliners.

Hydrogen backers pitch the fuel as an environmentally friendly alternative that will help airplane manufacturers align themselves with future emissions regulations. The emissions would be water, and the technology could be lighter than batteries.

The Cella technology is aimed at solving a challenge of hydrogen for use in passenger aviation. Whereas automobile designers can compress hydrogen gas inside carbon-fiber-wrapped tanks, on an aircraft that would be extremely hazardous. The advantage of Cella's system is that the hydrogen is stable, its toxicity is similar to gasoline, it's lightweight and its performance is similar to compressed gas, but without the safety issues, Bennington says.

Cella and Safran hope to develop a power system that could be used in commercial aircraft by the early 2020s, Bennington says. Among the challenges: Convince regulators that it can operate safely under extreme temperature and vibration conditions.

Keith Button
buttonkeith@gmail.com



Cella

Each gram of flowable hydrogen pellets from Cella Energy of London can produce as much as a liter of hydrogen gas. Cella expects to sign a contract with a subsidiary of Safran to develop solid hydrogen to supply electric power to airliners.

ICAO inching toward CO_2 emissions standards

New standards on carbon dioxide emissions that would change the airworthiness certification process for airplane manufacturers are winding their way through the approval process of the International Civil Aviation Organization.

ICAO's Committee on Aviation Environmental Protection, or CAEP, will meet in February to discuss the carbon dioxide standards and could then pass the proposal to the ICAO assembly for ratification in September, an ICAO spokesman says. At that point, the FAA and similar aviation regulators in other countries would decide whether to adopt the standard, which could go into effect in 2020.

The CO_2 standards would be the first of their kind for aviation. Currently in the U.S., airplane engine makers must pass emissions standards for nitrogen oxide, sulfur oxide and smoke, plus noise standards. A CO_2 standard — assuming the FAA opts in — would be similarly enforced: The engines and the new airplanes they power would have to pass the new standards before receiving their FAA certifications.

The U.S. Environmental Protection Agency would also have a role. Today, EPA sets aviation air quality standards based on ICAO standards, and the FAA enforces the standards through the certification process for new airplanes and their engines. With the proposed CO_2 standards, the EPA is expected to wait and see what CAEP proposes and then decide whether to go along or come up with different, possibly more stringent, standards.

The International Civil Aviation Organization is debating standards that would tie carbon dioxide emissions to airworthiness certification.

CAEP is also discussing regulating non-volatile particulate matter — meaning soot — in emissions. CAEP was expected to decide at the February meeting whether to proceed, and if so, whether to enact an interim standard while the final rules are developed, says an industry expert who asked not to be named discussing internal deliberations.

ICAO already has a prescription in hand provided by a subcommittee of SAE International, an engineering association that drafts standards, describing how to accurately and consistently measure non-volatile particulate matter by testing aircraft turbine engines, according to Robert Howard, chairman of the subcommittee and an engineer with the Aerospace Testing Alliance at the Arnold Engineering Development Complex in Tennessee.

The instructions, negotiated with regulators over two years, were formally adopted in November, and will guide mandatory emissions data collection that engine makers will have to abide by while ICAO builds a database of results that will help it determine what the new standards will be, Howard says. ICAO has been gathering non-volatile particulate emissions data using an informal testing script from the SAE subcommittee for about a year.

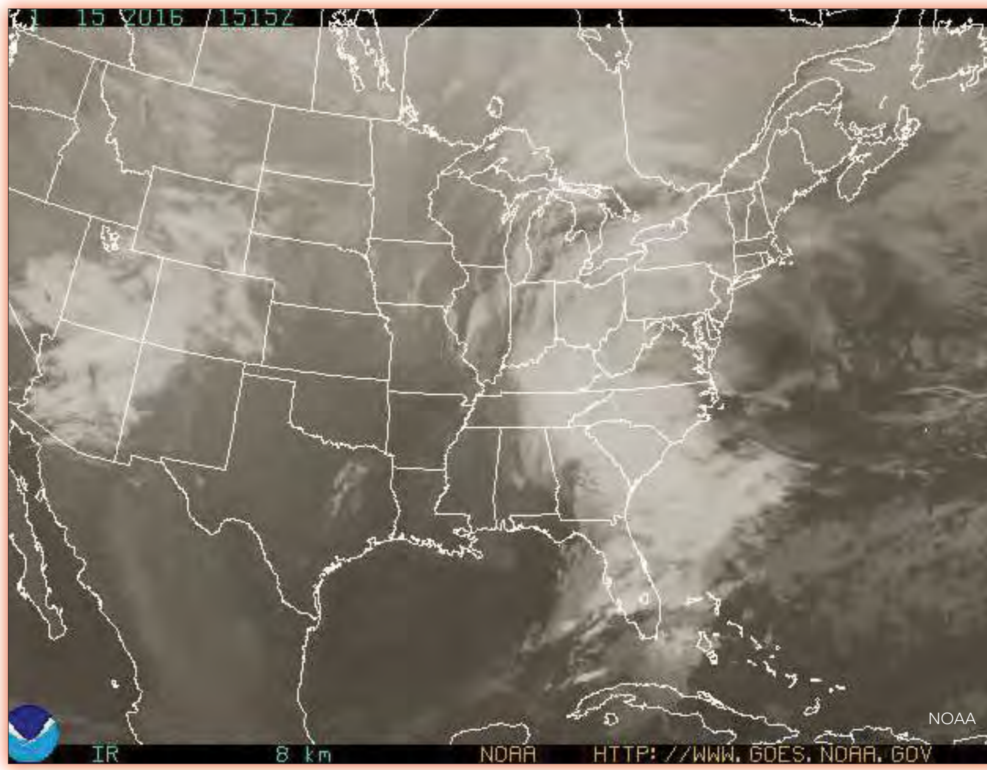
The testing measures mass and number of non-volatile particles in the exhaust. Any emission that exists as a particle when the exhaust leaves the engine is defined as a non-volatile. Particles that form later in the exhaust stream are volatile particles, meaning they can shift easily between solid and gaseous forms. The SAE subcommittee has been tasked with coming up with a protocol for measuring volatile particles, too.

The sampling approach will use techniques similar to those already required for measuring other jet emissions. For example, sampling probes will be installed in the exhaust path of an engine on its test stand, and the probes will channel the exhaust 20 to 30 meters away to isolate the measuring instruments from the engine's noise and vibration.

Keith Button
buttonkeith@gmail.com

Nudging NOAA to use commercial data

U.S. Rep. Jim Bridenstine, a Republican from Oklahoma first elected in 2012, has quickly staked ground as a vocal supporter of all things space, particularly the fast-growing commercial sector.



An infrared weather image from a NOAA geostationary satellite. Privately owned satellites could soon play a role, too.

Bridenstine is drafting a bill he calls the Space Renaissance Act. He characterizes the legislation as a repository of ideas that could be tacked piecemeal onto other legislative vehicles, such as the defense authorization bill.

Bridenstine says he has no illusions about the bill's chances of passage. "My goal with this bill is to start conversations, and where we can achieve consensus then we can take elements of the bill and insert them into parts of other bills," he told a Washington Space Business roundtable audience in January in Washington, D.C.

One of the conversations Bridenstine would like to start has to do with weather forecasting, a topic important to him and his constituents due to Oklahoma's reputation for tornadoes. Norman, Oklahoma, is home to NOAA's Storm Prediction Center, which tracks tornadoes and other severe weather.

As chairman of the subcommittee that oversees NOAA and its weather satellites, Bridenstine has been pushing the agency to bring commercial capabilities into the mix, something the Pentagon has already done in areas such as satellite communications, launch and Earth imaging.

At least three companies, Spire, PlanetIQ and GeoOptics, are planning constellations of satellites equipped with sensors that would measure distortion, or occultation, of GPS satellite signals caused by changes in atmospheric conditions. Algorithms would then be applied to derive temperature and humidity measurements, also known as soundings.

Spire, one the new breed of entrepreneurial space companies that have tapped into Silicon Valley's ethos, technology and capital, appears to have leapt ahead of the pack with the September launch of four GPS radio occultation microsatellites aboard an Indian rocket.

PlanetIQ, meanwhile, last year selected satellite and launch vehicle providers for its planned constellation of 12 satellites. Chris McCormick, CEO of PlanetIQ, said the company is fully financed through the launch of its first two satellites, which are slated to fly in December as secondary payloads on an Indian rocket. PlanetIQ is now raising financing for the remainder of the constellation, McCormick said, adding that the company is already working on its fourth generation antenna.

Another company, Tempus Global Data, has the rights to a different type of sensor that also would perform atmospheric soundings. The company is seeking partners that would host the hyperspectral sensors aboard geosynchronous communications satellites.

An obvious target market for these companies is NOAA, which Bridenstine and others complain has been slow to lay out specific terms and conditions under which it would buy commercial weather data. The agency last year released a draft commercialization strategy, but points out that its obligation to share weather data, regardless of source, with other nations could undercut commercial providers in other markets.

Bridenstine in the past has pushed legislation intended to force NOAA to be more proactive in engaging with the commercial providers. So far, the measure has failed to gain real traction. But in a small step, this year's omnibus appropriations bill includes $3 million for a NOAA pilot program to experiment with commercial data.

Warren Ferster
fersterx@gmail.com

From the Cold War to Kickstarter

World War II, Kickstarter and social media don't often come up together in conversations. Yet they embodied some of the key themes from a SciTech panel on aerospace innovation.

Four panelists — representing two generational poles — spoke about the past and future of technological advances. They depicted a fast-changing aerospace industry propelled in part by revolutions in cheap electronics, easier collaborations and quicker manufacturing. At the same time, they reminded the audience of how outside factors, not least of them war and peace, politics and federal budgets, can shape and constrain aerospace programs.

Zac Manchester, a post-doctorate fellow at Harvard University's Agile Robotics Laboratory, pointed to the proliferation of low-cost, capable electronics as one of the key developments fueling advances in space. Another is the growing ability for engineers and innovators to easily collaborate online, such as through open-source software or by tapping existing hardware and customizing it.

Manchester has raised nearly $75,000 through the online fundraising site Kickstarter in hopes of launching a tiny KickSat satellite into low-Earth orbit.

Mary Popp, a propulsion engineer with the Orion program at Lockheed Martin and Manchester's contemporary, said social media and more opportunities for firsthand experience can inspire the next generation of innovators. Popp, who majored in bioengineering at Lehigh University, switched careers after watching the final space shuttle launch in 2011, which she called "the most amazing, impressive thing I'd ever seen."

Two other panelists offered more historical perspectives. Hans Mark, a former secretary of the U.S. Air Force, reviewed the 65-year development of the tiltrotor technology. Work on what later became the XV-3 aircraft began in the early 1950s for the military. Today, AgustaWestland is preparing to begin production of its AW609, the first commercial tiltrotor aircraft.

"Technology development in the tiltrotor business was slow," Mark said.

Former astronaut William A. Anders candidly credited the Cold War for the Apollo program. The Soviet Union's launch of Sputnik 1 pressured Presidents Dwight Eisenhower and John Kennedy to expand Americans' space ambitions.

The basis for the Apollo missions "was not exploration, but to beat the Russians," said Anders, who in 1968 piloted the lunar module for Apollo 8.

Anders traced how the end of the Cold War led to the end of the Apollo mission, as well as the political calculations that led another president, Richard Nixon, to give rise to the space shuttles. That program, Anders said, was "one of the bigger policy mistakes this nation has made in space."

Kyung M. Song
kyungs@aiaa.org


AIAA

Zak Manchester of Harvard University's Agile Robotics Laboratory and Mary Popp of the Orion Space Program at Lockheed Martin, left, joined former U.S. Air Force Secretary Hans Mark (center) and former Apollo astronaut William A. Anders to offer generational perspectives on innovation.

Tough love for science, technology

Aversion to risk, proliferation of regulations and lack of strategic focus are some of the challenges confronting U.S. policies on aerospace science and technology.

Panelist Timothy Persons, chief scientist with the U.S. Government Accountability Office, called for an American reboot for science and technology, pointing to a growing number of patents being created in Asia. Persons said the U.S. should focus on international "coopetition," an international-partnership approach that NASA, the Department of Defense and other agencies have used with success.

Moon as a stepping stone to Mars

Should the U.S. consider building a habitat on the moon before exploring Mars? Some scientists and engineers believe that the moon could be a proving ground for Mars colonization technology.

For starters, they said, the International Space Station is not truly removed from assistance from Earth. Medical care is within reach via an emergency return trip from the ISS, and food arrives during resupply missions. This type of support would not be available in an environment as far removed as Mars or the moon, and we haven't studied what it would be like to maintain life long-term without that support, panelists said.

"We have so far been limited to the shallows of our home coasts on the cosmic ocean," said Alex MacDonald, program executive for Emerging Space with the Office of the Chief Technologist at NASA Headquarters.

The advances needed to get to a cislunar habitat may seem incremental, but those changes could open new and greater capabilities, he said.

"Our experience beyond low-earth orbit is constrained to the Apollo 17 mission," MacDonald said, noting that amounts to less than 13 days in an environment where Earth is more than a short trip away.

It may not be realistic to set up a colony on Mars with so little experience away from Earth, and the moon could be a good intermediate step toward that goal, panelists said.

MacDonald cited the need for an 80 percent improvement in the ability to recover oxygen before further steps toward deep space exploration can be taken. There also are some mission-critical components that have a life span of only six months.

All of the panelists agreed that there are many steps that need to be taken before humanity explores Mars.

Hannah Thoreson
hannaht@aiaa.org

Persons said one impediment was the nation's low tolerance for risks.

"We have a lot of resistance to failure, particularly in our political circles," Persons said. "Yet failure is often a very good teacher."

Jacques Gansler, a former undersecretary of defense and a professor at the University of Maryland, said recharging innovation requires a recognition for the need for change and leadership that wants to make it happen.

Gansler noted that every time there's an example of waste, fraud and abuse, Congress responds by passing more regulations. He said the current code of federal regulation is now more than 280,000 pages, bringing total compliance costs to an estimated $1.75 trillion annually.

Mark Albrecht, chairman of U.S. Space, a commercial satellite-services company, said that the federal government's science and technology policies lack a strategic objective that is "well-stated, clear and adequately resourced."

Albrecht said that despite great advances in avionics, thermal and propulsion, "In my time, I have never seen a dearth of a strategic overview for the United States national security and foreign policy in the 35 years I've been doing this."

Carissa Christensen, managing partner with The Tauri Group, a defense consulting firm, said private space companies are innovating more quickly by risking their own money.

In many cases, Christensen said, these companies are moving at a faster pace, geared more toward Silicon Valley than to Washington, D.C., and more aligned with the world environment.

Lawrence Garrett
lawrenceg@aiaa.org

Notable:

"The challenge I've issued to my designers is, give me free parts. Or better than that, give me less than free parts. Give me money back."

Greg Arend, United Launch Alliance, on the benefits of 3D-manufactured parts using composite materials

"It's like eating four-year-old Doritos. Disgusting!"

Matthew Simon, NASA's Langley Research Center, on the need for fresh food during planetary explorations

"The way you learn and become a good engineer is to fail."

Kurt Long, NASA's Ames Research Center

"You can't really point to what our strategic objectives are."

Mark Albrecht, chairman U.S. Space, on the U.S. government's science and technology spending

"You're going to see mail trucks that have drones coming out of them."

Treggon Owens, CEO of Aerial MOB

"Known failed practices continue to be practiced across engineering."

Scott Erven, associate director of Protiviti, on cybersecurity risks with electronic medical devices

Making air travel **even safer**

Jon L. Beatty, president and CEO of the Flight Safety Foundation

Jon L. Beatty's job is to help make air travel safer, which hardly seems like a tough gig. Flying has been growing inexorably safer since the 1940s. The number of fatal airliner accidents today is less than one third of the average during the 1970s, even though global air traffic has tripled. In fact, 2015 was the safest year on record worldwide with 17 accidents. It also marked the 10th straight year with fewer than 1,000 deaths aboard airliners.

Yet the chronic problems aren't going away. Pilots in rare cases lose control of their aircraft, and that remains the leading cause of accidents, especially in general aviation. The No. 2 cause is controlled flight into terrain, when pilots unwittingly collide into water, ground or obstacles.

As the head of the private Flight Safety Foundation, Beatty, a former executive at Pratt & Whitney, aims to harness and spread data to forestall accidents. Which airports are notorious for mishaps during approaches and landings, and why? What's the proper level of pilot training, and what would ensure pilots follow the procedures they've been taught?

***Kyung M. Song** spoke with Beatty at the foundation's new headquarters in Alexandria, Virginia.*

People in aviation like to say that the most dangerous part of flying is driving to the airport. What do you worry about most in terms of safety?

Aviation is still the safest form of transportation. What keeps me up at night is just the growth that we're seeing out there. Commercial transport is expected to grow at over 5 percent year over year. And when you think about where all that growth is going to come from, it's really coming from emerging countries. They don't have the luxuries of having the same levels of sophistication or maturity as some of the developed countries.

Pilot shortages are a big concern. How do you properly train qualified, capable pilots at that rate? One of [the foundation's] benefactors is Emirates airlines. They're bringing on 300 pilots a year, which is almost one a day. Which is just phenomenal.

What role does a private, independent entity such as the Flight Safety Foundation play?

We're the only truly independent, impartial international organization that's dedicated solely to improving global aviation safety, whether it's commercial transport, business aviation, helicopters or general aviation. If you were to do a Top 10 safety issues affecting aviation, they're almost identically consistent regardless of the segment.

Unstable approaches controlled flight into terrain, go arounds, pilot fatigue, loss of control in flight, fitness for duty.

You're talking about human factors largely.

I would say primarily human factors.

When you talk about human factors, is more training the answer? Or when you delve deeper into it, are there different root causes of some of these events?

There's no one cause, but automation brings a level of complexity that people years ago didn't have. Automation can be both a blessing and a curse, because sometimes with automation people become too reliant, and your basic flying skills can deteriorate. One of our board members has been involved with the FAA's advisory rule committee on pilot fitness. How do you screen for pilot fatigue? How do you screen for mental health? How do you screen for duty rest? Some of the new ultra-long-range business aircraft can fly farther than any one pilot can manage, so you start getting into multiple crews. Commercial transport is probably a little bit further along [in experience with ultra-long flights]. They're able to share lessons learned. One of the great things about safety is it's not competitive. [Airlines and manufacturers] know any accident affects the industry. Having come from the commercial side of it [mostly in commercial aircraft engines], you would never see Airbus, Boeing and Embraer or Bombardier sit together and talk about the challenges and how they can all cooperate.

How do the foundation's independence and impartiality distinguish you from the NTSB or the International Civil Aviation Organization (ICAO)?

The NTSB is the United States National Transportation Safety Board. We have members on our board from other industries, from other regions. I just got back from Taiwan and met with the head of their investigation board. We have observer status at ICAO. Whenever there's a big issue,

Interview by Kyung M. Song
kyungs@aiaa.org
@kyungmsong

Jon L. Beatty speaking at the International Air Safety Summit in Abu Dhabi, United Arab Emirates, in 2014. Beatty, who spent most of his career at Pratt & Whitney, calls aviation safety "a job that's never really done."

Wayne Rosenkrans/Flight Safety Foundation

and ICAO forms a committee, they almost always come to the Flight Safety Foundation because of our expertise. Malaysia 370 led to the aircraft tracking task force, and the Flight Safety Foundation was on that task force. For the Malaysia 17 aircraft that got shot down over Ukraine, our previous chairman, David McMillan, was asked by ICAO to be the chairman of the task force managing conflict zones. ICAO has to try to find a common way to manage traveling across different countries, and nothing is more sacred to a country than their sovereign airspace. [McMillan] was asked to come in because of our independent international impartiality to lead the meeting and to find a common ground that was not tailored to any specific country.

Given the industry representation on your board, does that mean you look out for safety issues as well as the interests of your members?

One of the things that's very impressive about our board is that they all are able to kind of check their companies at the door. I have never seen any of them put their company ahead of the greater good of safety. They would all agree that any accident affects their industry. Whether it's the Airbus aircraft that was [shot down] or whether it was Malaysia 370.

What about safety mandates or recommendations that affect operators' costs? Say, transponders on every aircraft or more frequent transmission of location?

We use [the foundation's members] as a sounding board, like when we were involved in the aircraft tracking task force. We worked with ICAO and IATA [the International Air Transport Association] and the major airframe manufacturers to try to find a solution that everyone could rally around. What would be an acceptable means of tracking and how would it be implemented?

What is the Flight Safety Foundation's position on aircraft tracking?

We support the current ICAO recommendations and the implementation schedules [an ICAO working group in September called for postponing by two years a November 2016 deadline for aircraft flying over oceans to begin reporting their positions every 15 minutes]. We and ICAO and IATA came up with a balanced, performance-based solution. The only criticism is that it would've been great to go faster. But when you're trying to find a balanced, performance-based solution that satisfies everyone's requirements, sometimes it's a little bit harder than doing it independently.

People wonder why we can't track all aircraft, at all times.

A lot of people don't understand that the majority of aircraft are tracked all the time. If you went to the majority of the major airlines in the world, they would actually tell you that, "We know where our aircraft are. There are no times when we don't know where they are." But unfortunately there are still dead spots in the world. There are actually longer-term solutions, whether it's ADS-B [automatic dependent surveillance-broadcast] or improved satellite tracking which will close in the dead spots.

There are lots of flights over oceans.

Lots of flights over oceans still do have periods of silence. But there are recommendations to close the gaps. There are timelines for implementation. There are reporting windows. What is an acceptable level of pinging frequency?

Where do you draw the line in terms of preparing for very rare events, such as a suicidal pilot, and balancing that with operational needs of the carriers?

That is a very difficult but great question. One of the first things that we always try to differentiate is: Is it safety or is it security?

Is security not a central mission for your foundation?

Jon L. Beatty

Title: *President and CEO of the Flight Safety Foundation since April 2014*

Age: *59*

Birthplace: *Bridgeport, Connecticut*

Education: *Executive MBA, University of Virginia Darden School of Business; B.S., aviation transportation, University of New Haven (Connecticut); aviation maintenance engineering degree, Parks College of Engineering, Aviation and Technology at Saint Louis University*

Previously: *President and CEO, International Aero Engines, East Hartford, Connecticut (2012-2014 and 2007-2010); senior vice president of airline customers (2010-2012) and vice president of operational commercial engine programs (2002-2007), Pratt & Whitney; vice president of programs and marketing, B.F. Goodrich Aerospace (1998-1999); vice president and general manager of avionics defense systems, Allied Signal (1981-1998)*

Residence: *Alexandria, Virginia*

Family: *Wife, Robin, and three grown children*

Interests: *Skiing, flying, fishing, coaching youth sports and collecting antique motorcycles (owns a 1947 Indian Chief and a 1971 Triumph Bonneville)*

We primarily focus on safety.

Parts of the U.S. and Europe are already congested. What happens 20 or 30 years from now when there's a lot more air traffic, just in terms of daily safety hazards of flying?

[Aviation] accident rate or fatality rate is at an all-time low. Yet you see that traffic continues to grow on an average of 5 percent a year. That means that the absolute number of accidents will continue to increase. So the traditional way how we improve safety has to change. Traditionally what would happen is there would be an accident investigation and you'd learn what the root cause is. You develop the corrective actions and then work with industry on an implementation plan. But we believe if you want to see the same level of improvements in safety we've enjoyed over the last 20 years, you have to really find a way to start sharing data. Because there is no such thing anymore as a domestic airline. All airlines are truly global. One of the projects we're working on with the FAA is called the Global Safety Information Project. It's a two-year project primarily focused in Pan-America and Asia Pacific. You think about maybe one airline and flying in and out of Rio de Janeiro, having unstable approaches or multiple go arounds. Wouldn't it be phenomenal if all airlines could share data globally and get to a place where you could mutually agree on what are the No. 1 issues flying into different airports?

What kind of data promises to most quickly improve safety?

The data that will absolutely help you is on unstable approaches and loss of control: The data on different approaches and landings coming to different airports, so that you can identify precursor's accidents and then mitigate those risks before the accident happens. That's why you want to share the data. You could find out: Is there a particular time of day or [certain] traffic where you see more unstable approaches? Or are go arounds more prevalent in certain seasons?

How concerned should we be about the integration of unmanned aircraft?

We're just starting to get involved in UAVs. It's good that the FAA and the regulators are starting to get more involved in it because we have seen several close calls. [Unmanned aircraft] have potentially hindered some rescue operations and firefighting situations. If there is some type of major accident or some type of major interference, you'll see that priority change pretty quickly.

I think they're supposed to sell us something like 800,000 drones in the U.S. alone this year.

What we're trying to figure out is how to add this to what we're doing where we can absolutely have value. Because it's a wide category.

Do you think the fears are overblown? An A320 versus a 5-pound quadcopter?

I think it's absolutely an emerging issue that needs to be managed. We're now working with our board to find out the best way to engage.

What about cybersecurity?

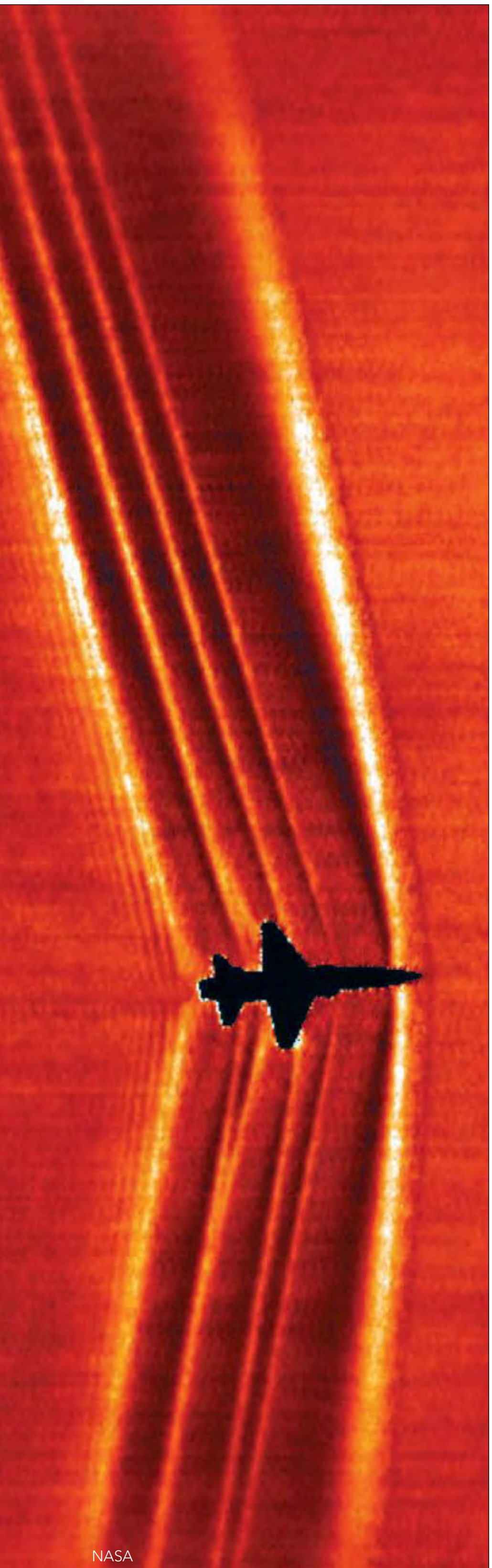
We stay more focused on the safety side, as compared to cybersecurity.

I guess when there's a major incident, it really doesn't matter whether it's called a safety issue or security issue.

That's true. It's just harder for us to get involved and add value on the cybersecurity side.

The question is, how do you really defend against an enemy of unknown nature?

It brings a whole level of: At what point do you take the throttle out of the pilot's hands? ▲



Visualizing shockwaves

Noise is the biggest hurdle standing in the way of supersonic air travel. Most people on the ground aren't fond of the rattling dishes and frightened pets left in the wake of sonic booms. Aircraft designers might be able to come up with quieter supersonic designs if they could watch the shockwaves from different designs in flight. Keith Button spoke to the NASA researchers who are devising techniques to do exactly that.

Your parents probably told you to never look directly into the sun, but that's where Edward Haering, a NASA aerospace engineer, discovered an imaging innovation that could soon help engineers design a supersonic airliner.

Haering, who works at NASA's Armstrong Flight Research Center in California, had an "aha" moment in 2013 while looking at slow-motion movies of a jet as it flew by the sun's edges. At the time, scientists assumed that the sun could only illuminate waves of compressed air as they approached the sun's disk perpendicularly and then again as the shockwaves exited the disk. The technique was developed 20 years earlier by another researcher, Leonard Weinstein, of NASA's Langley Research Center.

Now, Haering noticed something interesting about the sun spots.

"Those were twinkling as the shockwaves went by," he says. On the Internet about six months later, he came across photos of the sun taken with lens filters that showed a high density of speckles on the sun's surface. They were just what he needed to devise a new technique and software that would more fully illuminate shockwaves.

Haering's epiphany helped spark a spate of innovations over the last two years in the field of schlieren imaging, a term derived from the German word for streak. Way back in 1864, German physicist August Toepler devised the technique to photograph variations in density of fluids and air.

NASA researchers are now trying all sorts of backgrounds for exposing shockwaves, including desert scrub, the moon and even the stars. They are learning to derive fine-resolution imagery from these techniques, and they are weighing the tradeoffs of each.

"All these different applications have their pros and cons, and what we're trying to do over the next couple of years is to synthesize the best combination of these different techniques to get the best tool we can to test these future aircraft," Haering says.

If everything goes as the researchers hope, the new techniques will help aircraft designers solve one of the last great challenges in aviation: How to shape a supersonic airliner to soften its shockwaves or direct them away from land, to avoid rattling residents and terrifying pets.

Noise was a big drawback to the Concorde, which landed in the U.S. for the final time in 2003. Seeing the Concorde in testing, the FAA in 1973 banned overland supersonic flights, which meant the Concorde could land

Schlieren imagery makes shockwaves visible, as in this image of a T-38C jet trainer. It was taken with a method called background-oriented schlieren using celestial objects, or BOSCO, and then processed with NASA software.

only in coastal U.S. cities. Lately, though, there's been renewed interest in the possibility of a supersonic transport. NASA researchers are looking at testing "low booms" of about 75 decibels to see if that would be acceptable to regulators and the public. It would be up to the FAA and the International Civil Aviation Organization to set the standard. Sonic booms from military aircraft can reach more than 100 or 110 decibels.

Initial breakthrough

In 1993, Langley's Weinstein captured the first schlieren photos of shockwaves from supersonic airplanes in flight. He photographed airplanes from a ground telescope aimed at the sun, capturing images of the shockwaves coming off the planes. The photos showed the shockwave lines at the edges of the sun, unlike Haering's technique, which uses the sun's surface as a background.

Around the time of Haering's epiphany, James Heineck, a NASA photographic technologist at Ames Research Center in California, invented a method that uses the desert floor as a backdrop. He was inspired by Weinstein's work and also by a method invented in 1999 by researchers at the German Aerospace Center, DLR. They photographed helicopters in flight against backgrounds of white paint dots on concrete and grass. Heineck tested the desert technique in a series of flights in 2014 and 2015 at Edwards Air Force Base, California. He and four NASA colleagues wrote a paper describing their findings, and Heineck is slated to present it at the AIAA Aviation Forum in June in Washington, D.C.

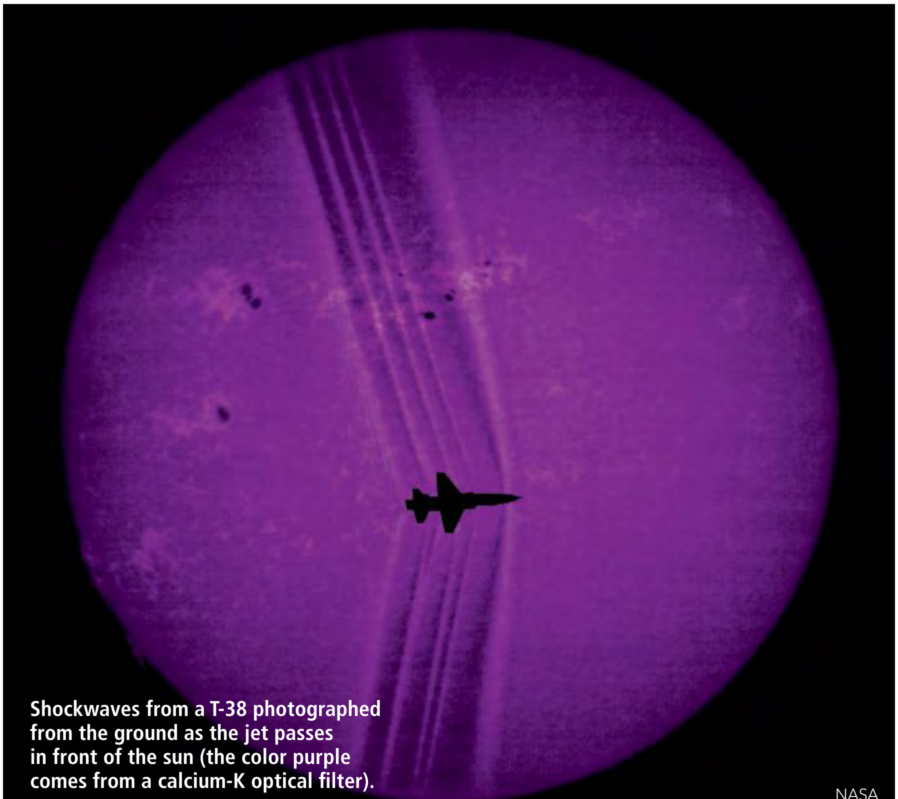
Riding in a Super King Air with a high-speed camera mounted in the floor, Heineck watched a video of the field of view below the turboprop and pushed a button to shoot a burst of photos each time one of the target jets — an F-15, F-18 or T-38C — flew underneath him through the Edwards supersonic-flight corridor. The images had to be shot fast, at 1,000 to 1,400 frames per second. More images give better depiction of the shockwaves against the Mojave Desert's 10-foot wide creosote bushes. Heineck's team contrasted those images against images of the background taken just before each jet passed through the frame

Coordinating the timing of the jet passing below was tricky, Heineck says. On some passes, the photos were taken without the jet in the frame. In others, the dots of bushes on the desert floor were too sparse to create an adequate speckled background. The most detailed images were taken when the target aircraft streaked by just 600 meters from the King Air, but that meant the pilot of the jet had to steer through a 60-meter-wide corridor to get in the frame.

Heineck dubbed the method AirBOS, for air background-oriented schlieren. One of AirBOS's advantages is that the field of view is wider than with schlieren images taken against the sun's edge as the background, which allows only a viewing angle of only a half degree. Another advantage is that researchers could do experiments that capture images from more than one aircraft at once, with formation flights, for example.

For the speckled-sun schlieren technique, Haering learned that were sunspots weren't the only feature that could serve as a backdrop. Various filters could be placed on the telescope to pick up narrow wavelengths of sunlight. One of the filters, called calcium-k, consists of a glass lens that detects the frequency of calcium atoms in the sun's chromosphere. This filtering technique showed lots of magnetic storms on the surface of the sun, making it look very speckled. The calcium-k method is called CaKEBOS.

Next, in March, NASA researchers plan to try a hydrogen-alpha filter that seems to have a lot of promise, Haering says. They are also looking for-



Shockwaves from a T-38 photographed from the ground as the jet passes in front of the sun (the color purple comes from a calcium-K optical filter).

NASA

A T-38C from the Air Force Test Pilot School was one of three target jets for NASA's schlieren imaging tests in the California desert.

US Air Force

ing says. They are also looking forward to trying out a recently purchased telescope and camera that provide five times the resolution of their previous equipment.

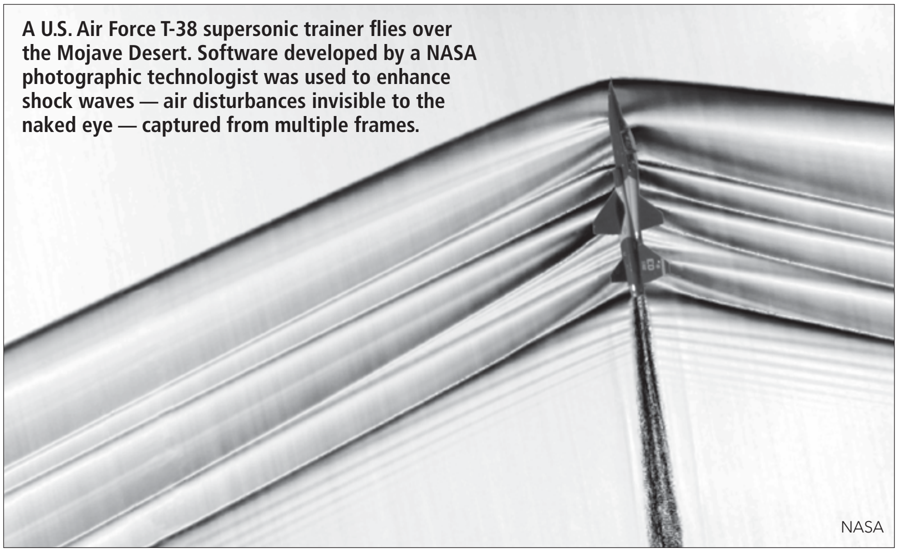
Another method uses the moon as a backdrop. NASA researchers have used its craters as the speckled background. They might also use the Milky Way stars in the nighttime sky as a backdrop, if the star light can be amplified enough for the high-speed digital cameras in the experiments. Schlieren imaging using celestial bodies, including the sun, has been dubbed background-oriented schlieren using celestial objects, or BOSCO.

Tradeoffs

Looking down on a plane or straight up at it has a big drawback. These viewing angles don't permit watching the shock waves as they come off the bottom of a supersonic aircraft. With a fighter jet, the solution is simple: Roll the plane 90 degrees as it enters the image frame. A supersonic airliner the size of a Boeing 747 would be far less maneuverable.

"You're not going to roll that [plane] 90 degrees easily and faithfully, and you're not going to do it quickly either," Haering says.

Luckily, researchers have found another option: Use the BOSCO technique to look straight ahead, at a time when the sun is low on the horizon, and then have the supersonic aircraft fly across the bow of the chase plane. That angle would give a profile view of the plane and the shock waves coming off its underside. Of course, an advantage of the ground-based techniques is that a second airplane



A U.S. Air Force T-38 supersonic trainer flies over the Mojave Desert. Software developed by a NASA photographic technologist was used to enhance shock waves — air disturbances invisible to the naked eye — captured from multiple frames.

NASA

isn't required for the photography, so the experiments are much less expensive. The advantage of looking down on a plane with AirBOS is that the desert background provides researchers with an extremely wide field of view, so they can see shock waves as far off to the side as the camera allows. Like with the sun's-edge schlieren technique, looking at the sun or the moon, the images are taken with only a half of a degree field of view, which is limiting, Haering says.

Taming noise

Researchers describe sonic booms in terms of how rapidly they change the air pressure for the listener. At Edwards Air Force Base, most of the sonic booms increase the air pressure by 1.5 to 2 pounds per square foot, or about the difference in air pressure of going down two flights of stairs. With a sonic boom, that air pressure change happens in a few milliseconds. How quickly the air pressure changes determines the loudness of the sonic boom.

To make booms quieter, researchers would be looking at dampening the air-pressure change and spreading it out over a longer time interval, making it less perceptible on the ground. Low-boom airplane configurations might smooth appendages on the fuselage or alter the shape of tip or tail to weaken the strength of the boom and distribute the shock pressure throughout the length of the fuselage.

Typically, the two strongest shocks come off the bow and the tail. Images show those two lines as the thickest and strongest lines of air disturbance. An old-generation supersonic airplane might have 20 or 30 little shock waves close to the body that combine into large, loud shock waves as they move farther away from the plane.

"They start to combine, until you get one huge shock in the front and one huge one in the back, and that's the 'boom boom' that you hear," Haering says. To avoid that scenario, aircraft designers might tweak the shape of a supersonic plane to produce many thin lines that would stay separated all the way to the ground.

Designers might not be able to learn that entirely from computational fluid dynamics or wind tunnel experiments.

Schlieren "gives you more truthful answers, in that with wind tunnels, you're forced to use some sort of sting" Haering says, referring to the pylon that supports the aircraft in a tunnel test. "It's extremely difficult to model [a flying aircraft] in a wind tunnel or CFD, to get the flow right and the propulsion system."

Keith Button
buttonkeith@gmail.com

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

—Rob Fuller, Lockheed Martin

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

—Jeffrey Puschell, Raytheon Company

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

—Kevin Burns, Northrop Grumman Corporation

Thank you to our participating sponsors.

LOCKHEED MARTIN

BOEING

AIRBUS

HondaJet

GE

Orbital ATK

NORTHROP GRUMMAN

AERION TECHNOLOGIES FORMERLY DESKTOP AERONAUTICS

BASTION TECHNOLOGIES

Raytheon

DARcorporation Design • Analysis • Research

DUNMORE AEROSPACE

MAROTTA

THE LINDE GROUP

PRECISION FLUID CONTROLS Valves for Propulsion-Flight-Ground

SMARTUQ™

ViGYAN

Xflow

As of 15 January 2016


NASA

CURBING

Airliners leave high-altitude cirrus clouds in their wakes, and if these contrails could be reduced or eliminated, their climate warming contribution could instantly be erased from the climate change equation. No one can do that today, because no one can say what size and duration of contrail will result from a particular combination of engine design, fuel and atmospheric conditions. ***Keith Button*** *spoke to the researchers who are aiming for this predictive ability.*

A Falcon 20 research jet approached close behind an Airbus A320 and settled into a cruising position within 300 meters. Inside the Falcon, climate researchers from the German Aerospace Center, DLR, monitored equipment as it recorded data about the exhaust and contrails from the A320's two V2527-A5 engines, a model commonly flown around the world.

The flights, conducted in Germany in September and October in coordination with NASA, were aimed at plugging a knowledge gap about aviation's impact on the climate. Researchers know that the contrails from thousands of airliners in the skies at any given moment have a net warming effect by reflecting infrared radia-

Contrails, such as these streaming from a NASA DC-8, form when moisture hits the soot from aircraft exhaust and forms ice crystals.

CONTRAILS

tion back toward the ground, just as natural cirrus clouds do. They also know basically how contrails form: Hot engine exhaust hits the minus-40-degree-Fahrenheit air, and as it cools, moisture clings to soot in the exhaust, forming ice crystals. What researchers can't yet do is predict the size and duration of the contrails that result under specific combinations of fuels, engine designs and atmospheric conditions.

If they could predict that, then regulators or the airline industry might be able to reduce aviation's climate footprint through the use of alternative fuels, low-contrail routes or changes to engine designs. Data from the flights last year is expected to be published in the coming months and will join similar data gathered by NASA in 2014 in a series of flights over California.

Such flights are not for the faint of heart, though. The counter-rotating vortices created by an airliner's wing tips are like mini tornadoes whose turbulence can induce motion sickness and flip small airplanes flying as far as 15 kilometers behind. The Falcon flew close to the A320 and between its vortices to avoid the most extreme swirling forces.

Why are researchers going to such lengths to gather this data? In part because of the conclusions in a 2011 report, "Global radiative forcing from contrail cirrus," written by two scientists from DLR's Institute of Atmospheric Physics near Munich. The authors calculated that contrail clouds have a greater warming influence, known as a positive climate forcing, than the direct effects of carbon dioxide, nitrogen oxides, soot and sulfate particles in an engine's exhaust.

by Keith Button
buttonkeith@gmail.com

"The contrail cirrus [coverage around the globe] at any given time exerts a higher radiative forcing than the CO_2 that has been emitted from all aircraft in history," says one of the paper's authors, Bernd Kaercher. He plans to apply Falcon 20 data to describe the physical mechanisms of ice formation so that better contrail predictions can be incorporated into climate models.

Data collection hurdles

One obstacle for climate scientists trying to study contrails is obvious: How do you study clouds that are 31,000 to 37,000 feet up, formed by airliners cruising at more than 500 mph and that can dissipate in a matter of hours or even minutes? Scientists say it is all but impossible to conduct a ground test that would realistically replicate the air pressure, temperature, humidity, turbulence and engine performance at cruising altitude. For that reason, firm answers to basic questions, such as the average lifespans of contrail clouds, have remained elusive. The best way to find out the impact of a certain fuel or engine design would be to fly it, and after the 2011 paper, researchers at NASA and DLR set out to show how that could be done.

> **"At the moment, it's still considered that our knowledge about contrails — about their effect in the atmosphere, at least — is quite low."**
>
> **Bernd Kaercher, German Aerospace Center**

Alternative fuels were of particular interest, partly because of ambitious government goals in the U.S. and Europe to increase use of cleaner fuel. The FAA wants aircraft to burn 1 billion gallons of alternative fuels in 2018. Compared to regular jet fuel, alternative fuels can contain half as many aromatic hydrocarbons, which burn poorly and can form soot particles. Less soot could mean fewer ice crystals, and that could spell smaller, shorter duration contrails. The DLR scientists named their flight project ECLIF, short for Emissions and Climate Impacts of Alternative Aviation Fuels. DLR wants researchers to meet in July to review the results and make plans for publication, possibly early next year.

NASA performed a similar test program with DLR in 2014 at NASA's Armstrong Flight Research Center in California. The NASA program was called ACCESS-2, the second part of its Alternative Fuel Effects on Contrails and Cruise Emissions program. NASA researchers inside an HU-25C Guardian chase plane followed a DC-8 powered by four CFM56-2C engines, which are among the CFM56 series, the most common on today's airliners. The engines burned a 50-50 biofuel-kerosene mixture that met jet fuel certification standards for commercial aircraft use. The 50-50 blend reduced soot emissions by 40 to 60 percent at cruising altitudes. The data suggested that ice crystal particle concentrations varied with those soot concentrations. But unlike lab tests, which show that soot and ice are highly correlated, the flight test data didn't provide enough statistical evidence to say for sure that reducing soot concentrations would reduce ice-particle concentrations, says Bruce Anderson, head of the Aerosol Research Group at NASA's Langley Research Center in Virginia. Researchers hope to develop a reliable system to estimate contrail ice crystal numbers generated at specified levels of soot emissions. They could then predict contrail formation. Detailed write-ups from the 2014 flights are expected to appear in peer-reviewed journals in October or November.

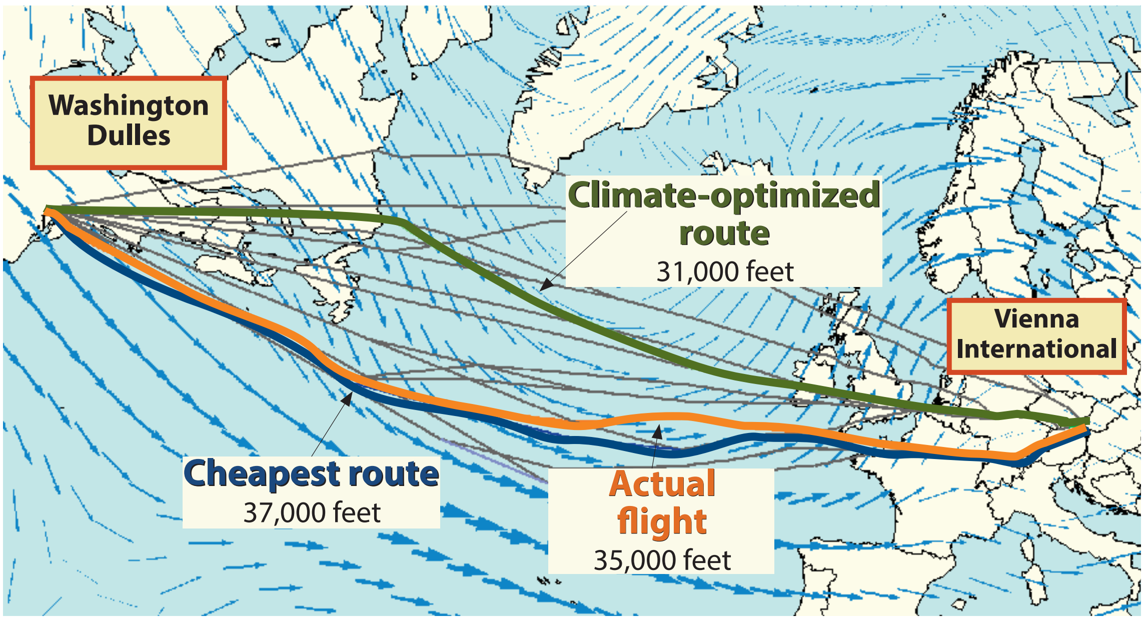
Whether alternative fuels can make much of a dent in climate change remains an open question. Computer simulations show that even a 50 percent reduction in the number of initial contrail ice particles leads to only a slight decrease in climate-warming effects of contrail cirrus clouds, says Ulrike Burkhardt, co-author of the 2011 paper. The solution might require new technologies, such as lean-combustion engines that mix air and fuel very efficiently, reducing soot emissions, she says.

Avoiding motion sickness

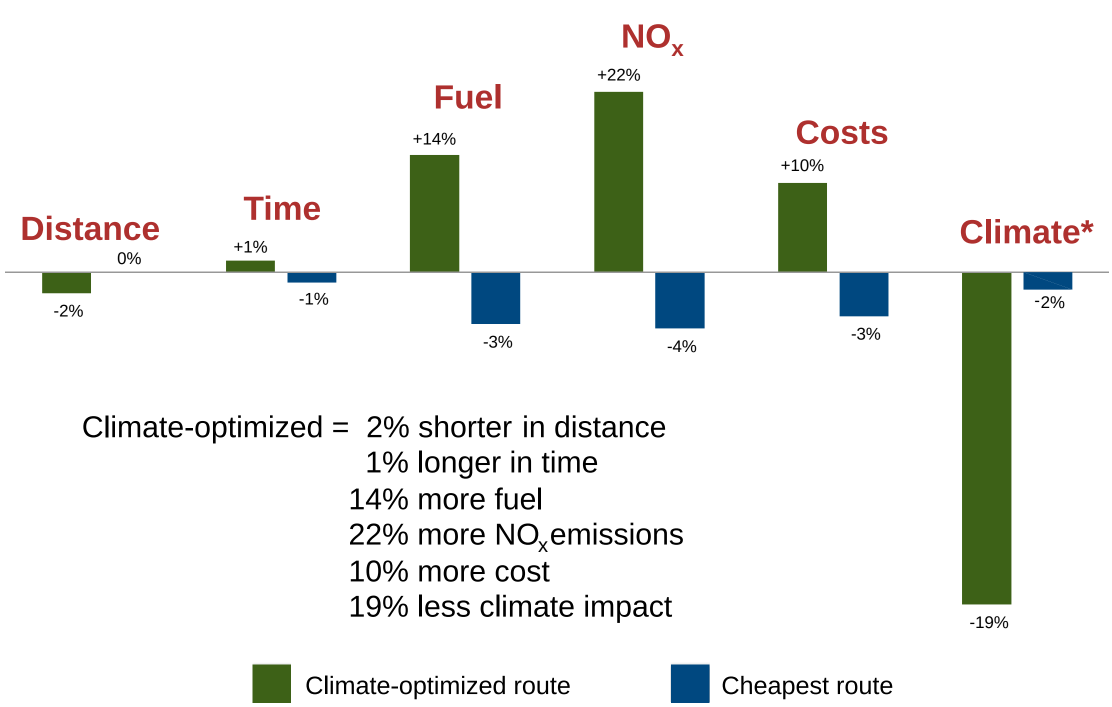
Gathering emissions data from an aircraft in flight required some interesting innovations. For starters, the Falcon 20 and the HU-25C Guardian top out at about 500 mph, but the DC-8 and A320 cruise at well over 500 mph. To compensate, the DC-8's

Climate-friendly flight

Top: An algorithm produced by researchers at the German Aerospace Center, and applied by the Eurocontrol air traffic agency, displays routes providing maximum cost reduction or least climate impact. The example here shows routes and altitudes through winter winds compared to an actual flight. **Bottom:** Burning more fuel doesn't always mean more climate impact. Reduced contrail formation in this example offsets the extra fuel burn.



Considers contrail formation, winds, weather, carbon dioxide, nitrogen oxides (NO_x) and other emissions
Minimizes fuel consumption and crew time
Actual flight shown for comparison



*About 85 percent of the drop in the effect on the climate comes from reduced contrails.

Sources: German Aerospace Center; Eurocontrol

A NASA research jet trails a DC-8 laboratory plane to measure the chemical components of the exhaust from a 50-50 mix of conventional jet fuel and plant-based biofuel.

pilots idled back on the outer two engines and the scientists sampled exhaust from the inner engines running at normal power settings.

That wasn't an option for the twin-engine A320, so the airliner's pilots tried cutting their speed by deploying the wing spoilers. That generated too much turbulence for the Falcon 20 to collect data effectively; the ride in the chase plane got so rough that the scientists got motion sickness. The Germans ended up having to idle back on the A320 engines so the chase aircraft could keep up and collect the in-flight exhaust data. Researchers are still determining whether the data can be accurately extrapolated to cruising conditions. A particular concern is whether flying slower generates less or more soot.

Another challenge was collecting and measuring the exhaust data. The instruments had to detect ice particles as small as .0005 of a millimeter and even smaller soot and aerosol particles.

"This is fraught with a lot of instrumental difficulties, because the environment is so strange. You're probing a highly turbulent, highly perturbed air behind an aircraft when nobody would usually fly and measure," Kaercher says.

On top of that, it had to be done with the same kind of probes that researchers rely on to measure ice particles, soot particles and liquid aerosols in natural clouds. Those probes are designed to detect the presence of 10 to 100 particles per liter of air, but the probes on the Falcon 20 had to accurately pick out millions of particles per liter in a contrail cloud.

These probes were "not built to measure in these extreme conditions, but they have been used to measure in these extreme conditions. So you have to be very careful in understanding what you actually measure," he says.

Contrails and climate change

Climate scientists estimate that civil avia-

NASA

tion comprises little more than 5 percent of the total human-induced climate forcings that are pushing temperatures higher. Contrail cirrus clouds account for about 3.4 percentage points out of those 5, whereas carbon dioxide, the next biggest contributor, accounts for about 1.6 points. The remainder comes from nitrogen oxides, water vapor, soot and sulfate particles.

The warming effect from all cirrus clouds — not just the contrail type — comes from the fact that they capture long-wave infrared radiation given off by the Earth's surface, absorbing and reflecting it back toward the surface, like a blanket holding in body heat. That more than offsets the cooling effect of the clouds reflecting some sunlight away from Earth. Lower, non-cirrus clouds reflect more sunlight away from the Earth, producing a net cooling effect.

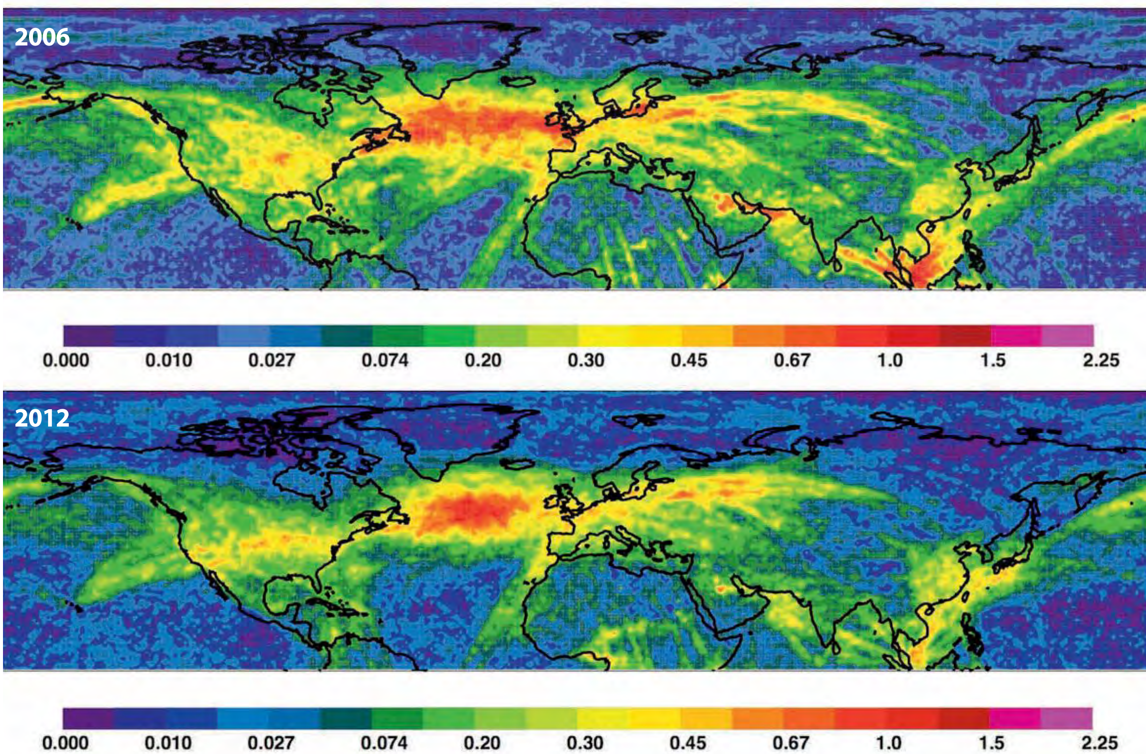
The complexity of studying a contrail cirrus cloud is that its shape and life span are dictated by more than the design of the jet. The amount of moisture in the atmosphere, temperature, wind speed and direction are main factors. Rising warm air, descending cold air, or changing air streams can merge the clouds with others or break them apart. Fallout is another factor. That's when ice crystals get too heavy to be carried by the cloud and they drop into lower levels of the atmosphere.

The significance of contrail cirrus clouds in the global climate change equation was not well known until Kaercher and Burkhardt studied the effect of all contrail cirrus clouds, not just the young line-shaped contrails. The scientists built a digital model of contrail cirrus clouds and simulated them across their life cycles from line-shaped clouds until they disappeared, typically when their ice particles encountered warm or dry air and sublimated. They found that the net warming effect was seven times greater when one considers the entire life cycle.

While 3 percent and 5 percent might

Fewer contrails?

Preliminary analysis by NASA researchers suggests that contrail coverage dropped between 2006 and 2012 despite growth in air traffic. Images taken by the Moderate Resolution Imaging Spectroradiometer on NASA's Aqua satellite during four months of each year were analyzed to detect contrails, then screened against flight data to remove non-contrail cirrus clouds. The averages from 2012 show a smaller red footprint over the North Atlantic, indicating diminished contrails. Researchers are refining the accuracy of the 2012 results.



NASA/Langley Research Center

not seem significant, "if every sector took the standpoint that its contribution is too small to warrant consideration, we wouldn't budge an inch forward," Kaercher says. "This is a moral or ethical issue to be judged by decision makers, and science can only provide a baseline for such a discussion."

The fact that contrails are short-lived, typically lasting two hours to a day, raises an interesting possibility for those worried about climate change. If contrails could suddenly be reduced or eliminated, their climate forcing effects would vanish immediately. That's in stark contrast to CO_2, which has been accumulating in the atmosphere since the start of the industrial age. Even if all CO_2 emissions were cut to zero, completely reversing the climate change tied to that accumulation would take more than 1,000 years, according to a 2008 study by Susan Solomon of NOAA.

"Cutting shorter-lived contrail cirrus has an immediate reduction effect on much of the total aviation radiative forcing that would allow us to buy time to reduce aviation carbon dioxide emissions more effectively," Kaercher says.

But "in my view, high priority should still be given to reduce carbon dioxide emissions from aviation due to [its] extreme longevity."

Counterpoint

Climate modelers are adjusting their estimates about the impact of contrails. A study published in June and revised in October concluded through weather computer modeling that contrail cirrus clouds might in fact have a less dramatic warming effect than previously believed. The study, headed by Ulrich Schumann, a DLR climate scientist, states that contrail cirrus cloud are drying out the upper troposphere, a region of the lower atmosphere where medium- and long-distance passenger aircraft often cruise. Cirrus clouds continue collecting moisture as they morph, until they harbor as much as 1 million times more moisture than what was put out by the engine, Shumann writes. When ice crystals in the cloud become too heavy, they fall, which dries out the upper troposphere.

Schumann's study suggests that the conditions needed to create contrail cirrus, as well as natural cirrus clouds, are becoming less likely and that new contrails might be adding a global cooling factor as they suck more moisture out of the upper troposphere. In Shumann's model, the fraction of flights that generate contrails is 3 percent lower than previously believed.

Factoring in the dehydration effect cuts the net forcing by 10 to 15 percent, Schumann says.

Images from the Moderate resolution Imaging Spectrometer instruments on NASA's Terra and Aqua satellites might back Shumann's finding, but scientists are still discussing that. Contrails can be seen in MODIS images until they become too fuzzy to distinguish from other cirrus clouds. NASA researchers reviewed MODIS imagery of the Northern Hemisphere taken in 2006 and compared the contrail coverage to imagery taken in 2012.

Early results, which have not yet been published, show 25 percent less coverage in 2012 than in 2006, says Patrick Minnis, a senior research scientist at NASA's Langley Research Center in Virginia. The Langley team isn't yet ready to say that the satellite imagery validates the conclusions of Schumann's weather model. There might be other explanations for why the total area covered by contrails dropped even as air traffic increased, Minnis says. For example, an increased number of flights may lead to more smearing of the line-shape clouds, or they may be overlapping or combining at a greater rate, making them indistinguishable from each other or natural clouds.

Working the problem

For Kaercher, a key question is how to avoid creating the most dangerous types of contrails: Those that are long-lived and have the greatest warming effect. Engines might be designed to emit fewer particles, or particles that turn into large ice crystals that drop out before they can form a cloud.

Contrail formation might also be reduced through air-traffic management. Aircraft could be directed around areas of very cold, moist air. In avoiding contrail formation, planners may have to make trade-offs with other climate changing emissions. For example, an airplane flying at a lower altitude might avoid creating contrails, but that could boost overall carbon dioxide emissions — which regulators are keen on lowering — because the flight path might be less fuel-efficient. The water content released in the engine combustion can also be a factor: More moisture can lead to more contrail formation. Newer, more efficient engines can create more contrail clouds than older engines because their exhaust is cooler. While they give off the same amount of water vapor, the relative humidity of the exhaust plume is higher, and that means water droplets can form more easily. The contrast between old and newer engines has been documented by flying airplanes equipped with each side by side, Kaercher says.

Another issue is that renewable fuels intended to lower carbon dioxide emissions for airplanes might create more contrail clouds because of their high hydrogen content, which would mean more moisture, says Anderson of the NASA Aerosol Research Group.

Scientists are going to have to give fuller answers about how contrails form and their effects on the atmosphere before policy makers can require reductions, Kaercher says.

"At the moment, it's still considered that our knowledge about contrails — about their effect in the atmosphere, at least — is quite low. So I think regulations won't come into effect soon," Kaercher says. "Research has to convince other communities — engineers and airlines — that we are certain enough in the scientific side of that assessment of these processes. Only then do we end up with regulation. Nobody will regulate something that is highly uncertain."

A set of cubesats photographed as they are released from the International Space Station. Private companies are developing launchers specifically designed to carry cubesats.

Light launchers under development with the support of venture capitalists and NASA could transform how cubesats and other small satellites reach space. Marc Selinger looks into the prospects.

by Marc Selinger
marc2255@yahoo.com
Twitter: @marcselinger

Liberating cubesats

Winning funds from NASA to build and launch a tiny cubesat is an exciting moment for a college professor and his or her students, but with that exhilaration comes a dose of reality. A cubesat typically must share a ride on a rocket purchased by a company or agency for a satellite or satellites that cost hundreds of millions of dollars. The schedule is controlled by the primary customer, and if that schedule slips, so does the cubesat mission. Also, cubesats often must accept a less-than-ideal orbit, because they are typically dropped off wherever the main payload is dropped off; cubesats lack their own propulsion systems, except with special permission. And to prevent electromagnetic interference with the primary payload, a cubesat must keep its power off during the launch, eliminating the chance to collect cubesat flight-performance data.

In short: "We're at the mercy of the primary," says Garrett Skrobot, lead for NASA's Educational Launch of Nanosatellites initiative, known as Elana.

Cubesat developers began pining for more and better launch opportunities not long after professors Jordi Puig-Suari of the California Polytechnic State University and Bob Twiggs of Stanford began conceiving cubesat design standards in 1999. Cubesats today range from 1-unit versions measuring 10 centimeters on a side to 3-unit versions measuring 30 centimeters long and 10 centimeters across. They are dispensed from a standard tube called a P-POD, short for poly picosatellite orbital deployer. Universities have long seen cubesats as a low-cost research and teaching tool, and now commercial companies, such as Planet Labs, an Earth-imagery provider founded by ex-NASA scientists, are seeing the potential, too.

The booming interest in small satellites, especially cubesats, has sparked a matching proliferation of small launcher concepts, ranging from shrunken versions of traditional rockets to a version that would be launched on a rail to others that would be released from fighter jets or other planes. The question, experts say, is how many of these concepts can survive to commercial viability over the next two or three years, given that most come from startup ventures.

The small-launcher market can support "healthy growth" for two or three launch companies, predicts P.J. King, co-founder of Firefly Space Systems, a small company based outside Austin, Texas, that is developing the ground-launched Firefly Alpha. King cautions: "There isn't healthy growth in the small market for 10 providers."

No one can say for sure who the winners will be, but if things go as NASA's Skrobot hopes, cubesats will soon be routinely launched on small rockets, and they will have all the rights of primary payloads.

"We can have propulsion systems on board. We can have our cubesats turned on and collect data as we're launching. It's opening the door to potential new opportunities for small payloads."

Flying for NASA

NASA wants to do what it can to support the nascent market and provide an opportunity to demonstrate the new launchers. It estimates that at least 50 cubesats will be looking for rides to orbit over the next three years. So in October, NASA awarded contracts totaling a little over $17 million to three companies under its Venture Class Launch Services competition, the word venture being a nod to the major role that private money plays in the sector. Each winner will demonstrate its capabilities, which NASA hopes will include lofting 15 to 30 cubesats on a single rocket. Firefly was awarded $5.5 million to launch its Alpha rocket. Rocket Lab of Los Angeles received $6.9 million to launch its Electron. Virgin Galactic was awarded $4.7 million to launch an aircraft-released LauncherOne rocket, the first of which is in development at its factory in Long Beach, California. Funds will flow to the contractors "via a series of milestone payments, each of which require[s] demonstrated progress towards the final launch," NASA says. "This approach is analogous to how NASA acquires launch services for larger payloads."

Among the Venture Class winners,

Students at the California Polytechnic State University place a research cubesat into a Poly Picosatellite Orbital Deployer, a standard tube used for dispensing cubesats.

U.S. Air Force

New players

The exploding interest in cubesats and other small satellites has caught the eyes of rocket entrepreneurs. Among the leading contenders are:

Manufacturer		Rocket	First flight
CubeCab Mountain View, California A seven-person company founded in 2014.		**Cab-3A**. A rocket that will be released from an F-104 fighter.	2016 or 2017
Firefly Space Systems Cedar Park, Texas An 80-person company founded in 2014.		**Alpha**. A ground-launched rocket powered by an aerospike engine with multiple small nozzles.	2017
Rocket Lab Los Angeles and Auckland, New Zealand An 80-person company founded in 2007.		**Electron**. A ground-launched rocket powered by the company's Rutherford engine, which uses liquid oxygen and kerosene-based Rocket Propellant-1.	June 2016
University of Hawaii Honolulu The school's Hawaii Space Flight Lab was founded in 2007.		**Super Strypi**. A rail-launched rocket in development by students and professors with the U.S. military's Operationally Responsive Space Office.	November 2015
Ventions San Francisco Founded in 2004, the company does not disclose its number of employees.	Photo not available	**SALVO** (Small Air Launch Vehicle to Orbit). Ventions is working with DARPA on this rocket, which would be released from an F-15 fighter.	Not disclosed
Virgin Galactic Long Beach, California Founded in 2004, the company now has more than 500 employees.		**LauncherOne**. An air-launched rocket to be released from a 747-400 commercial jet.	2017

Rocket Lab of Los Angeles and its New Zealand subsidiary are scheduled to fly first for NASA by April 2017, once they conduct the first Electron launch, now scheduled for June. Firefly and Virgin Galactic are scheduled to follow with launches by April 2018.

As for launch sites, Rocket Lab plans to launch from a new site on New Zealand's North Island. Firefly might use NASA's Kennedy Space Center in Florida. Virgin Galactic will fly its carrier plane from Mojave Airport in California and release LauncherOne over the Pacific Ocean.

Skrobot's Elana team has begun contacting scientists and others who are planning to launch cubesat missions to see which launcher would best meet their requirements.

"Right now, we're working hard to get the first flight manifested," Skrobot says. "If we can get through this demonstration phase, there is an opportunity that these [launchers] could be offered up for some potential science missions in the future."

Artist's concept of DARPA's Airborne Launch Assist Space Access rocket that was to launch cubesats from a Boeing F-15 fighter. DARPA halted work on the demonstrator vehicle in November following an explosion during tests.

Commercial businesses

Looking beyond the NASA contract, Firefly intends to mass produce its Alpha rockets, says King, the co-founder. Firefly plans to "get there often and drive volume purchasing," he adds.

Firefly says it has completed design reviews for Alpha, which will be powered by an aerospike engine that uses an array of small nozzles instead of a traditional single nozzle. This approach lets the plume adjust to the shifting atmospheric pressure, producing more average thrust than a single large nozzle engine, the company says. Alpha is scheduled to begin suborbital launches in early 2017 and orbital launches in early 2018. It will retail for $8 million and be able to deploy payloads of about 400 kilograms to low Earth orbit, the company says.

The first flight of Rocket Lab's Electron was bumped from 2015 to June, because it took longer than expected to get environmental approvals to build the launch site in New Zealand, says CEO Peter Beck. Work is now underway. New Zealand has "strict" environmental rules that require applicants to be "very thorough," he explains. There will be at least two more test flights after the first one in June. Rocket Lab says it has secured commitments for its first 30 launches and is on a path to conduct at least 100 launches annually.

In an indication that plans can be fluid among the competitors, Virgin Galactic announced a major change in December. Instead of releasing each LauncherOne from the Scaled Composites WhiteKnightTwo aircraft, it will use a Boeing 747-400 that was previously flown by the Virgin Atlantic airline under the nickname "Cosmic Girl." With WhiteKnightTwo needed for launching SpaceShipTwo, Virgin says it decided to give LauncherOne its own aircraft to meet high demand for the rocket.

Virgin plans to boost LauncherOne rockets frequently to produce "manufacturing efficiencies" and keep launch costs down, says Richard DalBello, vice president of business development and government affairs.

Specifically, the goal is to deliver 200 kilograms to sun-synchronous orbit for "single-digit millions," he says. "We think that will be compelling to the customers that we're talking to. You have to be flying a lot to get the [price] that we're talking about."

DalBello says an advantage of an aircraft launch is that it avoids the constraints of ranges, which are crowded, hard to schedule and susceptible to bumping flights.

Virgin says it is on track to begin flight testing LauncherOne in late 2017, and it projects that "soon thereafter" it will make the first launches for customers. It says it has sold several flights, including for NASA and OneWeb, an Arlington, Virginia, company that plans to field a constellation of 720 small satellites to provide global high-speed Internet.

In October, Virgin hot-fired LauncherOne's NewtonThree main rocket engine for 90 seconds.

Important endorsement

Bill Ostrove, an aerospace and defense analyst at Forecast International, says it remains to be seen whether these rockets can deliver on their promises, since they still have significant development work ahead

Generation Orbit

Generation Orbit is developing its GOLauncher 1, a single-stage rocket for hypersonic flight research. The Atlanta company earlier worked on the two-stage GOLauncher 2, which was to deploy cubesats from the belly of a Gulfstream business jet, until NASA changed its payload requirements.

of them. For instance, Rocket Lab says it can launch a 3-unit cubesat for $180,000 to $250,000, compared to perhaps $295,000 on a larger SpaceX rocket. But unlike SpaceX, Rocket Lab does not have years of flight experience to back up its cost projections, Ostrove notes.

Still, observers see the NASA contracts as important endorsements for Firefly, Rocket Lab and Virgin over their rivals.

"The fact that those three companies were selected … tells me that they are the safest bets to succeed of all the light launch vehicle startups," Ostrove says.

Other participants in the small-launcher sector include CubeCab, a Mountain View, California, company that aims to launch cubesats by rocket from an F-104 fighter, and Ventions, a San Francisco firm that is working with DARPA's Small Air Launch Vehicle to Orbit (SALVO) program to develop a launch vehicle that would be fired from an F-15 fighter. "CubeCab intends to provide hundreds, eventually thousands, of cubesat launch opportunities per year — with orbital debris mitigation plans — in order to eliminate the supply bottleneck and expand the market," says Adrian Tymes, CubeCab's CEO.

Some rival concepts have run into trouble.

Generation Orbit, based near Atlanta, received a $2.1 million contract from NASA's Enabling Exploration and Technology, or NEXT, program in 2013 to send up three 3-unit cubesats in 2016. Generation Orbit planned to fire its two-stage GOLauncher 2 from a Gulfstream 3G business jet, but then NASA changed its plans.

"NASA's payload mass requirement under NEXT increased and was rolled into the larger requirement under [the Venture Class Launch Services program] which was indeed too large for GO2," says A.J. Piplica, Generation Orbit's chief operating officer. The company is now focused on developing GOLauncher 1, a single-stage rocket designed to support suborbital research.

DARPA's Airborne Launch Assist Space Access, or ALASA, program was developing a launcher to be fired from an F-15 fighter. But DARPA in November halted work on the demonstrator vehicle after a new, high-energy propellant exploded during propulsion system tests in Utah. The agency says the program will now focus on "safety testing and certification" of the new monopropellant, which combines nitrous oxide and acetylene without the need for a separate oxidizer.

"If successful, such a system would provide greater performance and reliability in a much smaller and more affordable package than traditional bipropellant rocket systems," DARPA says.

The University of Hawaii, which is developing the rail-launched Super Strypi rocket with the U.S. Air Force's Operationally Responsive Space office as well as with Aerojet Rocketdyne and Sandia National Laboratories, had a setback in November on its initial flight attempt. Things seemed to go well at first, and the university posted a video showing Super Strypi's liftoff at the Pacific Missile Range Facility in Kauai. But the school later reported a "launch vehicle anomaly."

The cause of the failure is under investigation.

Space AT

International cooperation was all the rage after the fall of the Soviet Union and establishment of the International Space Station program in the 1990s. If humans were to colonize space for science and commerce, they would do so together as a multinational team. When Anatoly Zak traveled from the U.S. to the International Astronautics Congress in Jerusalem in October, he found a loss of consensus on the future of human space flight.

ANALYSIS

When top space leaders from the U.S., Russia, China and Europe gathered at the International Astronautics Congress in Jerusalem in October, there was no missing their mismatched and uncoordinated strategies in human space flight agendas. In a nutshell: NASA sounded eager to go to Mars; the European Space Agency discussed building an international "Moon Village"; China talked about building an Earth-orbiting space station of its own; and Russia discussed preparations for a lunar mission and for separating its modules from the International Space Station after 2024 to create its own station.

The new standard seems to be to defy the cliché that no country can succeed in space exploration without partners and that joint missions in space should improve relations on Earth. After two decades of cooperating on the ISS, there are signs that its collaborators are drifting apart on a sea of political turmoil.

"The challenge is right now, engineering-wise, we are willing to be dependent upon each other, but then our governments are not necessarily willing to," William Gerstenmaier, NASA's associate ad-

collaboration RISK


European Space Agency

The International Space Station is slated to be shut down in 2024, and its original partner countries are drifting apart to pursue separate visions for space exploration.

by Anatoly Zak
agzak@optonline.net

ministrator for human exploration, told me in a phone interview after each of us returned from IAC.

Advocates of international collaboration are worried, and my analysis of the discussions, many of which were behind closed doors, is that they should be. The end of life for the ISS is on the horizon, and it could take years to develop a comprehensive international program to succeed it with anything as ambitious. The space-faring nations don't have much time to bridge their differences and sacrifice their desire for fully independent space capabilities for the sake of a larger cooperative program.

NASA, which boasts the world's largest space budget, released a new doctrine right on the eve of the IAC. Called "Journey to Mars," it declared that the U.S. is "closer to sending humans to Mars than at any point in NASA's history."

The ambitious manifesto, however, provided no budget numbers or timeline for the journey. Robert Zubrin, founder of The Mars Society, went on his Facebook page and declared, "NASA announces its current plan for not going to Mars."

NASA begs to differ, pointing out that the main audience for the document might be among partner agencies rather than at home.

"The purpose of this document is not to get down to details of missions or specific hardware but talk more philosophically about how it is all linked," Gerstenmaier told me. He acknowledged that it "is not satisfying to my engineers, because it doesn't have enough specifics," but "politicians don't like it" for the same reason.

Still, he said, "it does provide [a] framework where other countries can start seeing how they want to play together."

For Gerstenmaier, the leading space agencies aren't diverging as much as it might appear: "I don't see them necessarily out of tune, we just recognize we run at different paces," he explained. "We get portrayed as going solely to Mars, but we are not going immediately. We are going to this proving-ground region [near the moon]."

European Space Agency

Johann-Dietrich Woerner, chief of the European Space Agency, stirred excitement at the 2015 International Astronautics Congress with a proposal to build an international lunar base called the Moon Village.

In Gerstenmaier's view, those plans to send missions into lunar orbit or Lagrangian points, collectively known as cislunar space, are well aligned with the efforts of other agencies, such as ESA and Roscosmos. He points to the European decision to provide the service module for one and possibly two upcoming missions of NASA's Orion spacecraft as a model for future piecemeal agreements with other space agencies.

Currently, NASA is anxious to learn what Russia finds when it sends robotic landers to the polar regions of the moon, as it plans to do before the end of the decade to probe for water ice.

"We would like to know: Are there resources on the moon that can be used for in-situ utilization to get propellant maybe for a Mars-class mission?" Gerstenmaier asked.

Under one scenario, U.S. astronauts and Russian cosmonauts might eventually take an Orion capsule into orbit around the moon and while in orbit remotely steer Russian rovers across the lunar surface. From lunar orbit, the crew could have an advantage over ground controllers back at home due to lower latency of communications. The same technology could be much more critical during the exploration of Mars, Gerstenmaier stressed.

During IAC's opening ceremony, Roscosmos chief Igor Komarov pledged to continue the Russian participation in the ISS until 2024 and to discuss the future of the human space flight program with its partners during the upcoming year. In parallel with continuing ISS operations, Roscosmos drafted a plan to mount a lunar expedition by the end of the 2020s to complement its plan to have its own space station ready by 2024 to continue Russian presence in orbit.

"I think one way or another, there will be a next-generation station in the low Earth orbit, for the very simple reason that a great deal of work and experiments for the exploration of deep space would be simpler and cheaper to be conducted there than let's say on the moon," Komarov told me in a sideline interview at IAC. "However, we think that the next goal [for the human space flight] will be the moon, not Mars. And we are talking about not just planting the flag and leaving, but organizing a long-term work, which would enable us to learn how to build settlements on other planets. I think the majority of our partners agree with us. We have no doubt that Mars would (eventually) become the key goal of the program, but our current strategy is to do it step by step. The moon is inevitable on that path and it is the most effective destination for resolving many of

ESA/Foster + Partners

The European Space Agency's vision for an international Moon Village includes using 3D printing to help build habitat structures out of lunar soil.

our current challenges…"

Vladimir Solntsev, the head of RKK Energia, Russia's manned spacecraft contractor, echoed Komarov, his new boss after a reform that made Energia a division of Roscosmos State Corp. Solntsev detailed the Russian space strategy during an IAC presentation he made via a translator, saying that entirely new technologies would be needed for a Mars mission, including closed-loop life-support systems, new propulsion systems and radiation protection. In an apparent reference to NASA's strategy, he opposed the concept of a Martian base on "economic" reasons.

My sense is that the real reason for Russia's anti-Mars stance is not the difficult engineering but the worsening economic situation in the country, which forced the space budget sharply downward beginning in 2015 after more than a decade of solid growth.

The lunar part of the Russian space agenda is finding more traction in Europe than its proposal to undock from the ISS in 2024 to create a new space station. The Russian proposal created some angst in Europe among advocates of international collaboration, but the newly appointed chief of the European Space Agency, Johann-Dietrich Woerner, restored some excitement when he proposed construction of a "Moon Village" — a loosely regulated international lunar base, combining human-tended and robotic components.

Woerner told me that his very public move was prompted by a less-than-successful attempt in late 2014 to initiate discussion of this idea with ESA's partners outside Europe — an apparent reference to NASA and Roscosmos. Woerner managed to generate some press, but he has yet to enlist support at the top of the space establishment.

"I had several meetings with Igor Komarov, from Roscosmos, about the subject, I had a meeting with [NASA Chief] Charlie Bolden, with the Japanese space chief Mr. Okumura, so we have all these interactions now and it is important to get them together," Woerner said.

Woerner wants space agencies to focus on areas of particular interest to avoid redundant spending. For example, ESA could provide various experiments and equipment, while Russia would probably be interested in transportation systems, he suggested.

Formulating an international plan doesn't have to be done immediately, but it can't wait long: "We have different opinions, we can put them together and, therefore, I hope that the proposal to start it is not too late, but there is an easy sentence: The earlier the better…but better late than never."

Russia is building the Luna-Glob robotic lander to send to one of the lunar poles to search for water ice. NPO Lavochkin, which is headquartered near Moscow, is the main manufacturer of the spacecraft.


NPO Lavochkin

In Woerner's view, implementation of lunar plans could start as soon as two or three years from now with smaller missions such as the Russian unmanned lunar lander, for which ESA pledged to supply scientific instruments and sophisticated landing equipment.

These relatively small missions could be funded on a one-time basis and eventually be folded into a larger international program: "If we want to do something like ISS, which I don't think [ISS is on the horizon] but maybe, then we need the full picture first and this will take some more time." He seemed less than enthusiastic about a Russian or Chinese space station. "I don't like that we will have several space stations at the end of the day, because [human space flight] has to be an international activity. So, we will discuss with our partners and I will be very blunt with my opinion."

Woerner acknowledged that there is no money in the current ESA budget for aggressive human space flight, but he said that he has seen enthusiasm for it across Europe, and he hints that small increases for the program could eventually materialize.

The toughest country to convince to join an international human space flight endeavor might be China. At the IAC, Xu Dazhe, the head of the National Space Administration, promised that the first modules of a Chinese space station would be launched in 2018. China says other countries are invited to participate, but the Chinese space station is being developed with no coordination with any foreign partner.

Why hasn't Chinese participation in the ISS ever materialized? The station partnership is based on full disclosure of technical information about space hardware and on mutual access by all parties to each other's space centers. The Chinese military, which largely runs the country's space program, likely finds that unacceptable.

The chief designer of China's manned space program, Jianping Zhou, says that after the assembly of its station is completed in 2022, it would become the destination for the Chinese astronauts for the following decade. Zhou told reporters that China has no intention of sending humans to the moon or Mars in the foreseeable future.

There are political problems, too. At the opening of the IAC, NASA's Bolden criticized his Chinese counterparts for what he said was their failure to make space cooperation "fully transparent and mutually beneficial." Bolden added: "If we are not collaborating with everybody, we find ourselves on the outside looking in."

No doubt, it would take a major political breakthrough to bring China and its unquestionable space potential into the joint space effort.

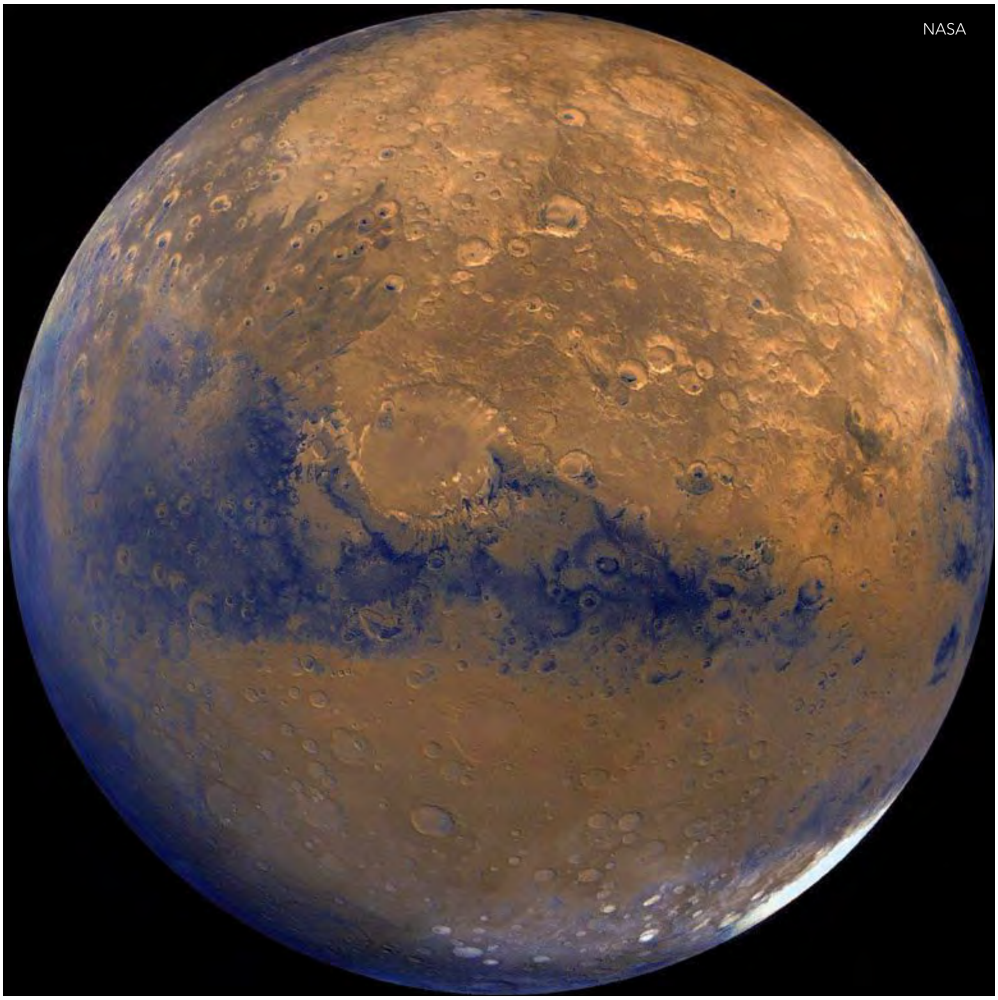
Without a broad international agreement signed by the heads of states, advocates of international collaboration rightly fear that the planning and conversation over what to do after the ISS will come to naught.

NASA officials hope ISS could serve as

a springboard for such collaboration, both in terms of the legal structure of an agreement and as a strategy for addressing the engineering challenges. In fact, in Gerstenmaier's view, the current agreements would allow further collaboration:

"What's amazing to me is that if you look at the ISS intergovernmental agreements, IGAs, they are flexible enough [for cooperation beyond the ISS]. The authors put the word 'exploration' in there, so I think I can even use some of the ISS IGAs for exploration activities," Gerstenmaier said. "Now, how far we can push that and when do we then need a separate intergovernmental agreement I don't know…"

The original legal framework for the space station enabled the partners to bring Russia into the project. It also enabled the ESA and NASA to barter a European-built service module for the Orion spacecraft in exchange for NASA's support of a European role in the ISS.


NASA

Unlike Russia and China, the U.S. is targeting Mars, not the moon, for human space exploration. Skeptics, including Robert Zubrin, founder of The Mars Society, question the feasibility of NASA's current plan.

Time is of the essence.

"The next couple of years [will be] pretty important if you really want to have a joint program," Gerstenmaier said. "The way I think of it, at the end of the 2020s our goal is to leave the Earth-moon system. So, if you get really serious about that, we really have to nail down our habitation systems, hardware performance and all those things. These things seem like they are a long way away, but I don't think they are so far away. We gotta start now thinking about how we want to cooperate. I think, what you are seeing now, each individual country start to flesh out what their humans' exploration plans are. And now the trick will be to take their individual plans and look for common areas where we can combine and operate efficiently, and kind of start to build maybe at first a loosely integrated plan in the next couple of years and then kind of cement that in place."

But there is another factor that requires a quick action.

"My concern is the station has a finite life and this is another urgency: We need this exploration program at least conceptually agreed to, so we can start moving in this direction before the station becomes like Mir, where it is so costly to just keep it in orbit. I know that point is coming and that requires work now," Gerstenmaier said. "I think we have a maximum of three years" to define a long-term strategy and reach a cooperative agreement.

Anatoly Zak is the publisher of RussianSpaceWeb.com and the author of "Russia in Space: The Past Explained, the Future Explored."

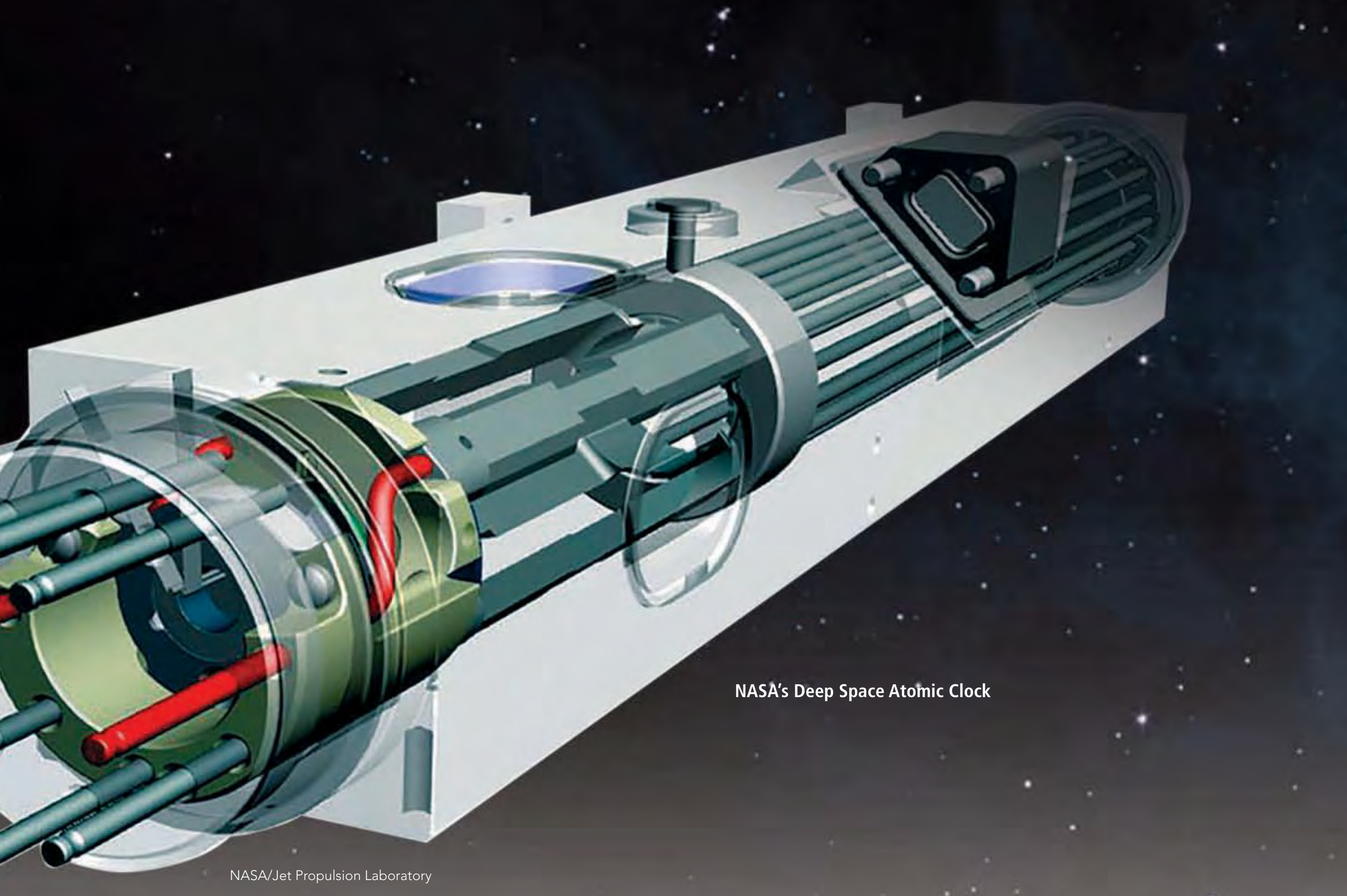
Keeping TIME in deep space

NASA is looking for new ways to sharpen deep space navigation and give scientists more flexibility. Debra Werner looks at an upcoming orbital experiment that could point the way.

by Debra Werner
werner.debra@gmail.com

NASA is preparing to send an experimental atomic clock into orbit, and if all goes as planned, the mission will demonstrate the potential for installing atomic clocks on future spacecraft bound for deep space. That would be a big breakthrough, because the locations of unmanned probes or crew vehicles bound for Mars could be calculated in a manner that would take up less of the communications time between a spacecraft and Earth. Scientists are already thinking about how they might use the extra antenna time.

NASA currently calculates the location of a spacecraft outside Earth's orbit by uplinking a radio signal to it from the Deep Space Network's antennas in California, Spain and Australia, each of which has an atomic clock. The spacecraft downlinks the signal to a DSN site, and with some math, the spacecraft's distance from Earth can be determined from the transit time of the signal. The atomic clock is crucial, because a nanosecond error in mea-



NASA's Deep Space Atomic Clock

NASA/Jet Propulsion Laboratory

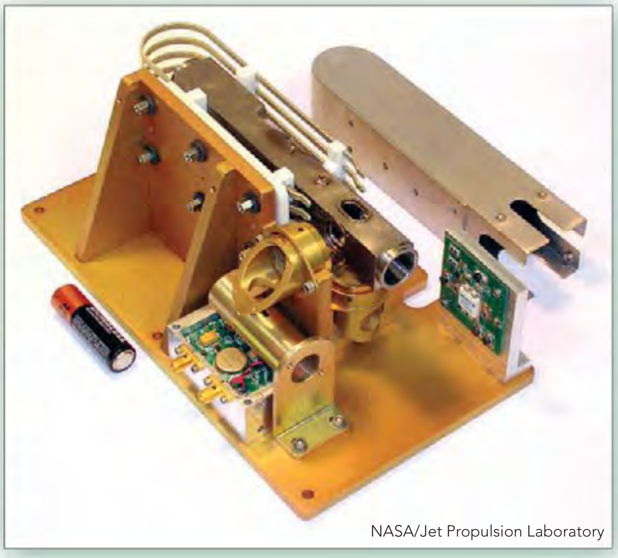
suring when the signal left and when it returned equates to a 30-centimeter error in locating the spacecraft.

It's a technique that has worked for decades, but NASA thinks it can do even better. As things stand, a spacecraft must intermittently stop downloading images and science data to receive and send the navigation signals. If an atomic clock were on the spacecraft in addition to the DSN sites, a one-way signal could be passed between the spacecraft and the ground, and scientists would not have to pause science transmissions for as long.

Proving that a small, accurate atomic clock can withstand launch and operate without someone at the ready to maintain it are among the goals of the Deep Space Atomic Clock experiment. The mercury ion atomic clock was built at NASA's Jet Propulsion Laboratory in California and will be launched as early as September on a yearlong demonstration aboard a U.S. military satellite.

Ground-based atomic clocks used for spacecraft navigation are the size of refrigerators. The Deep Space Atomic Clock demonstration unit measures 23 centimeters by 25 centimeters by 28 centimeters and weighs about 17 kilograms. NASA engineers plan to continue to shrink the design for future tests. Their next goal is to produce a 10-kilogram version that consumes 30 watts, compared with the current model's 45 watts.

Jet Propulsion Lab engineers have been testing the mercury ion atomic clock on the ground for more than a year. By March 1, they plan to deliver it to the company building the host satellite, Surrey Satellite Technology US, the Colorado-based arm of the British company. Surrey is making the Orbital Test Bed satellite for the U.S. Air Force.



The demonstration model of NASA's Deep Space Atomic Clock, which weighs about 17 kilograms. Ground-based atomic clocks used for spacecraft navigation are as big as refrigerators.

Atomic clock makers measure the accuracy of their products by how little they speed up or slow down, a factor called stability. "When [the Deep Space Atomic Clock] flies, it will be the most stable clock in space today," says Bob Tjoelker, the Deep Space Atomic Clock co-investigator at JPL. Deep-space probes don't carry atomic clocks, but GPS satellites do. "This first Deep Space Atomic Clock should be five to ten times more stable than GPS rubidium clocks," Tjoeker adds.

Science options, traffic management

If the Deep Space Atomic Clock works as predicted, future spacecraft would have more flexibility about how to use their high- and low-gain antennas for transmissions and science. Members of NASA's Europa mission team, for example, are considering the technology for their study of Jupiter's moon Europa sometime in the 2020s.

The Deep Space Atomic Clock also could alleviate some of the Deep Space Network's communications traffic jams. Because the network sends and receives tracking signals from all NASA satellites, some spacecraft wait hours to relay data.

"Usually there is a single antenna pointing toward Mars," says JPL's Todd Ely, the Deep Space Atomic Clock principal investigator. "So if one spacecraft is getting tracking another isn't."

With the Deep Space Atomic Clock, NASA could beam timing information toward Mars, and any spacecraft with access to the beam could collect the data and compute its location and trajectory with an onboard navigation system. This capability would be particularly useful for crews traveling beyond low Earth orbit.

"As humans begin to explore further, that makes a strong case to further develop the clock and navigation systems that would use it," Ely says.

Reliability

If Deep Space Atomic Clocks are to be widely used, engineers must show they can withstand the vibration of a rocket launch, temperature and magnetic extremes as well as harsh radiation — a significant challenge given the intricacies of the device. The clock uses electric fields to confine mercury ions to a radio frequency linear ion trap housed in a titanium vacuum tube. It uses an ultraviolet light source in a process called optical pumping to excite trapped electrons, moving them from one energy level to another. By observing ultraviolet light scattered by the trapped ions, the device steers the frequency output of an ultra-stable quartz oscillator to a value that is nearly constant.

The ground-based high performance clocks used for deep space applications typically operate in a tightly controlled environment. Plus, clock experts continuously monitor the devices and perform any necessary maintenance.

"It's a challenge to try to preserve performance in a less stable environment," Tjoelker says. "Some technology provides exquisite performance but requires human intervention for long life."

To meet the challenge of spaceflight, NASA engineers began by selecting the mercury ion for its low thermal and magnetic sensitivity. They also spent more than 20 years developing the ion trap technology to further reduce that sensitivity and make the clock durable.

While the Deep Space Atomic Clock is designed for a one-year demonstration, future versions will need longer lives. "The ultimate goal is to continuously operate for much longer, 10-plus years," Tjoelker says.

Still, getting the first version into space and proving it works will be a significant milestone. "New technology is a tough sell, but this demonstration definitely will retire a lot of risk," Ely says.

Would the U.S. consider using them on new versions of GPS satellites?

"Given the importance and the nature of GPS as a global utility, moving to new technologies requires extensive testing and demonstration of the capability," says Air Force Col. Steve Whitney, who leads the service's Global Positioning Systems Directorate, by email.

NASA/Jet Propulsion Laboratory

NASA plans to launch its experimental Deep Space Atomic Clock on a spacecraft in 2016. The device would have to be much tougher than ground-based atomic clocks in order to withstand extreme temperatures, vibrations and other forces.

AIAA FOUNDATION
Advancing Aerospace

25 Years Ago, February 1991

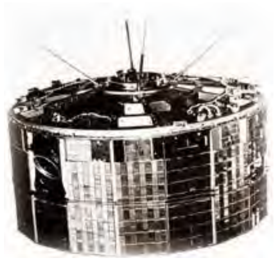
Feb. 24-28 Operation Desert Storm commences with devastating air attacks against Iraqi ground forces. In 100 hours, coalition forces led by the U.S. expel the Iraqi army from Kuwait and force a rapid Iraqi surrender. The brief war saw the widespread use of stealth technology, as the Lockheed F-117 spearheaded the 65,000 combat sorties. Of the 80 million kilograms of bombs and missiles expended, 7 million kilograms were precision-guided munitions. David Baker, Flight and Flying: A Chronology, pp. 483-484.

50 Years Ago, February 1966

Feb. 1 The retro-rocket system designed to slow NASA's Surveyor spacecraft to the surface of the moon is demonstrated by Hughes Aircraft and the Jet Propulsion Laboratory at Holloman Air Force Base, New Mexico. The solid-propellant retro-rocket weighs 635 kilograms. At the moon, it must slow the Surveyor from a speed of more than 9,300 kilometers per hour at an altitude of 75 kilometers to about 430 kilometers per hour by the time the spacecraft is 9 kilometers above the surface. From this point, there are throttable liquid-propellant vernier motors attached to the three landing legs of the craft that are used together to make fine-course adjustments and also further reduce the speed down to 5.6 kilometers per hour for the final soft landing. In this test, a Surveyor spacecraft is released from a balloon and the retro-rocket motors fired, followed by the vernier motors. But in the test, the verniers are shut down at 500-foot altitude and the craft descends by parachute. Flight International, Feb. 17, p. 283.

Feb. 2 Parachutist Nick Piantanida ascends in a balloon from Sioux Falls, South Dakota, and reaches a 123,000-foot altitude. This is an unofficial manned balloon altitude record. But Piantanida, who had planned to break the world's free-fall record by jumping from this altitude up to 7,000 feet before deploying his parachute, fails to do so when his spacesuit oxygen hose freezes and he is ordered to descend in the balloon's gondola. This is an experiment by Spaceco, a firm developing space survival and bail-out equipment. The Baltimore Sun, Feb. 3.

Feb. 2 The initial production model of Germany's HFB-320 all-metal, twin-engine, 10-seat business jet made by Hamburger Flugzeugbau flies for the first time. This is the only civilian jet ever to use a forward-swept wing. Flight International, March 3, p. 354.



Feb. 3 ESSA 1, the Environmental Survey Satellite No. 1, also designated Tiros OT-3, is launched by a three-stage Thor-Delta booster into a sun synchronous orbit to provide daily cloud cover pictures of the sun-lit portion of Earth and to transmit these pictures to ground station. This launch also brings the total number of objects in orbit to 1,000. New York Times, Feb. 4, p. 37.

Feb. 3 The world's first soft landing on the moon is achieved by the USSR when its Luna 9 spacecraft lands an instrument package near the Ocean of Storms, not far from Reiner and Marius craters. At a 76 kilometer altitude, the craft's retro-rocket is fired and its shock-absorbing system is prepared. A second before impact, the instrument capsule is ejected. The main spacecraft crashes but the spherical instrument capsule lands cushioned by a shock-absorbing material. The capsule's petal-like covers open, enabling the antennas to spring to position and transmit facsimile pictures to Earth. Sir Bernard Lovell, the British physicist and radio astronomer, says the pictures seem to destroy the theory that the moon's surface is covered with dust several feet thick and confirms another view that the moon's surface is hard and a sponge-like pumice stone substance that is suitable for landing heavy vehicles as well as humans. New York Times, Feb. 4, pp. 1, 37; Flight International, Feb. 17, pp. 284-285.

Feb. 7 The U.S. House of Representatives passes Bill H.R. 6125 amending the Air Museum Act and authorizes the construction of a National Air and Space Museum in Washington, D.C., to replace the original National Air Museum. The new building is expected to take five years to complete and to cost $40 million. NASA release; Aviation Week, May 3, pp. 58-59.

Feb. 17 France launches its Diapason 1, D-1-A, instrumented scientific satellite from the Hammaguir Range in Algeria with a three-stage Diamant booster. The satellite is designed for a three-month lifetime and is to transmit data on Earth's magnetic fields as well as to check French tracking stations. This is France's second-launch of a French sat-

Past

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

ellite by the Diamant booster and the first all-French space launch. Washington Post, Feb.18, 1966, p. A13; Missiles and Rockets, Feb. 28, p. 9.

Feb. 22 The Soviet Union launches its Cosmos 110 satellite carrying two dogs, Veterok and Ugolyok, for biological studies. These studies include determining the effects of cosmic radiation on living organisms. Similar launches have been made by the USSR but this is the first with the Cosmos spacecraft. After almost 22 days in orbit around the Earth, the dogs are safely recovered. Flight International, March 3, 1966, p. 357; David Baker, Spaceflight and Rocketry, p. 192.

Feb. 26 NASA launches its unmanned and suborbital Apollo/Saturn AS-201 mission, using atwo-stage Saturn IB launch vehicle to qualify the heat shields of the Command Module and Service Module, as well as major spacecraft systems including the rocket's 200,000-pound thrust J-2 engine, the U.S.'s highest thrust liquid hydrogen/liquid oxygen rocket motor. The mission also tests the effectiveness of the CM's ablative heat shield to withstand a reentry heat of 4,000 degrees Fahrenheit after it reenters Earth's atmosphere. This is the first launch of the Saturn 1B, an uprated version of the Saturn I, and the Apollo spacecraft. The heat shield tests cannot be made on the ground. New York Times, Feb. 27, pp. A1, A6; Flight International, Feb. 17, p. 283; Aviation Week, Feb. 14, pp. 53-54, and March 14, pp. 92-93.

Feb. 28 ESSA 2, the Environmental Survey Satellite No. 2, also designated Tiros OT-2, the is launched by a Thor-Delta booster. The primary objective of the satellite is to provide direct readout to a worldwide network of receiving stations. Washington Evening Star, Feb. 28, 1966, p. A1.

75 Years Ago, February 1941

Feb. 10 RAF Bomber Command completes its first attack with its new Short Stirling strategic bomber. Three Stirlings hit oil storage tanks in Rotterdam, the Netherlands. It is the first four-engine bomber used by Bomber Command and the first of three types of British-designed four-engine bombers used during the war. The other two are the Handley-Page Halifax and the Avro Lancaster. The Stirling is hampered by its narrow, 30-meter wingspan, which limits its service ceiling. This was a near-sighted requirement to enable the aircraft to fit in existing hangars. Subsequent designs are not constrained by this requirement. C. H. Barnes, Shorts Aircraft Since 1900, pp. 379-380.

Feb. 10-11 Britain carries out its first paratrooper operation of the war, an assault on a viaduct at Tragino, Campagna, in southern Italy. The attack is unsuccessful and the small group of parachutists is captured. Armstrong-Whitworth Whitley 5 aircraft are used to convey the paratroopers. Interavia, Feb. 20, p. 11.

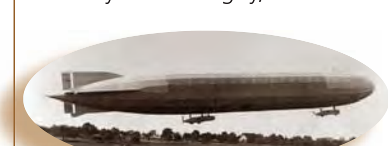
Feb. 25 Germany's Me 321 Gigant large-scale glider, designed for the airborne invasion of England, makes its first flight. The 55-meter wingspan glider, the largest in use with any air force in World War II, only sees service in small numbers and is never employed for the intended invasion of Britain. Later in the war, the airplane is also conceived as a means of airlifting V-2 rockets to scattered launch sites, but this plan is not carried out either. Messerschmitt Me 321 file, National Air and Space Museum.

100 Years Ago, February 1916

Feb. 9 In the U.S., Albert D. Smith sets an in-flight duration record of 8 hours and 42 minutes while flying his Martin floatplane. A. van Hoorebeeck, La Conquete de L'Air, p. 116.

Feb. 18 The Italian Air Force makes its first strategic strike against targets in Ljubljana, Slovenia, in the Austro-Hungarian Empire using a flight of Caproni bombers. David Baker, Flight and Flying: A Chronology, p. 83.

Feb. 21 The German dirigible LZ 77 is struck and brought down by anti-aircraft artillery near Revigny, France. A. van Hoorebeeck, La Conquete de L'Air, p. 116.



Feb. 21 Another Zeppelin is lost, this time near Namur, Belgium, when it is struck by a shell, forced down and destroyed. A. van Hoorebeeck, La Conquete de L'Air, p. 116.

Professor of Aerospace and Mechanical Engineering

The College of Engineering at Embry-Riddle Aeronautical University in Prescott, Arizona, invites applications for a tenure-track position in our Aerospace and Mechanical Engineering Department. This position start date is August 2016, at the Assistant or Associate Professor level. The department is particularly interested in interviewing candidates with proficiency in computer-aided design, aerospace propulsion, material science, advanced manufacturing, additive manufacturing, and machine design; however, candidates with expertise in other areas will be considered as well.

A successful candidate shall have a strong interest and ability in teaching undergraduate courses, teaching and monitoring undergraduate laboratory courses, and performing applied research. The ideal candidate shall be willing to collaborate with students on independent research and student organization projects. An earned doctorate in Aerospace or Mechanical Engineering along with related experience is highly desired; however, candidates with a Master's Degree and significant industry experience are strongly encouraged to apply.

A complete application package shall consist of a Curriculum Vitae with a cover letter, a statement describing the candidate's teaching philosophy, a statement describing the candidate's professional goals, contact information for at least three professional references, and the candidate's date of availability. All materials must be submitted in electronic form as a single file in portable document format (pdf) through careers.erau.edu (Vacancy Name: IRC62383). The full position description is available here. Queries may be submitted via email to Dr. Brad Wall at wallb@erau.edu.

AIAA Bulletin

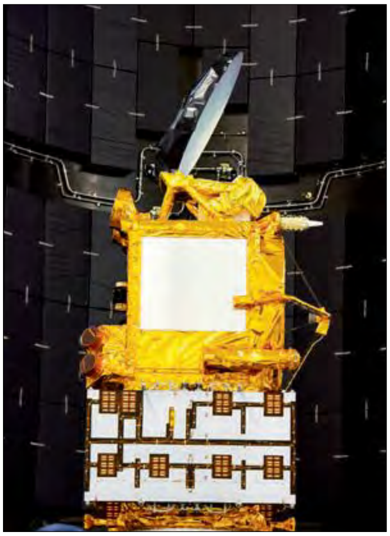


Image Credit: NASA

Credits: NASA/Bill Ingalls

On the left, the photograph shows the Jason-3 satellite in the SpaceX Payload Processing Facility at Vandenberg Air Force Base being prepared for encapsulation in its payload faring. The Jason-3 mission will continue U.S.–European satellite measurements of the topography of the ocean surface. It has the ability to monitor and precisely measure global sea surface heights, monitor the intensification of tropical cyclones, and support seasonal and coastal forecasts. Jason-3 data also will benefit fisheries management, marine industries and research into human impacts on the world's oceans. The mission is planned to last at least three years, with a goal of five years.

On the right, the SpaceX Falcon 9 rocket carrying the Jason-3 satellite launches from Vandenberg Air Force Base Space Launch Complex 4 East on 17 January 2016. Jason-3 will continue a 23-year record of monitoring global sea level rise.

FEBRUARY 2016

AIAA Directory

AIAA HEADQUARTERS
12700 Sunrise Valley Drive, Suite 200
Reston, VA 20191-5807
www.aiaa.org

To join AIAA; to submit address changes, member inquiries, or renewals; to request journal fulfillment; or to register for an AIAA conference.
Customer Service: 800/639-AIAA†

Other Important Numbers: ***Aerospace America*** / Greg Wilson, ext. **7596** • ***AIAA Bulletin*** / Christine Williams, ext. **7575** • **AIAA Foundation** / Karen Thomas, ext. **7520** • **Book Sales** / **800.682.AIAA** or **703.661.1595**, Dept. 415 • **Communications** / John Blacksten, ext. **7532** • **Continuing Education** / Megan Scheidt, ext. **7511** • **Corporate Members** / Tobey Jackson, ext. **7570** • **Editorial, Books and Journals** / Heather Brennan, ext. **7568** • **Exhibits and Sponsorship** / Tobey Jackson, ext. **7570** • **Honors and Awards** / Carol Stewart, ext. **7538** • **International Affairs** / Betty Guillie, ext. **7573**; Emily Springer, ext. **7533** • **Journal Subscriptions, Member** / **800.639.AIAA** • **Journal Subscriptions, Institutional / Online Archive Subscriptions** / Michele Dominiak, ext. **7531** • **Media Relations** / Duane Hyland, ext. **7558** • **Public Policy** / Steve Sidorek, ext. **7541** • **Section Activities** / Chris Jessee, ext. **7517** • **Standards, Domestic** / Hilary Woehrle, ext. **7546** • **Standards, International** / Nick Tongson, ext. **7515** • **Student Programs** / Rachel Dowdy, ext. **7577** • **Technical Committees** / Betty Guillie, ext. **7573**

† U.S. only. International callers should use 703/264-7500.

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

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

We are frequently asked how to submit articles about section events, member awards, and other special interest items in the *AIAA Bulletin*. Please contact the staff liaison listed above with Section, Committee, Honors and Awards, Event, or Education information. They will review and forward the information to the *AIAA Bulletin* Editor.

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2016			
Feb–Jun	**Introduction to Computational Fluid Dynamics**	Home study course	
Feb–Jun	**Advanced Computational Fluid Dynamics**	Home study course	
Feb–Jun	**Computational Fluid Turbulence**	Home study course	
Feb–Jun	**Spacecraft Design and Systems Engineering**	Home study course	
14–18 Feb†	**26th AAS/AIAA Space Flight Mechanics Meeting**	Napa, CA (Contact: Ryan Russell, 512.471.4190, ryan.russell@utexas.edu, www.space-flight.org/docs/2016_winter/2016_winter.html)	
5–12 Mar†	**2016 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, Erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
8–10 Mar	**AIAA DEFENSE 2016 (AIAA Defense and Security Forum)** **Featuring:** **AIAA Missile Sciences Conference** **AIAA National Forum on Weapon System Effectivenss** **AIAA Strategic and Tactical Missile Systems Conference**	Laurel, MD	**8 Oct 15**
16 Mar	**AIAA Congressional Visits Day**	Washington, DC	
5–6 Apr†	**51st 3AF Conference on Applied Aerodynamics: "Thermal Effects and Aerodynamic"**	Strasbourg, France (Contact: Anne Venables, secr.exec@aaaf.asso.fr; http://3af-aerodynamics2016.com)	
19–21 Apr†	**16th Integrated Communications and Surveillance (ICNS) Conference**	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, http://i-cns.org)	
16–20 May†	**SpaceOps 2016: 14th International Conference on Space Operations**	Daejeon, Korea	**30 Jul 15**
30 May–1 Jun†	**22nd AIAA/CEAS Aeroacoustics Conference**	Lyon, France	**9 Nov 15**
30 May–1 Jun†	**23rd Saint Petersburg International Conference on Integrated Navigation Systems**	Saint Petersburg, Russia (Contact: Ms. M. V. Grishina, +7 812 499 8181, icins@eprib.ru, www.elektropribor.spb.ru)	
13–17 Jun	**AIAA AVIATION 2016 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **34th AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **8th AIAA Atmospheric and Space Environments Conference** **16th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference** **46th AIAA Fluid Dynamics Conference** **17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **47th AIAA Plasmadynamics and Lasers Conference** **46th AIAA Thermophysics Conference**	Washington, DC	**5 Nov 15**
15 Jun	**Aerospace Spotlight Awards Gala**	Washington, DC	
16–17 Jun	**6th AIAA CFD Drag Prediction Workshop**	Washington, DC	
5–8 Jul†	**ICNPAA 2016 Mathematical Problems in Engineering, Aerospace and Sciences**	University of La Rochelle, France (Contact: Prof. Seenith Sivasundaram, 386.761.9829, seenithi@gmail.com, www.icnpaa.com)	
25–27 Jul	**AIAA Propulsion and Energy 2016 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **52nd AIAA/SAE/ASEE Joint Propulsion Conference** **14th International Energy Conversion Engineering Conference**	Salt Lake City, UT	**12 Jan 16**
5–7 Sept†	**Advanced Satellite Multimedia Systems Conference**	Palma de Mallorca, Spain (Contact: www.asmsconference.org)	

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

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.


Aerospace Spotlight Awards Gala
Wednesday, 15 June 2016
Ronald Reagan Building and International Trade Center
Celebrate!
AIAA members like Orville Wright and Charles A. Lindbergh have been celebrating outstanding accomplishments in aerospace since the first Honors Night Meeting held on the 34th anniversary of the Wright Brothers flight in 1937. We continue that worthy tradition this year at the 2016 Aerospace Spotlight Awards Gala on 15 June 2016.
Winner of the 1937 Reed Award, Eastman N. Jacobs said, "In honoring others, we honor ourselves." As a member of our aerospace community we hope that you will join fellow colleagues, constituents, and officials from the DoD, NASA, the FAA, and other government agencies for an evening of socializing and celebration.
We will be celebrating the recipients of the following awards:
• AIAA Foundation Award for Excellence
• Goddard Astronautics Award
• Reed Aeronautics Award
• International Cooperation Award
• Public Service Award
• Distinguished Service Award
• Daniel Guggenheim Medal
• 2016 AIAA Fellows and Honorary Fellows
Purchase tickets and tables online at www.aiaa.org/gala2016
AIAA
Shaping the Future of Aerospace
16-965

From the Corner Office

GOVERNANCE: A SEASON OF CHANGE

Jim Albaugh, AIAA President

AIAA is a storied organization having provided a forum for aerospace professionals and recognition of their accomplishments for over 50 years. AIAA was founded in 1963 with the merger of the American Rocket Society and the Institute of the Aerospace Sciences. Since that time the Institute's Constitution has remained essentially unchanged.

Conversely our world has changed tremendously since then. We are no longer dependent on face-to-face meetings to share information because online information technology facilitates instantaneous communication. The definition of aeronautics and astronautics has evolved as well. In the 1960s aerospace was very hardware driven; today it is digitally driven. In the 1960s the idea of unmanned vehicles was impractical; today they are a reality—and the future. Unfortunately our Constitution limits our ability to change with the times. While it made sense 50 years ago, it does not today. A simple example of that is our Constitution limits the scope of the communities or focus areas we can support.

We have a very strong Board supporting the Institute today. Over the last two years the Board has looked long and hard at how the governance of the Institute needs to evolve to support our mission as the premier Institute for promoting the arts and sciences of aeronautics and astronautics. Some of our findings were interesting. First, the Board determined that it is spending too much time managing the day-to-day activities of AIAA and not enough on the strategies required to stay relevant in the changing environment in which we live. Second, the Board identified many gaps between how it wants to operate as a governing body and organization versus how it actually is functioning.

To address these issues, in August 2014, the Board chartered a Governance Working Group to examine how we can continue to deliver to the membership what we do today but also become more strategic and responsive to the changing times. The working group's conclusions led them to recommend changes to the Constitution so that our governance structure could evolve. The Board believes that we must evolve in order to be more effective as an organization. However, the changes to the Constitution must be approved by a vote of the membership, so on the ballot during AIAA's 2016 election—beginning **21 March**—you will see a proposed new Constitution. The new Constitution contains much less detailed information on the structure of how AIAA is governed, allowing more flexibility and evolution in the future.

If the changes to the Constitution are approved by the membership a new governance system will be possible. In the proposed governance system, much of the current Board of Directors, renamed the Council of Directors, will continue to operate as they do today—working to support the day-to-day needs of the membership through the committees and sections. A separate group, called the Board of Trustees, will work exclusively on guiding the Institute strategically.

Other important changes will also be possible once the Constitution has been modernized and updated. Currently, some existing communities, such as the Corporate Member Committee and the Young Professional (YP) Committee, have no member representation at the Director level. (The YPs do have a liaison to the Board but in a nonvoting capacity.) The changes will ensure appropriate member representation in leadership as the organization evolves.

In addition, another proposed change facilitates the creation of new groups of member-driven committees under the Focused Interest Activities Committee (FIAC). The FIAC would run parallel to the Regional and Section Activities Committee and the Technical Activities Committee and provide a home for those communities that are not geographically based (sections) and not technically based. In the past such communities have been labeled "technical" because they have had no other home. An example would be the History "TC" or the Economic "TC" or the Management "TC." Best of all, the FIAC eventually would house new groups growing out of the changing face of aerospace that address cross-discipline and multidisciplinary topics that might not be purely technical. These communities would have the ability to elect Directors in order to have a voice on the Council of Directors.

In short the proposed changes enable more engagement and more representation by members in the organization while still maintaining the important aspects of how we currently operate.

The upcoming Constitution vote is important! You will be receiving more information about the proposed Constitution changes in the election materials. Also a governance website has been established at **http://aiaa.org/governance**. It can be reached from the AIAA home page. On the governance website you will find in-depth information on not only the Constitution changes but also the current status of the Governance Working Group and Board discussions. Please visit the governance website, and if you still have questions you can submit them on that site and we will answer them.

NEW AIAA CORPORATE MEMBERS

AIAA welcomed six new AIAA Corporate Members in January.

- **Aerion Technologies**, Palo Alto, CA
- **COMAC America**, Newport Beach, CA
- **FADEA SA**, Cordoba, Argentina
- **Los Alamos Technical Associates (LATA)**, Albuquerque, NM
- **Tecplot**, Bellevue, WA
- **UAE Space Agency**, Abu Dhabi, United Arab Emirates

To learn more about AIAA's Corporate Membership Program, visit **www.aiaa.org/Corporatemembership**.

Register for Congressional Visits Day

Make a difference in the future of aerospace at AIAA Congressional Visits Day (CVD; **http://www.aiaa.org/CVD**) on 16 March 2016. This event brings together passionate aerospace professionals and students in Washington, D.C., for a day of advocacy and awareness with lawmakers. Join us and let your voice be heard by your state's congressional delegation and staff on key policy issues that matter most. To register, go to **http://www.aiaa.org/CVD2016**.

AIAA 2016 KEY ISSUES

Aerospace & Defense Budget Funding and Procurement

Background: The aerospace and defense (A&D) industry is the nation's largest manufacturing exporter. A&D exports of $118.9 provided the economy with a favorable balance of trade of $61.2 billion in 2014. Sales in 2014 totaled $228.4 billion — up from $219.4 billion in 2013. Continued stability of the A&D industrial base is critical to our economy, national security, infrastructure, and future workforce. As the world's largest aerospace professional society, serving a diverse range of more than 30,000 individual members from 88 countries, and 95 corporate members, the American Institute of Aeronautics and Astronautics (AIAA) urges Congress to enact and sustain policies that will strengthen the long-term viability of the A&D industrial base.

Issue: Funding Instability. The A&D industry is facing one of its greatest challenges in history as Congress and the administration deal with mounting national debt and balancing the federal budget. All federal agencies face significant budget reductions, with the Department of Defense (DoD) potentially bearing the biggest burden. While all areas must be examined to identify unnecessary spending that can be reduced or eliminated, we must ensure that the nation's future is not mortgaged to address today's crises.

The Bipartisan Budget Act of 2015 provides two years of relief from sequestration cuts — increasing the discretionary spending caps set by the 2011 Budget Control Act by $50 billion for Fiscal Year 2016 and by $30 billion for Fiscal Year 2017. Under the budget plan, Fiscal Year 2016 defense spending would be raised to $607 billion. While this is a step forward toward stability, it is $5 billion less than the top-line figure that authorizers budgeted before the deal. Additionally, it does not address a recurring cause of damage to the A&D industrial base — the uncertainty and instability caused by funding the government for portions of the year on continuing resolutions.

The A&D industrial base possesses unique capabilities and expertise to address the distinctive and diverse missions required by its civilian and military customers. Operating on continuing resolutions prevents companies from adequate resource planning, strategic decision making, and providing sound guidance to investors. This additional uncertainty acts as a "speed brake" on the economy and employment, discouraging companies from ramping up hiring for new programs and creating a dangerous climate of risk aversion. This uncertainty is particularly harmful to the many small businesses providing technological innovation and A&D-unique components and subsystems that depend upon year-to-year contracts to sustain an already fragile industrial base — potentially resulting in single-source suppliers or elimination of domestic suppliers for items on critical development paths. If our supplier base is allowed to erode, the United States could risk losing its technological edge and be unable to address future threats to our national security or economic stability.

For far too long Congress has operated under continuing resolutions without a normal appropriations process. A return to a regular appropriations process is needed immediately so that the nation, including the A&D industrial base, can begin work on initiatives critical to a robust and secure future.

Issue: Reauthorize FAA. The six-month extension of the FAA Modernization and Reform Act (Act) will expire on 31 March 2016. The bill's expiration threatens several projects vital to our nation's future as an aerospace leader: placing unmanned aerial vehicles in the national airspace, meeting the growing demands for expanded commercial air travel, and developing the Next Generation Air Traffic Control System (NextGen).

Issue: Funding for the FAA Office of Commercial Space Transportation. The level of activity for commercial space operators has grown significantly in recent years. Examples include the commercial cargo and commercial crew programs in support of the International Space Station, the emergence of several space tourism companies, the increase in the number of licensed spaceports, and the efforts by a number of firms to develop dedicated smallsat launchers. To ensure that this growth can continue, and that public safety will be protected, it is vitally important that the FAA Office of Commercial Space Transportation has the resources that it needs to keep pace with industry's progress.

Issue: Reauthorize NASA. Since last authorized in 2010, NASA continues to prove why the United States is the world's leader in aerospace innovation. NASA's Mars Science Laboratory Curiosity rover, Kepler mission, and New Horizons probe have shown us a chemically-active Mars, hundreds of new worlds, and a Pluto more strange and majestic than we imagined. Commercial companies are revolutionizing space technology, including the first 3D printer on-orbit, and sustaining cargo resupply missions to the International Space Station (ISS). The ISS National Laboratory hosts a growing community of Fortune 500 companies conducting microgravity research. In December 2014, the Orion spacecraft completed its first successful test, orbiting the Earth twice. The Space Launch System (SLS) and the Orion are the next-generation human transportation systems that will explore farther into the solar system than ever before. SLS flight hardware is in production, engines and boosters are in testing, and the program is on schedule for its inaugural launch in 2018. In the skies closer to us, NASA tested cleaner aircraft fuels, developed new software for optimizing air traffic, and demonstrated new wing surfaces that can change shape in the air.

While AIAA commends the increased funding levels for NASA in the Consolidated Appropriations Act of 2016, we call on Congress to ensure that it continues to provide adequate funding and authorization going forward, which will make long-term planning and mission execution more predictable and successful. AIAA reminds Congress that uncertainty or instability of future funding, or delayed authorization of NASA, will place our industrial base and workforce at risk. Consequently, the federal government should authorize, appropriate, and manage NASA programs for long-term viability and sustainability.

AIAA Recommendations

- Appropriate 2017 Defense funding within the caps established by the Bipartisan Budget Act of 2015 no later than 30 September 2016.
- Employ sound budgetary principles for the long-term development and manufacturing of complex aerospace systems and architecture necessary to accomplish strategic national goals.
- Provide long-term reauthorization with adequate funding for the FAA in order to meet program requirements. This is also instrumental in providing certainty and stability for the aviation marketplace and workforce. Reauthorization should include adequate funding to successfully implement NextGen, commercial space transportation operations, safely integrate UAS into the NAS, and complete priority FAA modernization initiatives.
- Provide adequate funding and ample resources for the FAA Office of Commercial Space Transportation in order to keep pace with the continued progress of the commercial space industry.
- Provide long-term reauthorization with adequate funding for NASA in order to meet program requirements and maintain our nation's leadership in space exploration, research, and technology.

Aerospace & Defense Competitiveness and Security

Background: The aerospace and defense (A&D) industry is the nation's largest manufacturing exporter. Technology drives over half of the U.S. Gross Domestic Product. To keep our technology edge, we must continue to invest in research and development in an effort to compete with the growing investment by other nations. Stability and protection of the A&D industrial base is also critical to our economy, national security, infrastructure, and future workforce. As the world's largest aerospace professional society, serving a diverse range of more than 30,000 individual members from 88 countries, and 95 corporate members, the American Institute of Aeronautics and Astronautics (AIAA) urges Congress to enact and sustain policies that will strengthen the long-term viability of the A&D industrial base.

Issue: FAA Modernization and Reform Act. The six-month extension of the FAA Modernization and Reform Act (Act) will expire on 31 March 2016. AIAA strongly recommends that Congress reauthorize the full Act for a similar four-year period or longer.

Elements of the FAA Modernization and Reform Act will be necessary to create a more nimble and responsive FAA that is better able to work with the A&D industry and leverage the public/private relationships in aircraft certification as new platforms are brought to market. This Act encompasses many provisions to upgrade and reform the certification process and regulatory system for the aerospace industry, such as the Organizational Designation Authorization (ODA). ODA should be fully utilized to manage time and employee technical resources most effectively while maintaining the global standard of FAA safety. This can be achieved by maximizing autonomy for the ODA and creating a built-in continuous process improvement with metrics and guidelines for both the FAA and industry. Ensuring the proper functionality of the ODA would enable a cost-efficient, transparent, and timely certification process. This would result in substantially increasing in-service aircraft supported by the domestic workforce, thus contributing to the U.S. economy through prime contractors, suppliers, customers, maintenance services, etc.

The Act also targets the complete implementation of the Next Generation Air Traffic Control System (NextGen), which is essential to our national security, safety, and competitiveness. Overall, air traffic is ever-increasing with simultaneous activity of more and more commercial, business, general, and unmanned aircraft in the National Airspace System (NAS). Management systems need to be modernized to minimize pilot and air traffic controller workload and error. Reauthorizing this Act would provide funding to complete testing and installation for NextGen and thus establish a modern air traffic management system with the capability to expand and accommodate the growing U.S. traveling public.

Issue: Integration of UAS into NAS. The Association for Unmanned Vehicle Systems International's 2013 report on "The Economic Impact of Unmanned Aircraft Systems Integration in the United States" forecasts that the unmanned aerial systems (UAS) industry will create more than 100,000 jobs providing an economic impact of $82 billion over the next decade. Sections 331 – 336 of the FAA Modernization and Reform Act focus on the safe and appropriate integration of UAS into the NAS, which is arguably the most immediate regulatory need of the U.S. aerospace industry. AIAA recognizes the progress of the FAA to initiate a streamlined process for public UAS operators to comply with regulations and operate safely within the NAS

Issue: Space Traffic Management. Given the continuing proliferation of cubesats and the continued growth in orbital debris, the risk of collisions in space is becoming greater by the day. Such collisions not only endanger our astronauts, they also put all of our current assets in space at risk, including those for national security or scientific purposes, or for communications, navigation, or weather forecasting. The Department of Defense, through the Joint Space Operations Center (JSpOC), provides space situational awareness and conjunction analysis as a byproduct of its mission to protect national security assets in space. Currently, however, almost all of these analyses do not involve military spacecraft. The U.S. government must take appropriate action in the current fiscal environment to identify the lead authority for Space Traffic Management and Congress should authorize adequate resources for its implementation.

Issue: Export-Import Bank Board Appointments. While AIAA applauds the reauthorization of the Ex-Im Bank, constraints to the bank fulfilling its role and delivering benefits to the A&D sector and U.S. economy still exist. The bank reopens with three vacant seats on its five-member board resulting in the lack of a working quorum. Consequently, the bank can only approve small export deals. Any export transactions over $10 million—essentially large orders of aircraft and satellites—cannot be approved. This continues to place U.S. aerospace companies at a competitive disadvantage in the global market. AIAA calls on the U.S. Senate to confirm the President's three appointments to the Ex-Im Board as quickly as possible to ensure that all U.S. aerospace manufacturers can be considered for new, large export orders.

AIAA Recommendations

- Provide long-term reauthorization with adequate funding for the FAA in order to meet program requirements. This is also instrumental in providing certainty and stability for the aviation marketplace and workforce. Reauthorization should include adequate funding to successfully implement NextGen, commercial space transportation operations, safely integrate UAS into the NAS, and complete priority FAA modernization initiatives.
- Prioritize FAA Modernization and Reform initiatives to expedite streamlining of the FAA certification process and incorporate continuous improvement processes.
- Take appropriate action in the current fiscal environment to identify the lead authority for Space Traffic Management and Congress should authorize adequate resources for its implementation.
- Quickly confirm the President's three appointments to the Ex-Im Bank Board so U.S. aerospace companies can remain competitive in the global market.

Aerospace & Defense Workface Enhancement

Background: As the world's largest aerospace professional society, serving a diverse range of more than 30,000 individual members from 88 countries, and 95 corporate members, the American Institute of Aeronautics and Astronautics (AIAA) urges Congress to enact and sustain policies that will enhance a robust, technologically-proficient aerospace and defense (A&D) sector that is essential to our continued national competitiveness and security.

The adequacy and size of the U.S. science, technology, engineering and mathematics (STEM) workforce is an ongoing concern for the A&D industry. Scientists and engineers are essential to U.S innovation and economic growth. It is also critical to note that many middle skilled jobs, such as those in advanced manufacturing, require an ever-increasing array of STEM skills. To that end, the Government Accountability Office has reported that the number of STEM degrees awarded grew 55 percent from 1.35 million in the 2002–2003 academic year to over 2 million in the 2011–2012 academic year. AIAA commends the programs that previously have been put in place by Congress, and hopes to see these continually enhanced.

Since 1997, *Aviation Week & Space Technology* has published a Workforce Initiative Report annually. Last year's report highlighted that the A&D workforce continues to shrink at approximately 2 percent per year. It also highlighted a paradox in the predictions of massive A&D retirements by the baby boomer generation. The baby boomers are far from leading voluntary attrition; rather, those employees with 0 to 5 years of experience, i.e., young professionals, are leading voluntary attrition with 14 percent leaving the industry entirely. Maintaining the young professional A&D talent will be an ever-increasing challenge with the competition of modern technology firms. AIAA encourages Congress to promote policies that will provide a growth-sustaining path for the A&D industry workforce pipeline.

Issue: Workforce Preparation. AIAA applauds the work of the 114th Congress in passing landmark legislation that includes provisions enhancing the pipeline of STEM-educated workers into the U.S. economy. This legislation, the Every Student Succeeds Act, will help strengthen the pipeline of students with globally competitive 21st-century skills, including STEM skills, coming out of our nation's K–12 schools. However, AIAA strongly believes that the work is not complete and the 114th Congress should consider further legislation to bolster the STEM pipeline.

The NSF Graduate Research Fellowship, the oldest STEM program available to graduate students, should be enhanced to provide additional funding to graduate students in STEM fields today. In addition, without adequate funding and appropriations for the NASA budget, their well-known student programs (e.g., research grants, internships, etc.) will be limited and at further risk.

Congress should continue to encourage, support, and recognize industry's efforts and participation in the promotion of a STEM workforce and STEM education. Such efforts could include internships, co-op programs, apprenticeships, job shadowing, teacher exchange programs, etc., that expose students, teachers, and those transitioning into A&D careers to the challenges, rewards, and benefits of a STEM education and career. Congress should also periodically evaluate the success of current industry STEM programs through GAO studies, hearings, committee testimony, or other mechanisms and determine if other methods should be promoted.

Issue: Maintaining and Retaining a Skilled Workforce. In addition to implementing programs that help to inspire qualified individuals to enter and stay in the STEM workforce, industry, government, and academia must do a better job of sharing information and facilitating exchange with one another. Such efforts will go a long way to developing and preserving critical skills in the workforce. Federal incentives and/or grants should be more readily available to support industry, government, and academia partnerships that tailor training for high-level skills and provide R&D collaborations, e.g., Centers of Excellence. Some areas for these skills and collaborations could be: advanced manufacturing; information technology (IT); control systems; and autonomy. These opportunities would more actively engage young professionals and new STEM graduates in trending career paths as a function of the cutting-edge potential of the A&D industry.

Furthermore, there are excellent congressional efforts to transition qualified military veterans to civilian A&D careers, yet more emphasis could be placed on incentivizing industry's direct involvement in creating a process to categorize military skill sets. This process would provide a quicker and more seamless transition for veterans to enter the A&D industry at the proper career level.

The Department of Defense (DoD) has programs for the temporary exchange of DoD and private sector employees who work in the field of information technology in the Information Technology Exchange Program. This type of model should be expanded to include intergovernmental agreements throughout the A&D sector that includes exchange between industry, government, and academia alike. Congress should play a key role in encouraging the administration to develop a program that conducts this exchange. Mechanisms should be put in place to encourage industry to continue training and development activities with the current workforce.

Issue: Integrating New Knowledge into the Workforce. With many new, exciting fields emerging in A&D engineering, Congress must continue to work to develop programs that will help integrate these fields into the knowledge base and competency of the existing workforce. For example, advances in technology have increased workforce reliance on computational tools. This potentially adds risk to the research and design process unless a proper balance is encouraged to complete adequate end demonstrations of the technology through simulations, ground tests, and flight tests. Developing and sustaining the skills necessary to strike this balance is important to long-term U.S. preeminence in aviation, and teaching these skills in STEM mentoring programs ensures retention of hard-won lessons.

Issue: Foreign Professionals in STEM Fields. While bolstering the U.S. base of STEM workers, Congress should also renew its interest in facilitating the immigration of foreign professional workers in STEM fields. Efforts in the 112th and 113th Congress to pass legislation that would provide expedited immigration avenues to foreign workers in STEM fields failed, and it is AIAA's belief that these efforts should be revived in the 114th Congress, albeit with a sensitivity to the high-security level our country is experiencing. Legislation like the I-Squared Act of 2015, which would raise H-1B visa caps and exempt those who hold advanced STEM degrees from counting against the caps, represents a common sense approach to high skilled immigration. Highly skilled, foreign-born workers who have been educated at U.S. colleges and universities in STEM fields are engines of entrepreneurship and economic growth. Keeping more of these foreign-born STEM graduates in the United States is vital to ensuring economic prosperity throughout the A&D sector and enhancing that sector's contributions to U.S. competitiveness. If those graduates are able to remain in the United States, it alleviates the likelihood that they will establish a business that will compete with U.S. interests in their home countries or elsewhere. An international A&D workforce is also reflective of an industry that operates globally.

AIAA Recommendations

- Continue to pass legislation that enhances the pipeline of STEM-educated workers into the U.S. economy.
- Enhance NSF Graduate Research Fellowship funding.
- Appropriate funding for NASA through reauthorization to provide financial stability for research grants and/or fellowships.
- Provide tax incentives for industry to participate in STEM programs and training and development programs for the incoming, existing, and transitioning workforce, e.g., internships, apprenticeships, and tailored courses.
- Pass STEM visa legislation similar to that considered in the 112th Congress to encourage the retention of foreign professional STEM workers in U.S. industry.
- Direct more exchange between government, industry, and academia in the A&D sector via inter-government personnel agreements, and provide incentives for stakeholders to participate in these activities.
- Develop programs that enable integration of emerging A&D fields into the knowledge base and competency of the existing workforce, including the skills necessary to complete end demonstrations of new technologies.

AIAA ANNOUNCES ITS CLASS OF 2016 FELLOWS AND HONORARY FELLOWS

AIAA has selected its Class of 2016 AIAA Fellows and Honorary Fellows. The induction ceremony for the new Fellows and Honorary Fellows will take place at the AIAA Aerospace Spotlight Awards Gala on 15 June at the Ronald Reagan Building and International Trade Center in Washington, DC.

"AIAA Honorary Fellows and Fellows represent the best of the aerospace community," said AIAA President Jim Albaugh. "These individuals have advanced the state of the art of aerospace science and technology, making unique contributions to the profession. AIAA congratulates the members of the 2016 Class of Fellows and Honorary Fellows on their selection."

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

Dennis Bushnell, NASA Langley Research Center
Mark Lewis, Institute for Defense Analyses
John Tracy, The Boeing Company

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

Richard Ambrose, Lockheed Martin Corporation
Brian Argrow, University of Colorado Boulder
Daniel Baker, University of Colorado Boulder
Kyung Choi, The University of Iowa
John-Paul Clarke, Georgia Institute of Technology
Steve Cook, Dynetics, Inc.
James Crocker, Lockheed Martin Corporation
Mary Cummings, Duke University
Russell Cummings, U.S. Air Force Academy
Jean-Jacques Dordain, European Space Agency (retired)
James Gord, U.S. Air Force Research Laboratory
Je-Chin Han, Texas A&M University
Jonathan How, Massachusetts Institute of Technology
C. Russell Joyner, Aerojet Rocketdyne
Konstantinos Kontis, University of Glasgow
Ping Lu, Iowa State University
Walter O'Brien, Virginia Polytechnic Institute and State University
T. Kent Pugmire, Standex Engineering Technology
Ganesh Raman, Illinois Institute of Technology
Ajit Roy, U.S. Air Force Research Laboratory
Brian Smith, Lockheed Martin Corporation
Marilyn Smith, Georgia Institute of Technology
Robert Strain, Ball Aerospace
Mark Whorton, Teledyne Brown Engineering

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 on AIAA's Honors Program, or the AIAA Honorary Fellows or Fellows Program, please contact Patricia A. Carr at 703.264.7523 or triciac@aiaa.org.

CELEBRATE 20 YEARS WITH A $20 DONATION

The AIAA Foundation is excited to be celebrating our 20th anniversary with a fundraising campaign to engage your support. With the goal of 10,000 members each donating $20, the AIAA Foundation hopes to raise $200,000.

Your generous support of the AIAA Foundation will significantly enhance our educational programming and provide the funding necessary to support our K–12 STEM programs, including classroom grants and hands-on activities, university design competitions, student conferences, and recognition awards.

The AIAA Foundation has already accelerated the future of aerospace by:

- Funding more than 1,200 K–12 Classroom Grants, impacting over 120,000 precollege students
- Awarding aerospace scholarships to more than 1,300 undergraduate and graduate students
- Supporting more than 400 student conferences, engaging more than 13,000 students with practical, hands-on STEM-based projects
- Sponsoring design competitions that have generated more than 1,200 teams, engaging more than 14,000 students
- Inspiring more than 200 student branches, 8,000 student members, and 4,000 Educator Associates with resources to further their career path

With your support of this campaign, the impact to our programming will be significant. Please consider making a $20 tax-deductible donation — $20 for the 20 years of leadership and resources that the AIAA Foundation has provided.

AIAA strongly believes in the importance of our educational programs and will match individual and corporate donations up to $1 million dollars (of unrestricted funds).

To learn more and to donate, please visit **www.aiaafoundation.org**.

Call for Papers for the 2016 International Powered Lift Conference

The International Powered Lift Conference (IPLC) focuses on the latest developments in Vertical and/or Short Take-Off and Landing (V/STOL) aircraft research, concepts, and programs. The IPLC, which was first held 25 years ago, is a joint AIAA-AHS-SAE-RAeS technical meeting. SAE is the host organization this year, and the IPLC will be held in conjunction with the SAE 2016 Aerospace Systems and Technology Conference on 27–29 September 2016 in Hartford, CT. IPLC 2016 will bring together engineers, technologists, and managers to discuss the latest developments in V/STOL, and will focus on three primary thrusts: Advanced Rotorcraft, Jet-Lift Concepts and Technologies, and recent progress in Electric Propulsion Applications to V/STOL.

The deadline for submitting paper offers is **26 February 2016**; Review Ready Manuscripts are due to session organizers by **5 April 2016**; and Final Manuscripts and copyright assignments are due to SAE by **19 July 2016**. The full Call for Papers and relevant information can be found on the SAE website at **http://www.sae.org/events/astc/**.

The Third Annual Joint Workshop on Transformative Vertical Flight Concepts: Enabling New Flight Concepts through Novel Propulsion and Energy Architectures will be held in conjunction with IPLC/ASTC on 29–30 September.

JEFFRIES AEROSPACE MEDICINE AND LIFE SCIENCES RESEARCH AWARD PRESENTED

Hubert “Vic” Vykukal (left), recipient of the 2015 AIAA Jeffries Aerospace Medicine and Life Sciences Research Award, with Brian Pomeroy, Chair of the AIAA Sacramento Section (right). The award recognized Vykukal for outstanding, long-term contributions to human space exploration through the development of advanced space suits and protective systems technologies.

STEM ENGAGEMENT EXPERIENTIAL LEARNING PROGRAM FOR HIGH SCHOOL SCIENCE FAIR STUDENT WINNERS

A Collaboration Between AIAA National Capital Section and NASA Goddard Space Flight Center Education Office

Dr. Supriya Banerjee, AIAA Foundation K–12 STEM Outreach Committee and AIAA National Capital Section and Dr. Natalia Sizov, AIAA National Capital Section

In 2014, the AIAA National Capital Section (NCS) led an effort to collaborate with the NASA Goddard Space Flight Center (GSFC) Education Office to develop a new STEM Engagement Experiential Learning Program for area science fair student winners. The program includes a three-day, hands-on, experiential learning visit to NASA Goddard Space Flight Center during the summer. This collaborative effort was developed to provide broad STEM exposure to the local students, beyond their classroom experience, and inspire future scientists and engineers.

The program included access to the GSFC's various facilities and laboratories, such as the 3D printing center (top), mock Mission Lifecycle planning through active participation in critical phases (bottom left), visit to Wallops Flight Facility, and also included discussions with GSFC Center Director Chris Scolese (bottom right), Nobel Laureate Dr. John Mather and Astronaut Paul Richards. The students found the program to be educational and inspirational and conveyed their appreciation to NCS.

Program Details

- Science Fair judging: The AIAA NCS judges students with aerospace-related projects at eight DC-area regional science fairs: Northern Virginia Regional Science and Engineering Fair, Loudoun County, Fairfax County, Prince William-Manassas Regional Science Fair, Prince George's Area Science Fair, Montgomery County, Charles County, and the Washington, DC STEM Fair.
- Selection: The 1st, 2nd and 3rd place student winners are selected at the regional science fairs.
- Number of students: A total of 26 students were selected to participate in the program.
- Length of the program: Three days
- Location of the program: NASA GSFC
- Program development: By NASA GSFC Education Office
- Cost: The NCS pays for the student lunches and for the students' bus trips between NASA GSFC and Wallops Flight Facility.

Student feedback from **Anusha Dixit, Poolesville High School, Maryland**: During the three-day internship experience, the other winning students and I were given a tour of GSFC's facility in which we learned a great deal about the recent missions undertaken by NASA, including MMS. It was structured to mirror that of a real mission, which I thought was a concise way to sum up NASA's work in three days. On the first day we got to look at the structural aspects of missions, and visited the material engineering room, which was reminiscent of the R&E room in my own school on a grander scale. Being able to see where the various aspects of spacecrafts are actually constructed up close was extremely inspiring, especially to imagine the groundbreaking work that took place there. On the second day of the experience, we visited the Wallops Flight Facility in Virginia. We were shown several aspects of the launch process, including visiting a hangar and a robotics facility where current technologies that will be used in space are developed such as robotic arms. It was one thing to be told about such facilities in situations such as the classroom, and quite another to be able to see them in action, and be able to speak to an actual pilot about his experiences. On the third day, we were able to experience a mission in all its different parts, ranging from communication to power to attitude control. This aspect of the experience was of most interest to me, as it was interactive as well as informative and educational about each specific area without sounding like a lecture. By spending time with each expert, I was able to learn about the actual calculations that take place in order to ensure the success of a mission, which is more than I could probably ever learn in the classroom.

The NCS thanks NASA GSFC Education Office and the GSFC employees who made this program possible for the students. For questions related to NASA GSFC Education Office, please contact Dr. Robert Gabrys, Director, Email: robert.e.gabrys@nasa.gov.

DR. JOSEPH POWERS APPOINTED AS NEW EDITOR-IN-CHIEF OF THE *JOURNAL OF PROPULSION AND POWER*

On 7 January 2016, AIAA President James Albaugh formally appointed **Dr. Joseph Powers** as Editor-in-Chief of the *Journal of Propulsion and Power* (*JPP*).

Dr. Powers currently serves as Professor and Associate Chair of the Department of Aerospace and Mechanical Engineering, with a concurrent appointment to the Department of Applied and Computational Mathematics and Statistics at the University of Notre Dame. He has been at Notre Dame since 1989, and his professional duties include research program development in theoretical combustion, leading a research team in the Center for Shock Wave-processing of Advanced Reactive Materials, teaching undergraduate and graduate courses, and various department, college, and university service work, including supervision of undergraduate programs in Aerospace and Mechanical Engineering. He is known as an outstanding educator and a rigorous and thoughtful scholar who treats others with fairness and respect.

Dr. Powers has significant experience as an author and a reviewer, and has provided exemplary service as an Associate Editor for *JPP* since 2003. His dedication and willingness to work with authors have assured the highest quality of scholarship in the journal, and he will enthusiastically build on the success of his predecessors. An Associate Fellow of AIAA, Dr. Powers is the recipient of the AIAA Distinguished Service Award from the AIAA Propellants and Combustion Technical Committee. He is a member of the Committee on Standards in Computational Fluid Dynamics and has served as a conference organizer and session chair for various AIAA conferences. He is a member of the International Colloquium on Dynamics of Explosions and Reactive Systems, the Combustion Institute, the Society of Industrial and Applied Mathematics, and the American Physical Society. Dr. Powers holds B.S., M.S., and Ph.D. degrees from the University of Illinois at Urbana-Champaign.

Dr. Powers was selected from a competitive pool of applicants, and becomes the fourth editor-in-chief of the journal. Established in 1986 with the support of AIAA's propulsion-related technical committees, *JPP* had its roots in the American Rocket Society's journal, *Jet Propulsion*, and provided a broader venue for papers than the *Journal of Energy*, which ceased publication in 1983. Powers succeeds Douglas Talley of the Air Force Research Laboratory, who served as editor-in-chief of *JPP* from 2010 to 2015.

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

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

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

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

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

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

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

CALL FOR NOMINATIONS

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** unless otherwise indicated.

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

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

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

Nomination Deadline 1 June 2016

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

Nomination Deadline 1 July 2016

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

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

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

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

Children's Literature Award 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 of the late Admiral Luis de Florez and is presented for an outstanding individual achievement in the application of flight simulation to aerospace training, research, and development.

Excellence in Aerospace Standardization Award recognizes contributions by individuals who 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 Awardis 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 **31 December** of the year preceding the presentation.

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

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. The emphasis should be upon the high quality or major influence of the piece rather than, for example, the importance of the underlying technological contribution. The award is an incentive for aerospace professionals to write eloquently and persuasively about their field and should encompass editorials as well as papers or books.

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

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

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

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

OBITUARY

Associate Fellow Vice Died In November

U.S. Air Force Major (ret.) John M. Vice passed away on 12 November 2015.

Vice graduated with honors from the University of Wyoming with a B.S. in aeronautical engineering, and earned his M.S. in aerospace engineering from the Air Force Institute of Technology. After retiring from the Air Force, he was a founding partner of Skyward Limited in Dayton, OH. His long career in aircraft survivability was recognized by AIAA with the Survivability Award in 2014 (For leadership and technical contributions instrumental in enhancing aircraft survivability through test and evaluation, combat data collection, and aircraft battle damage assessment and repair), and his work continues to contribute to the safety of our country. Vice was a member of the AIAA Survivability Technical Committee from 1989 to 1996.

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

Upcoming AIAA Continuing Education Courses

AIAA Home Study Courses
https://www.aiaa.org/homestudy

Home study courses let you work at your own pace while still providing interface with the instructor. Students receive instructions for completing the course, along with a course notebook, problem sets, and accompanying texts. Over five months, they follow a proven curriculum of reading and homework assignments, and forward completed homework assignments to the instructor for review and comment via mail, email, or fax. The instructor will also answer questions by email or phone. The time required varies depending on the course and the student's prior knowledge, but in general, amounts to about 20 hours of work per month. Course completion certificates are awarded upon satisfactory completion of all homework assignments. These are self-paced courses.

1 February–30 June 2016

Introduction to Computational Fluid Dynamics (Instructor: Klaus A. Hoffmann)
This introductory course is the first in 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. You can use the computer programs to develop your own code, or you may modify the existing code for assigned applications.

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 A. Hoffmann)
This advanced course is the second in 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. You can use the computer programs to develop your own code, or you may modify the existing code for assigned applications.

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 A. Hoffmann)
This advanced course is the third in the three-part series 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. You can use the computer programs to develop your own code, or you may modify the existing code for assigned applications.

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

Spacecraft Design and Systems Engineering (Instructor: Don Edberg)
This course presents an overview of factors that affect spacecraft design and operation. It begins with a historical review of unmanned and manned spacecraft, including current designs and future concepts. All the design drivers, including launch and on-orbit environments and their effect on the spacecraft design, are covered. Orbital mechanics is presented in a manner that provides an easy understanding of underlying principles as well as applications, such as maneuvering, transfers, rendezvous, atmospheric entry, and interplanetary transfers.

Key Topics
- History
- Design drivers
- Orbital mechanics and trajectories
- Systems engineering
- Design considerations
- Mass, power, and cost estimation