June 2014

AEROSPACE AMERICA

A wildfire's newest enemies

Commercial airtankers take shape with no time to waste

page 28

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AEROSPACE AMERICA

June 2014

DEPARTMENTS

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BULLETIN

ON THE COVER

A DC-10 operated by 10 Tanker Air Carrier drops retardant in Greer, Ariz. (U.S. Forest Service photo)

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Editor's Notebook

A conversation worth having

The state of U.S. firefighting aircraft always shocks me this time of year. Wildfires destroy property and regularly kill Americans, including 19 Hotshots in the 2013 Yarnell Hill, Arizona, blaze. Yet, last June, the very same month of the Yarnell fire, the U.S. awarded a mere $158 million in contracts to convert former airliners and military planes into airtankers. I say mere, because the total expenditure on those aircraft would buy you a single state-of-the-art fighter plane.

As powerful as private aircraft like the 10 Tanker DC-10 and Coulson's C-130Q are proving to be, they are not the product of a long-term, strategic plan for combating wildfires, which are an inanimate foe that kills Americans as surely as terrorists threaten to do. The nation's aerial firefighting capabilities are better than in 2002, when two airtankers failed in midflight, killing their crews, but that doesn't mean the country has done enough.

Why not make these refurbished planes supplements to new airtankers that would be built from green airframes, similar to the way the Navy's P-8A Poseidon maritime surveillance planes are derived from the Boeing 737-800?

I might have thought I was alone in wondering this, but then the letter on the facing page landed in my email. It comes from an AIAA member who lives in San Diego, one of a growing list of ground zeros in what's becoming the decade of the wildfire. The writer hopes to start a dialogue about the merits of building new firefighting planes that would be embedded in an overall firefighting strategy.

It's a crazy idea in these budget times, right? Maybe not. It's worth remembering that the U.S. still spends $40 billion a year on Homeland Security, $70 billion on the intelligence community, and $600 billion on national defense. The debate and dialogue over how to allocate that funding should be ongoing and it should be adjusted as the threats change. The conversation shouldn't be hamstrung by bureaucratic lines, including the fact that firefighting is considered a Department of Agriculture and Forest Service role. Fighting fires is so similar to military and homeland security operations in terms of precision technology and networking equipment that it would be a mistake not to include it in the same conversation.

It's time to have the dialogue that the letter writer suggests.

Ben Iannotta
Editor-in-Chief

An X-Prize for firefighting planes

After 30 years in the industry and 25 as an AIAA member, I am moving into retirement with a sense of pride as to what I have witnessed but also sadness as to the future of aerospace engineering in this country. I would like to suggest a program that could rekindle the spirit of producing vehicles designed to meet the country's needs and perhaps restart a strong partnership between academia and the industry.

Simply put, I have spent most of my career in southern California. As this area enters another year of severe drought and the recent forecasts on global climate change do not bode well for the future here, wildfires will become more frequent and catastrophic. The tools available, particularly aircraft, to meet this growing challenge are antiquated and mostly a modification away from the original design function of these vehicles. What is desperately needed is a new vehicle, designed from the ground up with the express purpose of fighting large scale, fast moving fires. This may need to be a collaboration of aerial and ground vehicles, both of which do not exist today. Manned large vehicles or an air armada of drones, the possibilities are enormous, limited only by our collective imagination.

If we could harness the imagination of the university faculty and students and meld this with a ready market to entice industry participation, perhaps a new "X-Prize" might be launched to design and build the fire fighting system of the future.

It is obvious there is a need; the question is can we rise to the challenge to invent and produce a new system.

David V. Siriano
San Diego

Healthy in deep space: Regarding our June cover article, "Cancer and deep spaceflight," **Claudio Bruno of Glastonbury, Conn.**, writes that "it was about time" someone dug into the topic. In his view, the health risks have for too long been considered "an annoyance rather than an issue. In fact, deep space missions beyond the Van Allen belt should be planned together with Life Science people." For a human mission to Mars, "either new materials capable of coping with the energy spectrum of solar and [galactic cosmic radiation] must be invented, or spacecraft must travel faster, negating chemical propulsion and Hohmann [transfer] orbits. That leaves open the nuclear propulsion option (see Peter Turchi's letter in this same issue, Page 3); studies shows it's viable, if costly in the short term, but, just as the radiation issue, it is an option most dislike hearing about. Wonder how long it will take to sink in."

Defending climate change science: Our April letters section quoting climate change skeptics drew some strong responses. **David Hickerson of Colorado Springs** challenged skeptics to "get off your couch and go to Denali Park in Alaska and see the evidence for yourself….The glaciers have shrunk back, and there is forest growing now where it was not able to grow before. The soil is thawing enough to allow trees to grow." Hickerson writes that the decision comes down to this: "Do you believe the science coming from our government, our universities, and scientists around the world or that coming from the Oil and Gas industry that have an invested reason to keep you using their product?" **David Ardila of Pasadena, Calif.**, writes that "these presumably technically-oriented readers are confusing reality with ideology. The problem is that, at the end, reality always wins." He advises skeptics to examine the CO_2 records gathered by NOAA on Hawaii's Mauna Loa mountain (*http://www.esrl.noaa.gov/gmd/ccgg/trends/*), and to look at "pictures of Venus, with its powerful greenhouse effect due to CO_2." Failing that, he writes, get inside a car and note how it gets "hot because the IR radiation is trapped by glass, which plays the role of CO_2." Scientists do disagree on some aspects of climate change, he adds: "Are all corals in the ocean going to die or only most of them? Which species will disappear and which will adapt? What will be the consequences of all this for the overall food chain? And the really big question: what, if anything, should we do about it?"

Correction: The article, "Thinking differently about an engineering degree," (May, page 14) misstated Debra Facktor Lepore's collegiate experience in the automotive industry. Lepore completed a summer internship with transmission developer General Motors Hydramatic. The reference to a second automotive company was a transcription and editing mistake.

All letters addressed to the editor are considered to be submitted for possible publication, unless it is expressly stated otherwise. All letters are subject to editing for length and to author response. Letters should be sent to: Correspondence, Aerospace America, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, or by email to: beni@aiaa.org.

Europe seeks better tracking, black box tech

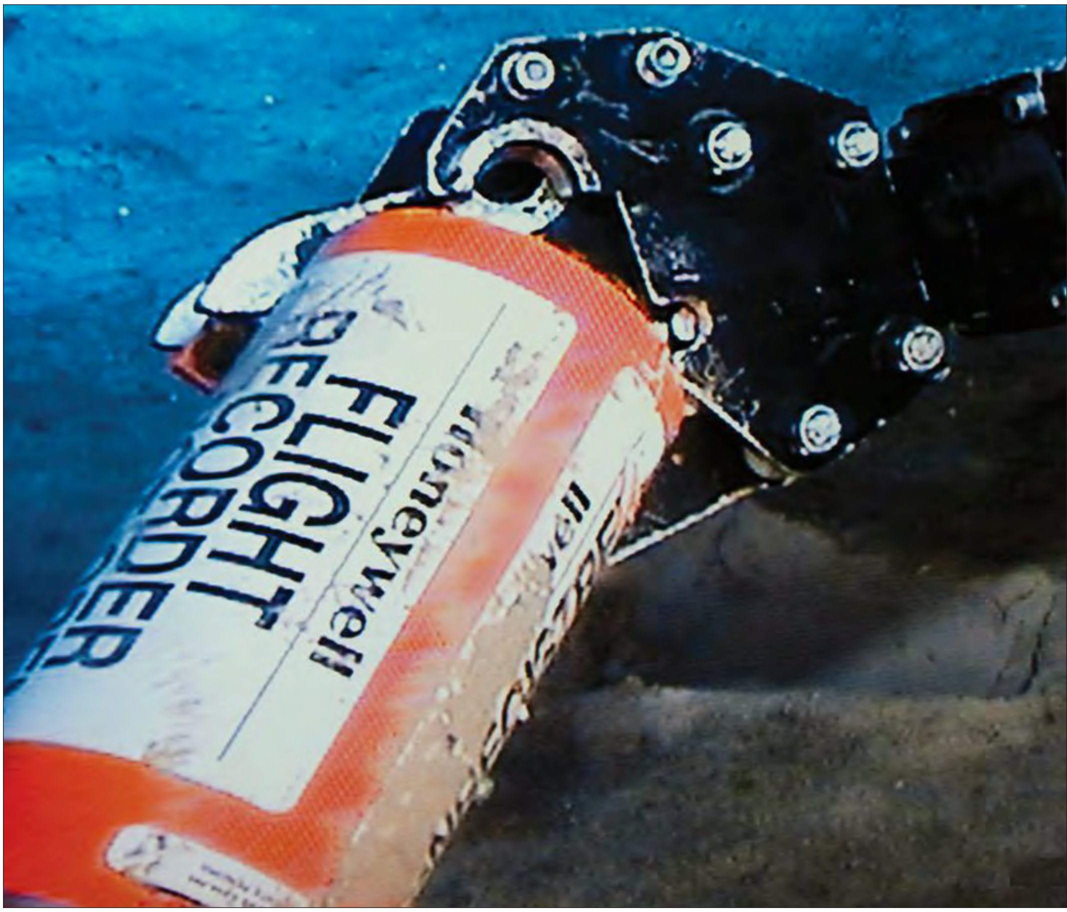
The loss of Malaysia Airlines Flight 370 has given added impetus to European aviation safety programs and regulatory proposals aimed at tracking aircraft in oceanic and European airspace and improving the performance of underwater locating devices for cockpit data recorders.

Eurocontrol, the Brussels-based inter-governmental agency, has asked the European Union to study how new generations of Inmarsat and Iridium communications satellites might let planes over the Atlantic tie into the multi-national Automatic Dependent Surveillance-Broadcast ADS-B network that authorities around the world are collaborating to establish. The ADS-B network is in place in some regions, but not yet others. It displays aircraft GPS coordinates to air traffic controllers, provided the aircraft radios are in range of receiving towers or their positions are broadcast via secondary surveillance radar transponders. Connecting via the Inmarsat or Iridium satellites could ensure more reliable and widespread position broadcast services, say aviation safety experts, but agreement will be needed on common standards and airborne receiver configurations before these can be introduced throughout the airline community.

Also last month, the European Aviation Safety Agency proposed new performance standards for flight recorders and underwater locating devices for all aircraft registered in the European Union. The proposals include extending from 30 days to 90 days the acoustic transmission time of the devices fitted onto voice and data recorders like those on Flight 370; extending the minimum cockpit recording time from two hours to 20 hours for new aircraft with a maximum takeoff mass of over 27,000 kilograms; and fitting aircraft that fly over the oceans with longer-range 8.8-kHz location beacons.

Starting on Jan. 1, 2019, EASA wants to ban magnetic recording tape in voice and data recorders, magnetic wire and frequency modulation.

"The proposed changes are expected to increase safety by facilitating the recovery of information by the safety investigation authorities," according to the text of the proposals. "They will address 13 safety recommendations from safety investigation authorities, improve [International Civil Aviation Organization] compliance, and bring benefits for flight recorder serviceability and preservation, and for the retrieval of an aircraft after an accident over water."



The flight data recorder from Air France Flight 447 was found in the Atlantic Ocean 23 months after the plane crashed. New rules proposed in Europe would make such devices easier to locate.

New protection for aviation employees in EU

Eurocontrol

Eurocontrol air traffic management facility. The European Union approved a measure that will give employees the right to appeal punishments they say resulted from reporting safety incidents.

In the latest example of the international push toward "fault-free" air safety reporting, the European Union has agreed to establish an appeals mechanism for airline crewmembers and aviation professionals who say they were punished for reporting safety-related incidents.

Under just-culture conditions, individuals are held accountable for willful violations and gross negligence, but not for "honest errors," according to Eurocontrol, the Brussels-based air traffic management agency. The thinking is that this kind of climate will lead to more sharing of safety information across the industry. The European Parliament, one of two EU legislative bodies, embraced the concept in a 2003 directive that established a mandatory reporting mechanism for serious safety violations.

The appeals mechanism was passed in February and will go into effect on November 15, 2015. Employees in EU countries who allege they were punished for reporting safety-related incidents will have a new right of appeal to their national legal systems.

Aviation safety experts say fault-free reporting is vital for catching technical or procedural problems before they lead to fatal crashes. This is especially true in an age when crashes are on the decline, giving safety experts thankfully fewer opportunities to conduct post-crash investigations. Last year was the safest ever in terms of fatalities among scheduled airlines, according to the International Civil Aviation Organization. Fatalities declined to 173 in 2013, down from 372 in 2012. In fact, since 2010, annual fatalities are down by 76 percent.

BEA

The introduction of a just culture would increase the number of aviation safety incidents that are reported and investigated, advocates say. "A change in Danish law in 2001 to a non-punitive stance resulted in the number of air traffic control safety reports rising from 15 a year to 900, according to Naviair, Denmark's air traffic service provider," according to a 2012 report by the International Air Transport Association, "Safety: The Blame Game."

But shifting to a fault-free society is not easy. "There is a very real and understandable need to get closure in the event of a disaster, and part of that closure is to work out what happened and whose fault it is," says Andrew Charlton, an aviation lawyer with Aviation Advocacy, based in Geneva, Switzerland. "Coupled with that is the fact in common law countries such as the United Kingdom and the USA there is a custom of justice being adversarial and about finding fault and liability. In civil law countries — such as most of continental Europe — the prosecutor has a mandatory requirement to find out what happened and allocate fault."

The legislation was hotly debated in the European Parliament, with many governments wanting to soften proposals from the European Commission — the executive body of the EU — that would have further protected employees. One compromise was that whistleblowers in countries where legal protection is relatively low will now be able to alert the European Aviation Safety Agency, a European Union body, rather than their own national safety regulator. In a separate legislative program, the European Commission has ruled that all European governments must introduce "just culture" safety reporting systems by 2019 to their air traffic management agencies as part of the Single European Sky program.

Advocates say there is no evidence that aviation organizations which encourage safety incident reporting become more vulnerable to legal challenges.

"No organization in a low-probability high-consequence industry such as aviation has been prosecuted successfully when they have a safety management system operating with just culture in place," says David Gleave, an independent aviation accident investigator based in the U.K.

Project aims for months of non-stop flight

Airbus Defence and Space

Record-setter: Zephyr 8 would be a longer flying version of Zephyr 7, seen here in trials at Yuma, Ariz. This version stayed aloft for 336 hours 8 min, a record that Zephyr 8's developers at Airbus plan to break.

As popular as unmanned planes are, they haven't been able to approach the persistence of satellites. This may change about a year from now with the first flight of the high-altitude Zephyr 8, the latest version of the solar-powered plane that Airbus Defence and Space has dubbed a "pseudo satellite." The company started the program for this new version in late April.

The solar-powered unmanned craft will be designed to fly at altitudes up to 70,000 feet with an endurance of several months. Its predecessor, Zephyr 7, set an endurance record in July 2010 in a test flight from the U.S. Army's Yuma Proving Ground in Arizona. That version stayed aloft for 336 hours, 22 minutes and eight seconds, according to the Federation Aeronautique Internationale. Zephyr was originally developed by U.K. company QinetiQ, which sold the program in 2013 to Astrium, rebranded the Airbus Defence and Space Group in January.

Zephyr 8 developers are seeking to extend the performance of previous versions by increasing endurance rather than payload capacity.

"We fly at an altitude of 66,000 to 70,000 feet; there is a little bit of a yo-yo in our altitude profile, because we have to reduce the altitude at night," says Airbus's Jens Federhen, who heads the Zephyr program. He attributes this to the "still-insufficient specific energy of our batteries. Once that improves, we'll be able to maintain a high altitude during the night," he says.

One way of lowering costs, says Federhen, would be to build the plane to fly for several years without interruption. "But that would mean all the mechanical parts would have to be reliable enough to really sustain such a long-duration mission. These are quite expensive, so it might be cheaper to land the aircraft after a couple of months, replace a couple of parts and then re-launch it."

Airbus Defence and Space is currently talking to several potential military and civil customers for a range of Zephyr applications — including Earth observation, communications relay and meteorological measurement. The U.K. Ministry of Defence is already a customer.

The next big improvement in calculation models for weather prediction will come from "permanent monitoring of weather data at the frontier between the stratosphere and troposphere," predicts Federhen. "A solar-powered aircraft is the ideal vehicle for objective and permanent, repetitive measurements," he says.

Zephyr 7 is made of carbon fiber, weighs 110 pounds, has a 74-foot wingspan and operates on lithium-sulphur batteries. Trials with the plane have included shooting high-definition live video with a 100-gram camera, and program developers have been able to achieve 50-centimeter resolution using a commercial off-the-shelf device, says Federhen. This could be reduced to 20 centimeters or 10 centimeters with customized equipment. In time, further development of Zephyr could enable the craft to fly with radar-based payloads, he says.

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Mantis shrimp spending delivers surprising payoff

The U.S. Air Force dedicated $600,000 in 2012 to study the mantis shrimp — its club-like appendage, specifically. That priority might sound odd today, given that U-2s and A-10s could be bound for the bone yard because of spending cuts. But the colorful peacock mantis shrimp packs a powerful punch, and the tiny club that delivers that punch could hold the key to developing stronger, thinner composite aircraft hulls, an Air Force-funded study suggests. That could ultimately save money through reduced aircraft fuel consumption.

Researchers led by chemical engineer David Kisailus of the University of California in Riverside found that setting carbon fibers in the same spiraled arrangement as in the mantis shrimp's club produced a material that is more resistant to impact than conventional aerospace composites.

The findings are described in the paper, "Bio-inspired impact-resistant composites," published in March by the journal Acta Biomaterialia.

Kisailus began studying the four-inch-long mantis shrimp in 2007, with National Science Foundation funding of $450,000 over four years. He was interested in ultra-hard properties found in nature, and the creature had a well-documented reputation for toughness. When hunting, the mantis shrimp launches its club with the speed of a .22 caliber bullet, bringing a punishing 500 Newtons of force down on its prey — and it can do so thousands of times before finally molting and forming a new club.

"Obviously, as a scientist, the question is…how can it survive so many high-rate impacts?" Kisailus says.

In search of answers, Kisailus had looked to the interior region of the club. There he found layers of fibers made of a kind of carbohydrate, set in a helicoidal, or spiral, arrangement with an amorphous mineral mixture sandwiched between those layers. This pattern, he concluded, helped absorb the tremendous forces the mantis shrimp brings to bear on its appendage.

More recently, Kisailus and his collaborators developed a carbon fiber panel that mimicked this biological structure and tested it against conventional aerospace material. In both impact and residual pressure tests, the mantis shrimp-like plate came out on top. And a follow-up ultrasonic scan revealed that the cracks that formed in the mantis shrimp-inspired slab did not cut through the sample, but instead spread laterally, perhaps accounting for the material's ability to absorb punishment without shattering.

Kisailus says he was not surprised by the performance of the helicoidal panel.

Engineers typically set out to "make things that cannot fail," but when they do fail they fail catastrophically, he says. "Nature takes a totally different approach. Nature builds things that will not fail catastrophically. They'll fail locally. So you'll have a lot of little failures inside a material, but the whole component still performs its function," he says.

The team plans to set up a company in September called Nature Inspired Industries. Kisailus says that thinner, stronger aircraft paneling could translate into lighter planes and greater fuel savings for airlines. He's also looking to the automotive, helmet and body armor industries for prospective markets. "The beauty of this is we can change whatever materials are inside. It doesn't have to be carbon fiber. There could be other materials for other applications," he says.

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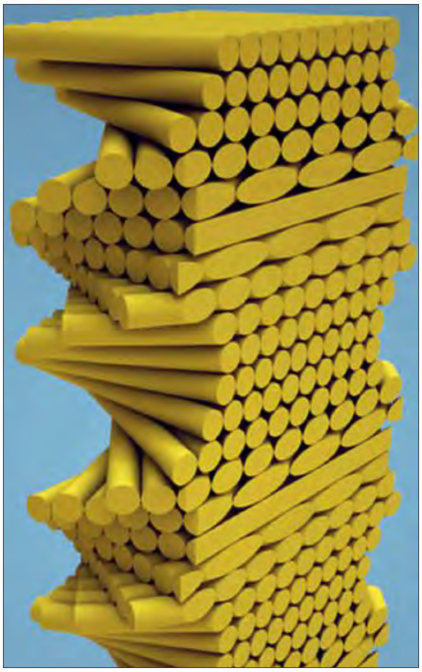

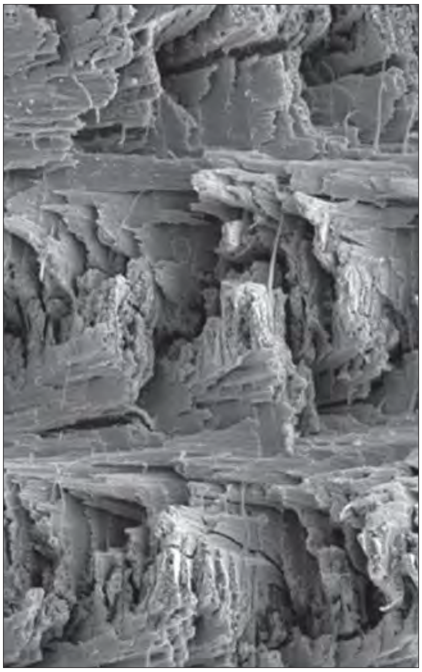

University of California, Riverside

Hard as shrimp: Composite material, left, mimics the spiral structure of the mantis shrimp's ultra-strong shell. Developed with funding from the Air Force and National Science Foundation, the material may enable far tougher, lighter aircraft frames.

Easing small drones into U.S. skies

Knowing that it could take many years to fully integrate unmanned aircraft into the U.S. airspace, the FAA is encouraging companies to apply for exemptions from rules that today bar unmanned aircraft from flying commercially unless they go through a long, case-by-case approval process. The new exemption procedures will be geared toward proposals for limited, low-risk operations, the FAA says.

Filmmakers hope to take advantage of the bird's eye views from unmanned planes. Farmers want to monitor crops for precision agriculture. Energy companies want to inspect powerlines, pipelines and natural gas flares.

Representatives of these industries "have approached the FAA and are considering filing exemption requests, which would begin the process," the FAA's Jim Williams told an audience last month at the Small Unmanned Systems Business Exposition in San Francisco.

Filmmakers argue they should not be required to obtain airworthiness certificates for unmanned aircraft if they follow the Motion Picture Association of America's procedures for the use of manned aircraft operating on closed movie sets, including the use of professional pilots. The FAA plans to review exemption requests, publish its decisions in the Federal Register and seek public comments. As soon as one exemption is approved, other companies interested in performing similar operations will be able to duplicate the exemption request and receive their own exemptions within a few weeks, said Williams.

Parrot USA

Flying camera: The Bebop aerial photography drone from Parrot. The FAA will consider requests for exemptions from rules that bar unmanned planes from flying commercially without going through a long approval process.

The exemption process would buy the FAA time to chart a course to integrate unmanned craft into the airspace for good. The agency is drafting rules for commercial operation of unmanned aircraft weighing less than 55 pounds and plans to publish them for public comment by the end of 2014. That would be the first step in a rulemaking process that Williams said can require seven to 10 years. "It's gonna take time," he said.

During those years, the FAA will consider exemption requests and also continue to process applications on a case-by-case basis. As of May, the agency had issued only one such approval. In September 2013, the FAA allowed for ConocoPhillips to operate four Insitu ScanEagles to map ice and monitor whale activity in the Chukchi Sea near the Arctic Circle. Additional unmanned aircraft flights are expected to occur over the Arctic Ocean in the summer of 2014, Williams said.

In the FAA Modernization and Reform Act of 2012, Congress directed the FAA to expand the use of unmanned aircraft in the Arctic. The legislation also instructed the agency to prepare for full integration of unmanned aircraft in the national airspace, but did not establish a schedule for that integration. Instead, Congress directed the FAA to publish milestones and "get something done by 2015," Williams said, adding the agency has succeeded with its publication in November 2013 of the Unmanned Aircraft Systems roadmap and comprehensive plan.

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Missile defense technology bound for Romania and Poland is tested at the Aegis Ashore facility in Hawaii.

A new mission for missile defense?

Some in Congress want to know if American-supplied missile defenses in Europe could be adapted to shoot down a new kind of ground-launched cruise missile that the U.S. reportedly believes Russia has tested.

The United States has long sought to put Russia at ease about its plan to adapt the Aegis seaborne anti-missile system for use from land in Romania and Poland, saying the goal is to install the radars and rockets in Europe to counter a small number of Iranian missiles.

Some lawmakers began questioning the wisdom of those assurances after the New York Times reported in January that the U.S. had informed its NATO allies about the alleged cruise-missile testing. The article raised concern in the U.S. about a possible violation of the Intermediate-Range Nuclear Forces Treaty, which eliminated ground-launched ballistic and cruise missiles with ranges of 300 to 3,400 miles.

The House Armed Services Committee's strategic forces subcommittee wants the Pentagon to write a report by Sept. 1 of this year detailing the systems that could defend U.S. forces and allies against Russian missiles prohibited by the treaty.

The Republican-led subcommittee calls for an examination of the planned Aegis Ashore sites in Romania and Poland. Other options that would be studied include: moving the Aegis Ashore system in Hawaii to Japan, the Baltic region or the South Caucasus; increasing the deployment of Aegis missile defense ships in the Baltic, Black, North and White seas; positioning Patriot or THAAD land-based interceptors in Eastern Europe, the South Caucasus or East Asia; and transferring a ground-based radar prototype from the Marshall Islands to the Baltic states, the South Caucasus, Eastern Europe or East Asia.

The chairman of the Joint Chiefs of Staff would provide the report in consultation with the commanders of U.S. Central, European and Pacific commands. Air Force Gen. Philip Breedlove, who leads European Command, told the New York Times in April that if Russia deploys a treaty-violating missile in Europe, NATO "will have to consider what to do about it….It can't go unanswered." With its bill, the House subcommittee showed it "is paying close attention to the general's concerns and wants options for addressing them," says Rebeccah Heinrichs, a national security consultant and former manager of the House Missile Defense Caucus.

But even if the subcommittee's proposal were to survive the legislative process and become law, it is unclear whether the United States could afford missile defenses aimed at Russia.

"Given the size and sophistication of Russia's ballistic missile arsenal, I believe it would require significantly greater investment, both by the United States and NATO allies," says Ian Williams, director of advocacy for the Missile Defense Advocacy Alliance. "Much would depend, however, on the level of protection sought. Protection against a limited strike with shorter range missiles would be easier to attain by enhancements and expansion of our regional [ballistic missile defense] systems that have proven highly reliable. However, protection against a larger strike with longer range missiles would require greatly increased detection and discrimination capabilities, as well as increased interceptor capability and [an increased] number of those interceptors."

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Armstrong's new footprint

The first man on the moon now has another, more earthly legacy. The center where Neil Armstrong flew as a test pilot now officially bears his name.

"Before he put that footprint down on the moon, he put a footprint down right here," said California Congressman Kevin McCarthy, author of the resolution that designated the name change.

NASA's Dryden Flight Research Center was technically renamed the NASA Neil A. Armstrong Flight Research Center in March, but the change was celebrated with a formal ceremony on May 13. The complex is the primary research site for atmospheric flight, including space exploration and operations as well as aeronautical research and development. Formerly an alternate landing site for the space shuttle, the center is now developing launch abort systems for the Orion Multi-Purpose Crew Vehicle.

So why the name change? Armstrong logged more than 2,400 flight hours over seven years at the center, taking to the air in 48 different planes—including the B-29, KC-135, X-1B and X-15. He applied his engineering skills as a research test pilot and took the rocket-powered plane to the limits of space, gathering data for future airplanes and spacecraft and testing the reaction control systems that would provide direction for those craft in a vacuum.

The facility was previously named for Hugh Dryden, an aeronautical engineer and NASA's first deputy administrator. Dryden's work contributed to high-speed flight research and the development of X-planes. He also led development of the "Bat," a radar-homing guided missile used in World War II to sink ships.

This isn't the first time the center has changed its name. In the past 70 years, it's been called NACA—the National Advisory Committee for Aeronautics, NASA's predecessor—the Muroc Flight Test Unit, the NACA High-Speed Flight Station, the NASA High-Speed Flight Station, as well as the NASA Hugh L. Dryden Flight Research Center.

But while Dryden is relinquishing a flight center, he's gaining a test range. The Western Aeronautical Test Range, whose radar systems and communications networks support research vehicles, satellites and even the ISS, is now the Hugh L. Dryden Aeronautical Test Range.

Several hundred people attended the May 13 ceremony, including the families of Armstrong, Dryden and others who have served at the center. NASA Administrator Charles Bolden noted that Dryden's leadership and aeronautical prowess helped pave the way for Armstrong's spectacular flight achievements.

"Both Dryden and Armstrong are pioneers whose contributions to NASA and our nation are unequalled," Bolden said. "This renaming is a fitting tribute that honors both their legacies."

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Lauren Biron

NASA's Neil A. Armstrong Flight Research Center, during May 13 ceremonies marking its renaming. In the foreground is the experimental X-1E, sister of the X-1B aircraft that Armstrong flew at the center.

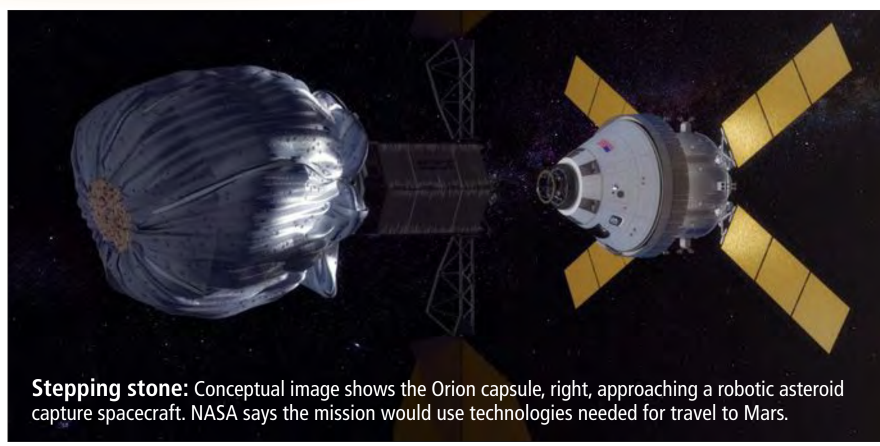
Explaining the asteroid mission

NASA's proposal to grab an asteroid and move it closer to Earth is far from a done deal. Proponents of the Asteroid Redirect Mission want to be sure public perceptions and policy decisions about the mission's future are made based on the facts. Veteran astronaut Tom Jones, who worked on the study that proposed ARM, looks at some of the questions the mission has sparked.

Two years ago the concept seemed like science fiction: A solar-powered robot half the length of a football field would approach and snare a 500-ton asteroid, tucking it into a 10-meter fabric duffle bag. The robot craft would tug its catch into a stable, high lunar orbit, waiting for an Orion spaceship and crew. Orion would dock with the robotic asteroid retrieval vehicle, still nestling the captured asteroid in its grip. A pair of spacewalkers would then unwrap their shiny present and reveal the asteroid's secrets.

In brilliant sunshine, they would tap and probe the rock's 4.6-billion-year-old surface, marveling at a crescent Earth and moon hovering silently in the endless void. Where else might this road to an asteroid lead?

The controversial Asteroid Redirect Mission, ARM, got its launch in 2012 with a report from the Keck Institute for Space Studies. I was a member of that study team. In spring 2013 NASA adopted the concept, but it has faced strong headwinds in Congress. The agency held a public forum on ARM in March, and I've joined another Keck Institute study on applying ARM technology to deep space exploration. ARM has generated lots of questions; here are a few answers:



NASA

Stepping stone: Conceptual image shows the Orion capsule, right, approaching a robotic asteroid capture spacecraft. NASA says the mission would use technologies needed for travel to Mars.

■ Is the Asteroid Redirect Mission real?

The president requests $133 million in NASA's 2015 budget to advance solar-electric propulsion, examine asteroid capture technologies and develop ARM mission design and operations. In early April, the House Science Committee's space subcommittee quickly passed a NASA authorization bill that notably does not bar spending on the asteroid mission. However, the bill does require that NASA report to Congress on the mission's proposed cost and schedule. It also directs the agency to identify advances in technologies that move us closer to human expeditions to Mars, as well as technologies and experience that could not be gained from lunar exploration.

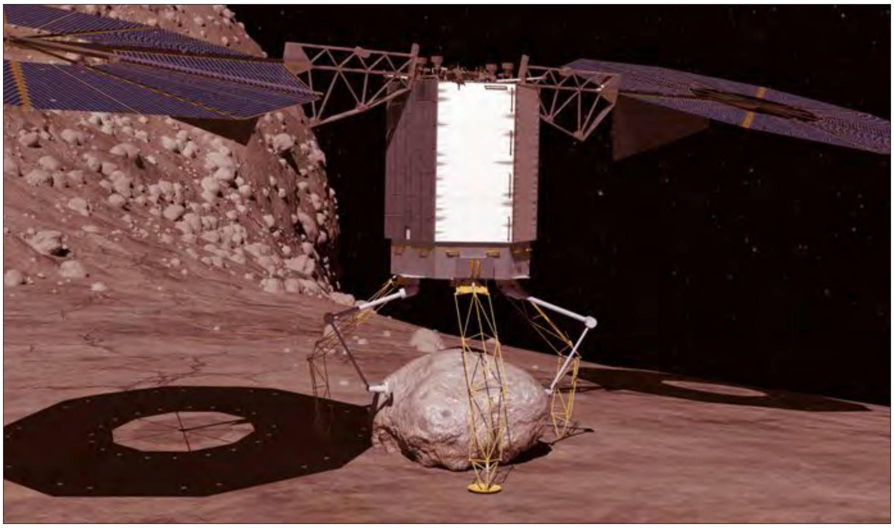
> **The story behind the name**
> The R in ARM stood for retrieval when the concept was announced in 2013, but NASA quickly swapped retrieval for redirect. The agency believes this term more accurately reflects how the robotic spacecraft will gently shift an asteroid's natural orbit toward capture by lunar gravity, rather than suggesting it would physically tug a 500-ton rock back using brute force. —Tom Jones

The agency views ARM as its best bet for returning astronauts to another celestial body for the first time since Apollo; NASA also says ARM technology would play a key role in getting to the Mars system in the mid-2030s. NASA's March 26 Asteroid Initiative Opportunities Forum laid out the current mission status and the progress expected before the Robotic Mission Concept Review, scheduled for early 2015.

■ What is the current mission concept?

The ARM robotic craft would launch in 2019, rendezvous with a roughly 7-meter near-Earth asteroid, or NEA, demonstrate one or more planetary defense deflection techniques, then capture and redirect the asteroid into lunar orbit. An alternate approach NASA planners are evaluating would be to visit a larger NEA (easier to spot and characterize) and retrieve a large boulder from its surface. Astronauts would rendezvous with the robotic craft around 2023 and begin scientific sampling, instrument emplacement and resource activities, work that future crews would continue for a decade on the ancient, water-rich object.

NASA says the mission would provide systems and operations experience required for Mars exploration. ARM would demonstrate advanced solar-electric propulsion, improve the detection, tracking and characterization of NEAs and demonstrate some basic planetary defense techniques. It would also enable close scientific examination and prospecting of a small celestial body, opening the door for in-situ resource production, says NASA.


NASA/AMA

Boulder plan: In this concept drawing, the spaceframe legs capture a piece of a large asteroid. The craft would then carry the boulder back to lunar orbit.

■ Has NASA chosen an asteroid target?

NASA's NEA search program, now funded at $40 million annually, is aimed at finding not just hazardous asteroids but also potential ARM candidates. The ideal target would have an Earth-like orbit, be on a course to visit Earth's neighborhood in the 2020s, have a mass between 500 and 1,000 tons, spin more slowly than 2 rpm, and have a composition like that of water- and organic-rich carbonaceous chondrite meteorites. These small, dark asteroids are tough to see, but a handful have surfaced as suitable candidates.

One such NEA is 2009 BD, which rotates slowly and will approach Earth in the 2020s at relatively low velocity.


JAXA

Plan B: Boulders strewn across Itokawa. Asteroids this size are too large to bag, but a rock from one of their "rubble pile" surfaces could be plucked up robotically and carried away for analysis.

But infrared measurements from NASA's Spitzer Space Telescope indicate the asteroid is smaller than 5 meters in diameter, with a mass of just 30-145 tons. Its high albedo — the amount of light it reflects — also suggests its silicate minerals harbor little or no water.

Getting infrared spectra to identify small, water-rich asteroids is even harder than finding them in the first place. There are currently about seven potential ARM capture targets; the upgraded search program should add one or two every year between now and the 2019 launch.

■ Is more than one approach being considered?

Because these small target asteroids are so elusive, NASA is also weighing the tactic of going to a larger NEA and returning a multi-ton boulder from its surface. Japan's Hayabusa probe visited asteroid 25143 Itokawa in 2005 and found the surface studded with hundreds of boulders. ARM could return a block of up to 50 tons from Itokawa's orbit. Radar observations suggest boulders are present on 101955 Bennu, a dark, possibly water-rich carbonaceous asteroid about half a kilometer across. NASA's OSIRIS-REx sample return mission, launching to asteroid Bennu in 2016, should confirm this. ARM could return up to about 20 tons from Bennu's orbit in the mid-2020s.

Six boulder-retrieval candidates are currently known, and the number is expected to double by 2019.

■ How will ARM capture an NEA?

ARM's targets are fragments of larger, rubble-pile asteroids and so are likely to be highly fractured blocks of material harboring some surface dust and gravel. To snare and retain an asteroid and associated debris, the capture craft would use a flexible, tough fabric bag. The ARM craft would fly the bag, held open by inflatable struts, over the asteroid and then close the bag's mouth around it, trapping it inside. With any debris hazard contained, the retrieval craft would despin the NEA using thrusters, then begin thrusting toward its lunar and astronaut encounter.

In the boulder-grab alternative, the ARM spacecraft would hover some 20 meters over a suitable block resting on a large asteroid's surface. Thrusters off, the ship would slowly free-fall to the surface, absorbing the very light contact forces with a set of articulating landing/capture legs. Once down, the spacecraft would retract several legs to enfold the boulder, or grapple it with a pair of capture arms. Springs or thrusters would pop the craft and its prize off the surface.

NASA is studying which approach — bag or boulder-grab — offers the best chance for success. The agency's Robotic Mission Concept Review in early 2015 will decide which system moves into development.

Why place the asteroid in a distant lunar orbit?

ARM's 50-kilowatt solar-electric propulsion system must tweak the captured NEA's natural solar orbit just enough to arrange an encounter with Earth's moon. A pair of lunar gravity swing-bys would loop the stack into a distant retrograde orbit. At an orbital radius of 71,433 kilometers and a period around the moon of 14 days, even an uncontrolled asteroid would be stable for at least a century.

What would astronauts do there?

Performing their own lunar swing-by, the Orion astronauts would arrive nine days after launch and spend five days docked to the ARM craft. During two extravehicular activities, the crew would sample the asteroid, place instruments on it, outfit it for future crew and robotic visits. Then the astronauts, having ventured farther from Earth than any other humans, would use another lunar gravity assist to return home. Mission duration would be just under four weeks.

What comes after ARM?

The crew's return with several tens of kilograms of asteroid samples would be only the beginning of a long investigation and exploitation campaign. The instruments placed on the asteroid might examine its interior structure and physical properties, or demonstrate water and volatile extraction. International and commercial probes might arrive, along with follow-on astronaut crews, to further dissect the object and test resource processors. In parallel, NASA would be aiming at more distant NEAs and the Mars system.

Will ARM advance human exploration of Mars?

Asteroid capture and exploitation would use many of the techniques and technologies needed to reach Mars. Solar-electric-powered tugs could haul multi-ton cargoes — habitats, landers or propellant — to the Mars system. Proximity operations and extravehicular activities would pave the way for expeditions to more distant NEAs. Those journeys would last a year or more and take crews several million miles from Earth. Finally, low-gravity asteroid experience from ARM would prepare astronauts for work on the Martian moons Phobos and Deimos. With possible water resources and an advantageous location for Mars surface expeditions, these asteroid-like moons could host human explorers by the 2030s.

Most important is that asteroids and the Martian moons may offer us propellant and water sources where we need them, in cislunar space and in the Mars system. Tapping those resources would be a breakout move for NASA, human exploration and commerce. We could break our dependence on Earth for the hundreds of tons of propellant that each human venture to Mars would require.

Is nabbing a small asteroid the best we can do?

Asteroids are the only deep-space destinations for NASA approved by the administration. The International Space Station faces decommissioning in 2024, and NASA has no plans for humans in low-Earth orbit after that. If Orion and the Space Launch System don't have a defined mission for the early 2020s, they will likely be canceled. Waiting for a better offer than ARM would guarantee that U.S. astronauts won't return to deep space until the late 2020s at best. At worst, we'll wait and watch as the nation abandons human spaceflight.

Meeting the ARM's propulsion, operations and extravehicular goals would take us to another celestial body and position us for interplanetary voyages. Keeping our sights on Mars, we could use ARM to unlock the native resources that would take us not only there, but anywhere we choose to go.

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AIAA
Shaping the Future of Aerospace

Bearing heavy loads

Flying a helicopter with thousands of pounds of equipment slung beneath it can be a white knuckle experience. Erik Schechter explains how computational fluid dynamics is being applied to predict how helicopters will react under various load and weather conditions.

Department of Defense

CONEX: A pallet of medical supplies dangles from a UH-60 Black Hawk helicopter. Buffeting in bad weather can cause a CONEX — a container express — to twirl and rock.

A quick resupply by helicopter is sometimes the only thing that can stave off disaster for survivors of a hurricane or for troops pinned down by the enemy with ammunition running low. But the crew of the helicopter must fly cautiously, especially if the supplies are slung beneath their aircraft in the typical fashion — dangled from a gimbal and tether and stored inside a large, non-aerodynamic metal box called a CONEX, short for container express. Depending on weather conditions and the helicopter's forward speed, it can be buffeted by the wind and bad weather, and the aircraft's forward speed can produce a turbulent wake similar to the one experienced by motorists stuck behind an 18-wheeler on the highway.

At minimum, such buffeting can cause drag. But it can also play havoc with the sling load, causing it to twirl around on itself, tangling its cables, or sending it rocking back and forth — an instability that can be relayed back to the helicopter with dangerous consequences. "You're asking the poor pilot to fly this helicopter with this horrible swinging back and forth and spinning going on beneath it," says Marilyn Smith, a professor of aerospace engineering at the Georgia Institute of Technology.

It's not uncommon for pilots facing such situations to feel forced to jettison their sling loads.

Aerospace engineers try to keep that from happening by testing assorted cargo configurations in flight to advise pilots how fast they can go before complications develop. That can get expensive, given that it can cost $4,000 an hour to fly a UH-60 Black Hawk. Computational fluid dynamics (CFD) software models could, in theory, be a more affordable alternative, but they have reputations for being slow, computer hogs.

Enter Smith and her team at Georgia Tech. While attempting to study loads with traditional computation, the team encountered a computation roadblock that left them no choice but to find a CFD shortcut — a bit of serendipity that is beginning to pay off with quicker modeling of complex load dynamics.

"This is not a CFD code," Smith explains. "It's what's called a reduced-order modeling code." Reduced-order models attempt to accurately depict a phenomenon without employing high-fidelity CFD modeling, and Smith says that the one her team developed does just that for sling loads. "Basically, we are taking information from tests — wind tunnel tests and flight tests — and from CFD computations. And we are combining it with what we know about physics of these configurations" — to produce a quick and versatile software model that goes beyond its source material.

U.S. Army Aviation officials have been sponsoring Smith's research through the Vertical Lift Research Center of Excellence based at Georgia Tech. These officials do not expect the new model to completely eliminate test flights, but they are very excited about the prospect of its significantly reducing the number of future tests. "If we have to test only one-tenth of our configurations, it's a huge money savings," says Bill Lewis, director for aviation development at the Army's Aviation and Missile Research, Development & Engineering Center.

Finding the limits of CFD models

In 2010, the Georgia Tech team began looking at the air flow effects on non-streamlined "bluff" bodies, rectangles in particular. Researchers reviewed the scientific literature on previous experiments and noticed that the aerodynamic side force on a static box varies with changes in the angle of attack and the ratio of the box's dimensions. Though this observation would have no bearing on the CFD model the researchers first developed, it would later prove useful in the reduced-order model, says Daniel Prosser, a doctoral student working with Smith.

Smith and her team moved on to high-fidelity software simulations in late 2012-early 2013. Using a NASA CFD code called FUN3D, they broke down the air flow field around the bluff body into millions of grid cells and calculated the fluid properties — velocity, pressure and density — for each one. This data was then passed on to a library, or set of computer subroutines, used to simulate the six-degrees-of-freedom motion of a tethered load.

The Georgia Tech researchers expected their model to predict the behavior of a tethered object in flight. However, they found serious discrepancies once they compared their results against experiments conducted in 2010-2011 by Georgia Tech's Experimental Aerodynamics Group in the university's John J. Harper Low Speed Wind Tunnel. The software model predicted that, at certain speeds, the sling load's cable would spin, twisting on itself. Yet that didn't happen at all in the wind tunnel.

It took a while to figure out what went wrong, but the team concluded that their CFD model did not take into consideration friction acting upon the gimbal holding the tethered load in the tunnel. "What we hypothesized is that the model of our tether that we're using in our simulation had some assumptions built in, and one of those was that there wasn't any friction in the gimbal which attached to the tethers," Prosser says.

At that point, the team could have "de-bugged" their model and run it all over again, but doing so was simply not feasible. Solving for millions of grid cells, high-fidelity CFD models are, computationally speaking, very expensive: it can take a supercomputer weeks to process just 15 seconds of data. "If we had tried adding in some friction to the gimbal model, we would have had to run a whole new simulation, and then maybe that value wouldn't have worked," Prosser explains.

What the team needed was a short cut. So in September 2013, they began work on a reduced-order model that could solve their problem in a matter of minutes instead of weeks.

Devising a quick and accurate model

Looking back at the published work of others in Israel, the U.K. and the Army's Aeroflightdynamics Directorate, Georgia Tech researchers developed a reduced-order model that takes the real-life experimental results of a non-streamlined bluff body both in wind tunnels and flight tests, and combines them with a physics model of how air flows over an aerodynamic form in motion. Together, those two data sets — and a bit of extrapolation — provide a model of sling load behavior at a given speed, crosswind and scale.

"We started putting all this stuff together so that we could try to reverse-engineer to find the gimbal friction, and what came out of it was something that was extremely fast, orders of magnitude faster than CFD," Smith says.

What would take a CFD model an hour to calculate, the reduced-order model can do in .04 seconds — and do so reliably. According to Smith, the new stripped-down approach gets nearly the same results as the CFD model and wind tunnel tests. Finally, besides being fast and accurate, the reduced-order model, because it relies in part on physics, can be reliably applied to different speeds and different sized objects, she says.

Others have tried to develop a reduced-order model, but the approach taken at Georgia Tech takes into account variables not addressed before. The team looked at the random influence of turbulence and the phase lag, the delayed reaction of air flow to a body changing its angle of attack. The model also allows researchers to solve second-order differential equations that address the influences of velocities and acceleration, helping aerospace engineers to predict things like load autorotation, which is when the cargo load spins and twists its cables.

Smith sees the reduced-order model ultimately included in the comprehensive codes used by aerospace engineers for the rapid prototyping of new helicopters.

"By adding a module that allows them to take into effect accurately the behavior of these sling loads, then they can do a better design of the actual vehicle before it ever gets to the point of being operational," she says.

Georgia Tech Research Institute

RMAX: Research on a Yamaha RMAX unmanned helicopter at Georgia Tech benefits from a new technique that provides accurate and far faster modeling of dynamic loads.

"Unless you actually include these dynamic interactions correctly, you're not going to be able to model it, and that's where we are going beyond what people have done before," Smith says.

Besides being able to determine how fast a helicopter can safely fly with a particular sling load, the reduced-order model is now being used by other Georgia Tech faculty to develop guidance and navigation control systems for vertical takeoff and lift drones. Eric Johnson, a professor of avionics integration and director of the UAV Research Facility at Georgia Tech, has been working with a Yamaha RMAX helicopter, but his Georgia Tech UAV Simulation Tool lacked a way of modeling aerodynamics of sling loads. Now he can incorporate a reduced-order model into the simulator.

"That's a huge deal," Johnson says.

Future improvements

The next step for the Georgia Tech team is to extend the reduced-order model beyond rectangles to cylinders, flat plates and other shapes. To do so, researchers will have to conduct new wind tunnel tests on or apply CFD software models to these new shapes. But once they have completed this preliminary stage, they will have the raw material for future applications of the reduced-order model, Prosser notes.

Smith adds that the model can also be augmented in other ways: It could be sped up and made more comprehensive. "This is not as fast as it can go. We haven't tried to optimize the speed yet," she says. "We are also looking at what happens when we get higher-order fidelity…in other words, when we add more corrections or states."

Erik Schechter
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Continuing Education Courses and Workshops

AVIATION 2014

14–15 June 2014 — Atlanta, Georgia

Business Management for Engineers
Instructors: Alan Tribble and Alan Breitbart

Summary: This course will help individuals with a strong technical background in science or engineering prepare for the transition from a role as a technical contributor to a business leader.

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

Summary: You will learn how to evaluate sensitivity of the design to variables, initial requirements, and constraints, and how to select the best approach among the many that are currently available.

3rd AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III)

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

PROPULSION ENERGY 2014

31 July–1 August 2014 — Cleveland, Ohio

Hybrid Rocket Propulsion
Instructor: Joe Majdalani

Summary: The purpose of this course is to present and discuss fundamental theory alongside research findings with emphasis on unsolved problems, open questions, and benchmark tests.

Missile Propulsion Design, Technologies, and System Engineering
Instructor: Eugene Fleeman

Summary: Attendees will gain an understanding of missile propulsion design, missile propulsion technologies, launch platform integration, missile propulsion system measures of merit, and missile propulsion system development process.

The Application of Green Propulsion for Future Space
Instructors: Alan Frankel, Ivett Leyva, and Patrick Alliot

Summary: Topics include a brief history of hypergols; what is considered green and what is driving the green propulsion movement; figures of merit and lessons learned in the development of green propellants; flight experience and applications for the various classes of satellites; and challenges for current and future green thrusters and systems.

2nd AIAA Propulsion Aerodynamics Workshop

Summary: The focus of the workshop will be on assessing the accuracy of CFD in obtaining multi-stream air breathing jet performance and flow structure to include nozzle force, vector and moment; nozzle thrust (Cv) and discharge (Cd) coefficients; and surface pressure prediction accuracy.

SPACE 2014

3–4 August 2014 — San Diego, California

Decision Analysis
Instructor: John Hsu

Summary: Different decision analysis methods will be introduced starting from the traditional trade study methods; then continue to trade space for Cost as Independent Variable (CAIV), Analytic Hierarchy Process (AHV) which is part of the Analytic Network Process (ANP), Weighted Sum Model (WSM), Potentially All Pairwise Rankings of All Possible Alternatives (PAPRIKA), and Decision Analysis with Uncertain information/data.

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AIAA
Shaping the Future of Aerospace

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U.S. Air Force

A leader for lean times

Interview by Jim Canan

Gen. Mark A. Welsh III

The Air Force budget is tight with no letup in sight, and it's up to Chief of Staff Gen. Mark A. Welsh III to align the service with that reality by shifting to what he calls "strategic agility." The service is transitioning from a wartime posture, when budgets for equipment were flush, to what Welsh calls "more of a peacetime footing."

In the months and years ahead, the Air Force and the defense industry are going to need to work together to control and cut costs, or both will fail, he warns.

Welsh knows Air Force technology well from his years flying F-16s and A-10s, and from his role as CIA's associate director for military affairs from 2008 to 2010.

Jim Canan met with Welsh in his office at the Pentagon.

Where is the Air Force heading? What are your major challenges?

Let's begin with our missions. The president gave the Air Force five missions in 1947, and they are still our missions: air superiority, airlift, ISR [intelligence, surveillance and reconnaissance], command and control, and strike. We've added space superiority, that's the only change. Now the big question for us is how do we do those missions in three different domains – not just in the air domain, but also in and through space, and in and through the cyber domain.

The different domains give us access to different targets, different approaches to create different kinds of effects, both kinetically and non-kinetically – access that we didn't have in the past. Our task will be to get more efficient while remaining operationally capable in the mix of those missions and domains.

How do you factor the rise of automation, of remotely piloted aircraft – RPAs – into all that?

Right now, less than 10 percent of our Air Force is unmanned aircraft, but the impact is significant. The key is not to jump into buying unmanned aircraft for all mission areas. We're not ready for unmanned aircraft carrying nuclear weapons, or deploying soldiers and Marines without crews in the cockpits.

Will we ever have an all-automated Air Force?

I don't think so. Humans will always be necessary in air operations and air combat. If you can minimize human risk and still conduct warfighting activities successfully, which is our job, you should do it wherever possible. But you cannot eliminate human risk in warfighting. We see our job as being so good at what we do that no one is ever tempted to initiate conflict with us, and if it happens, to minimize the time we are in conflict by being overwhelmingly capable. We don't want a fair fight. We want to dominate.

What does the future hold for unmanned aircraft?

Our best indicator will be their progress in the commercial aircraft industry. I think we will see an explosion in the remotely piloted aircraft business when the big companies start moving and delivering freight in unmanned platforms. Companies are already experimenting with delivering packages in remote locations.

When it becomes financially beneficial to companies and acceptable to the FAA and others in terms of safety to allow these machines to operate in national and international air space, the world is going to change. The Army has been delivering ammunition, food and water in unmanned aircraft to forward operating bases and outposts in Afghanistan all along, using smart parachutes that maneuver to precise landing points. We are working with the FAA right now at Grand Forks Air Force Base to figure out how to manage flying manned and unmanned aircraft in the same air space. That is very hard to do right now.

Will the Air Force have enough money to develop and incorporate all the technology required for new and legacy systems?

Our big question is how much new will we have to buy versus how much will we have to modernize what we already have. It's all driven by the threat. We believe the future threat will demand that we have the F-35 [fighter] to supplement the F-22 in an air superiority fight, because we obviously won't have enough F-22s to maintain air superiority in a large conflict. Only platforms as advanced as the F-35 and the F-22 will be successful in the combat environment of 10 years from now, able to operate against the integrated air defense systems that we expect as many as 25 countries around the world will have. About 10 countries have them now. Those systems have better technology, better sensors, better integration among sensors, better weapons ranges, improved ability to share tracking data and information. So we will have to raise our game to operate against them.

And your other top priorities?

We also have to have the KC-46A air tanker, because [of] its ability to refuel multiple types of airplanes with both boom and drogue refueling. Our KC-135 and KC-10 tankers are getting very old. When we deliver the last KC-46 we'll still have 200-plus KC-135s that are 65 years old or older. Our grandkids will be flying them. As the world's leading superpower, that's just not what we ought to be doing.

And then there's the new bomber you're planning.

The long-range strike bomber will enable us to conduct an extended air campaign anywhere. We will need 80 to 100 of them. Our B-52s will not continue to fly until they're 100 years old or older, although it must seem that we're trying for that. We have to replace them. We have only 20 B-2s. So the F-35, the KC-46, and the bomber are the three systems that we think are fundamental to our combat capability moving forward, and we're trying to protect those programs in every way we can.

Will it be possible to protect them?

I think so. Our funding cuts are dramatic. We've had to cut 50 percent of our modernization programs because we don't have enough money to continue them. Our problem is in adjusting from the plan we had with previous funding levels to the plan in existence today with the projected funding levels. We have roughly 20 percent less budget per year than we expected to have three years ago. That makes things difficult.

What is the key to handling this situation?

We have got to be realistic about what we can continue to afford. We have got to upgrade some things in our legacy systems to keep them viable against the threat, and this is where technology comes into play. We have to choose the right technologies for us to invest in, see to it that they are available at the lowest possible cost in the shortest possible time frames, and apply them in the smartest possible way.

Is your teamwork with industry satisfactory? Is industry thinking far enough ahead?

I'm worried about the defense industrial base, about small businesses, not just the big ones. But I'm confident that things are now going in a good direction. The Secretary of the Air Force [Deborah Lee James] has taken the lead. She spent a lot of time in the defense industry, and she understands the Air Force. She started a dialogue with the defense industry in the past year, and she intends to meet routinely, twice a year, with a number of its CEOs. Bill LaPlante [assistant secretary of the Air Force for acquisition] will meet with industry COOs [chief operating officers] at least quarterly. The issue is not individual programs or products, but how to change the game in our relationship with the defense industry.

What do you mean by changing the game?

Our platforms and systems and technology simply must be both achievable and affordable. Our price curves are out of control. We have gone from a $500,000 airplane in World War II to a million-dollar airplane in the Vietnam era 30 years later to a $100-million dollar airplane in the F-22. That price curve is just not sustainable. The Air Force and the industry have to figure out how to not just constrain the curve but shatter it.

We don't really understand all the factors that go into price curves in the detail and with the intuitive thinking that the industry does. We must work together to make this change, because if it doesn't happen, we won't be able to afford an Air Force, and they will be out of business.

But it takes big buys to keep unit costs down, and tight budgets work against that, don't they?

That's the point. We have to change that model, change all of our acquisition models. We have to understand the metrics that the senior leadership of the Air Force and the defense industry must track and understand, [and do so] together, in order to make that change. For example, is the big problem the length of engineering and manufacturing development programs? Can we shrink that from five years to one? If so, how does that help us change the whole acquisition process?

We need to look at, among other things, the technology that industry uses for production tooling, for production line development, and at the major costs in their production facilities. We need to explore how the Air Force can develop our system requirements in ways that will help industry minimize those costs. Industry has training programs for its own people, in the same systems that it is producing for us, that cost 50 percent less for their own use than for government use. What drives that cost differential? We should be looking at it together and figuring out how to eliminate that cost.

What's the role of technology?

Industry is investing in technology to help the companies do better. They don't have the extra money that they once spent on just building things and offering them to the Department of Defense. So they are trying to figure out how to target their money better, just as we are with our S and T [science and technology] dollars.

You mentioned the need to refine requirements.

What's most important is controlling our requirements for everything we buy, whether it's a platform, a sensor, a training program, whatever it is. If we keep adding requirements, costs keep going up and programs keep getting delayed and never go away. And then Congress limits funding for the programs to make us get them under control, which also causes schedule delays and cost increases. It's a vicious circle.

How do you see the future role of the Air Force, its place in the world?

The Air Force of a superpower is built not to support a counterinsurgency fight but to be able to engage in and win the high-end, full-spectrum fight. We did pretty darn well at supporting the counterinsurgency, counterterrorism fight in Afghanistan, but it wasn't a full-spectrum fight. Air superiority has not been a major factor in Afghanistan. Close air support and ISR and airlift and air drop have been, but most people aren't aware of that. In the big fight, we would face a higher-end threat, and we simply must be able to provide air superiority and do interdiction and ISR in contested air space.

Biography of a pioneer

"Sally Ride: America's First Woman in Space," by Lynn Sherr

Reviewed by Craig Covault

ABC-TV correspondent Lynn Sherr's biography of Sally Ride is superbly sourced and thought provoking.

Sherr chronicles Ride's love of physics, her astronaut training, and her spaceflight career. She discusses the leadership and educational skills Ride displayed in establishing her science education foundation. Sherr does not sidestep personal matters, including Ride's bisexuality.

The book, set for release June 3, gives readers lots of anecdotes about how the first six woman astronauts worked with shuttle personnel inexperienced in dealing with women, including the requirements for their space hygiene kits. More serious anecdotes reveal the difficult aspects of the fame that engulfed Ride and how she responded to it.

This is a heartfelt biography written by a journalist who became a close friend of Ride, who died in 2012 at 61 of pancreatic cancer. Sherr chronicles in absorbing detail Ride's battle with cancer and her death in La Jolla, Calif. Ride's family and Tam O'Shaughnessy, her partner of 27 years, cooperated fully in the writing of the biography, providing extensive interviews and Ride's personal papers, according to Sherr. About 150 other people who knew Ride (including this journalist) were interviewed and quoted.

Ride and five other women were selected in 1978 as non-pilot mission specialist astronauts. Ride nevertheless became a pilot of NASA's Northrop T-38 supersonic jets and flew her own Grumman Tiger, a light plane that she owned with fellow astronaut Mike Lounge, who died a year before Ride.

The book details Ride's enthusiasm for simulator training that focused on operating the 50-foot-long Canadarm from the shuttle's aft cockpit, and on serving in the forward cockpit as the center flight engineer during launch and reentry.

Ride flew into space for the first time in 1983 on Challenger's STS-7 mission, a launch that she famously described as an "E-Ticket" ride. She spent eight days aloft on her second flight, Challenger's STS-41G mission.

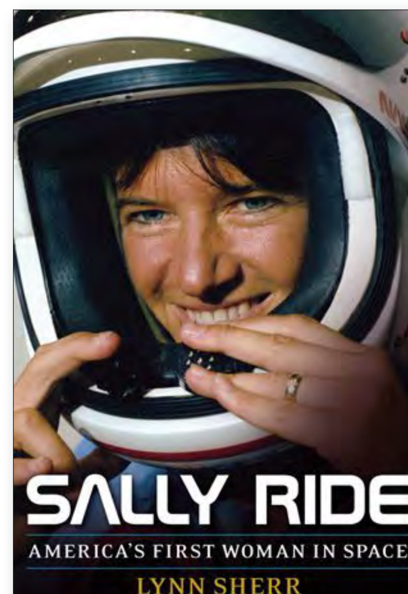
This is not just an account of Ride's professional life, however. Sherr describes Ride's relationships with two women and four men, including astronaut Steve Hawley, whom Ride married in 1982 then divorced in 1987 as her heart drifted to O'Shaughnessy. Sherr quotes each of them discussing their time with Ride.

> **"Once the bright new face of NASA, she became its conscience, repeatedly agreeing to help get the agency back on track or chart its future."**
> Lynn Sherr

The biography explains that Ride was a feminist whose lifelong focus on science, excellence and leadership won over skeptical men and inspired children around the world.

Throughout the book, Sherr depicts the news media as pummeling Ride with personal questions, sometimes reflecting the very stereotypes she hoped to change. Some of the best examples, says Sherr, were at the STS-7 prelaunch press conference, where questions asked of Ride included "Do you weep?" and "Do you ever wish you were a boy?"

The book discusses how Ride twice sought psychiatric therapy, first to help her cope with enormous media pressure, and again years later when she grew insecure about whether she was maintaining her own standards of excellence with her educational programs.



Simon & Schuster

Ride had her eye on future generations. She founded Sally Ride Science in 2001 to create science fairs and educational materials on physics and space exploration, targeting them at upper elementary and middle school students. Sherr shows us that Ride was driven to provide young students, especially girls, with positive early experiences in science, technology, engineering and math.

The book devotes parts of two chapters to Ride's work as a member of the accident investigation boards that examined the Challenger explosion in 1986 and the disintegration of Columbia in 2003. Sherr says Ride exposed flaws in NASA's management and safety oversight that were key factors in the disasters, which killed 14

NASA

Sally Ride conducts de-orbit preparations in the aft flight deck of the Challenger orbiter in 1983.

astronauts. The book presents new details about the drafting of the influential post-Challenger study chartered by NASA that became known as the "The Ride Report." Ride and her co-authors called for an aggressive "Mission to Planet Earth" program of environmental satellites and a program to return astronauts to the moon as a stepping stone to Mars. Ride criticized what she considered disarray in NASA human mission planning.

Ride was chosen to participate in the 2009 Review of Human Space Flight headed by former Lockheed Martin CEO Norman Augustine. Sherr quotes Augustine as saying he wanted Ride on his panel because "she possessed the credibility that comes from experience, the courage to say what needed to be said and the fact that she was not a zealot." The panel's findings would lead to cancellation of the Constellation return-to-the-Moon program proposed by the Bush Administration and the 2011 shutdown of the shuttle program — measures Ride supported, much to the consternation of her many NASA colleagues.

This book is perhaps most valuable for its eloquent summary of Ride's professional life: "Once the bright new face of NASA, she became its conscience, repeatedly agreeing to help get the agency back on track or chart its future," according to Sherr.

PUTTING OUT THE FIRES

An Air National Guard C-130J equipped with a Modular Airborne Firefighting System drops retardant near Palm Springs, Calif.

Air National Guard

One was a museum piece. Others were airliners.

Debra Werner looks at the work to turn

these planes into commercial airtankers

in time to make a difference this year.

California is being wracked by a drought of historic proportions, and the summer fire forecast calls for an expanding zone of above-normal fire potential, from Northern California into central Oregon and northwestern Nevada and into the Midwest.

Against this backdrop, five U.S. companies have been selected by the U.S. Forest Service to prove that their converted airliners and military turboprops can lay retardant down exactly as needed to block the spread of wildfires. Before these planes can be tried against actual fires, they must go through grid testing, a technique that hasn't changed much in decades. The companies go to a nearby range and recruit volunteers, hourly workers or even inmates to prepare the field. Each tanker drops retardant onto a grid composed of 3,000 stakes pounded into an empty field. Each holds a three-inch-deep white plastic cup that resembles a Cool Whip container. After each drop, 30 to 40 people hurry into the field to put a lid on each container, which is then marked with its location and weighed.

This is how the Forest Service verifies the performance of the commercially owned airtankers that once formed the core of its aerial firefighting capability, a fleet it is struggling to reconstitute. When enough of those planes aren't available, the service borrows planes from the Air National Guard or states like Alaska or governments like Canada's. The Forest Service has been doing a lot of borrowing lately, because the fleet of 40 commercial planes available to it in 2001 has dwindled to a large handful — 10 as of May: two freshly refurbished next-generation planes, and eight older, "legacy" airtankers.

The coming months could mark a turning point in what has been a long effort by the Forest Service, Congress and the White House to reconstitute the commercial fleet as the backbone of the U.S. firefighting capability. The service has yet to recover from the calamitous year of 2002, when the wings literally fell off two rented airtankers in midflight, one a Lockheed C-130A built

U.S. Air Force

When there aren't enough commercial airtankers, the Forest Service puts its Modular Airborne Firefighting Systems into service. The portable 3,000-gallon retardant systems are rolled aboard Air Force C-130 aircraft.

in 1957, the other a Consolidated-Vultee PB4Y-2 Privateer built in 1945. The crashes killed all aboard, prompted the Forest Service to ground 33 out of 40 airtankers, and focused attention on the airworthiness of refurbished planes.

by Debra Werner

Army National Guard

10 Tanker Air Carrier operates two converted DC-10 airliners each fitted with an 11,600-gallon retardant tank.

More than $158 million in refurbishment contracts awarded in June 2013 were supposed to pay off last fall with the debut of seven newly converted planes. But only two were ready on time: A converted DC-10 provided by 10 Tanker Air Carrier of Albuquerque, N.M., and a C-130Q provided by Coulson Aircrane of Portland, Ore.

The technical and certification challenges have proved daunting for most contractors. Legacy tankers like those that crashed in 2002 typically carried about 2,000 gallons of retardant, and their piston engines meant top speeds of about 185 knots. The Forest Service wants turboprops or jets that can rush to the fire zone at 300 knots, slow down to less than half that speed, and in five or six seconds drop 3,000 gallons of retardant in predictable, repeatable patterns of controllable thicknesses.

Converting aircraft into tankers requires strengthening their structures to hold the mixture of water, fertilizer, thickener and red coloring agents that make up fire retardant. The aircraft and their tanks have to pass static tests before they can get to the grid tests. The final blessing must come from a group called the Interagency Airtanker Board, which includes representatives of the Forest Service, Department of the Interior and National Association of State Foresters. The board has to approve the planes for field trials, and the FAA also must certify that each company has established satisfactory maintenance and inspection programs for its planes.

Everyone must be convinced that the planes can safely carry thousands of gallons of retardant, release it without losing control, and do so repeatedly.

"That process has proven to be more complex, challenging and time-consuming than we initially estimated," says Forest Service spokeswoman Jennifer Jones. "We were hopeful we would be able to get [the seven refurbished planes] all flying last year, but that hasn't happened."

At stake for the competitors is millions of dollars in hourly flight fees and exclusive-use payments, plus the satisfaction of getting into the fight this fire season with planes that would fly faster, spread more retardant, and drop it precisely on target. The Forest Service plans to spend $50 million this year on its campaign to refresh the tanker fleet.

HEDGING THEIR BETS

It remains to be seen whether all the aircraft from the 2013 awards will be ready for this fire season. The Forest Service expressed doubts in December when it issued an $8.7-million sole-source contract to Neptune Aviation of Missoula, Mont., to operate two BAe 146 aerial firefighters for one year.

The British Aerospace 146 is a 29-meter-long regional airliner powered by four turbofan engines. It is a popular candidate for conversion to a tanker because of its fast cruising speed, short takeoff and landing capability and low-speed maneuverability. Minden Air of Minden, Nev., for example, was chosen in 2013 to convert a BAe 146 as one of the seven airtankers.

The Forest Service said that it needed to award an additional BAe 146 contract to

Neptune without a competition because the availability of all seven next-generation tankers for the 2014 fire season "remains uncertain and default termination of those contracts remains a possibility." Three of the five next-generation tanker firms protested that award, and on March 31, the Government Accountability Office ruled that even though the Forest Service needs more airtankers than it currently has on contract, multiple suppliers are capable of supplying the aircraft, so they must be given a chance to bid for the work.

The Forest Service and tanker operators are focused on qualifying additional aircraft for the upcoming fire season. Aero Air President Kevin McCullough says his firm's two MD-87s will be ready to begin fighting fires in June. Minden Air plans to get its plane into action this year, but did not predict exactly when. Aero-Flite of Kingman, Ariz., declined to comment on the status of the firm's effort to qualify two British Aerospace Avro RJ85 regional jets.

If the planes aren't ready, the service might again have to turn to friends for help. In 2013, the agency called in tankers from the Canadian government, the Air Force and the state of Alaska. The Forest Service maintains eight sets of 3,000-gallon retardant tanks, known as Modular Airborne Firefighting System, designed to be rolled into the cargo doors of military C-130 cargo jets it borrows from the Air Force when it needs to supplement its tanker fleet.

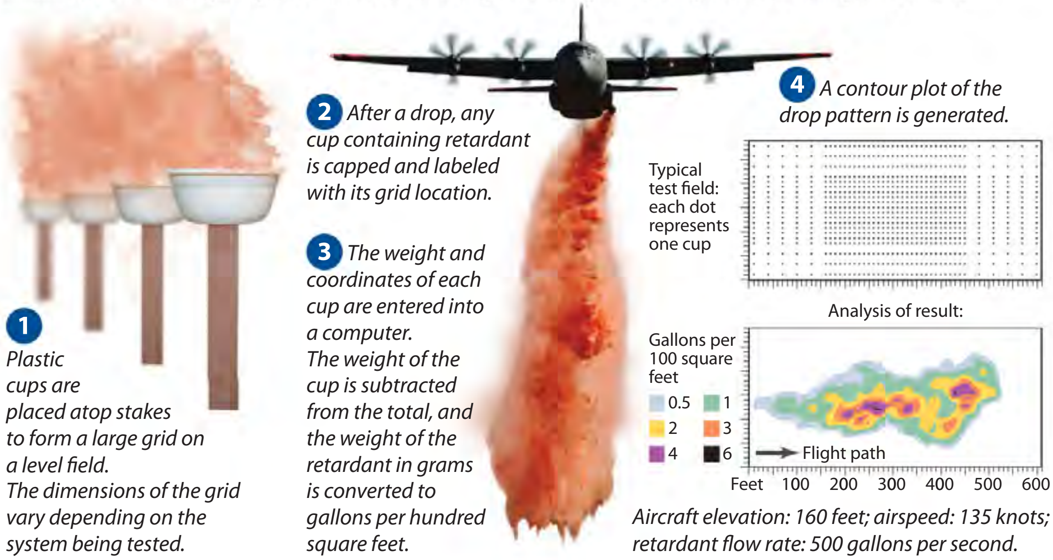
> **"Terrain, wind, poor visibility due to smoke and the fact that the aircraft is fully loaded, maneuvering all over and not far from stall speed makes the job quite risky."**
>
> **— Jerome Laval, veteran airtanker pilot**

The Forest Service is about to get its own fleet of C-130s. Sens. John McCain of Arizona and Dianne Feinstein of California wrote language in the 2014 National Defense Authorization Act signed into law in December to transfer seven surplus U.S. Coast Guard HC-130Hs to the Forest Service. Before those aircraft can fight fires, however, they need to be structurally reinforced and fitted with retardant delivery systems, a process this is expected to take years.

The Forest Service calculates that the commercial fleet will need to include a total of 18 to 28 large airtankers to adequately meet demand. It won't know the exact

FINAL EXAM

Before a new airtanker can be tried out on an actual fire, it must pass the cup-and-grid test, a series of flights to evaluate its ability to make multiple equal-volume retardant drops in a straight line, a key tactic for walling off a wildfire.



Source: U.S. Department of Agriculture

Graphic by John Bretschneider

number until it sees how well its new aircraft perform in action.

Those planes have to pass seven to 14 days of grid tests before they can go to field trials. The Forest Service measures and graphs the ability of tankers to drop retardant on a specific location and also their ability to vary the thickness of the retardant. A gallon per hundred square feet might suffice to block the path of a fire burning across a grassy field. A dense forest might require eight gallons per hundred square feet.

"If the aircraft is performing well and workers have no problems, we might be able to do six or even eight drops in a day," says Ryan Becker, mechanical engineer at the Forest Service's San Dimas Technology and Development Center. "Typically we do three or four a day."

To lay down retardant in the right area and correct amount, pilots carefully control their altitude and airspeed. "When you come down to make a drop, you have to be at the proper height — 150 feet is ideal — and flying between 120 and 140 knots max," says veteran tanker pilot Jerome Laval. "Terrain, wind, poor visibility due to smoke and the fact that the aircraft is fully loaded, maneuvering all over and not far from stall speed makes the job quite risky."

Once the drop is made, pilots face another daunting challenge. After releasing between 20 percent and 50 percent of the aircraft's total weight in five or six seconds, they have to carefully control the aircraft to prevent it from rising very quickly. "It's very similar to military tactical missions," says 10 Tanker President Rick Hatton, a retired U.S. Marine Corps F-4 pilot. "You have to get rid of a lot of weight and put it at the right spot at the right time."

NEW TECHNOLOGY

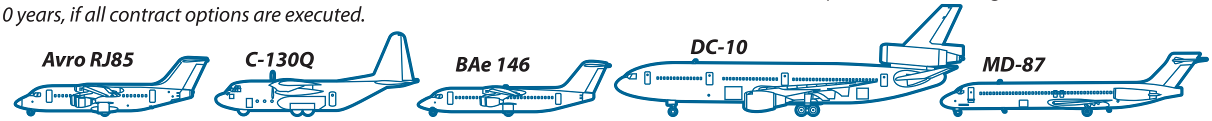
In the 1990s, companies began using computers to control the opening of the tanker's doors and produce a constant flow of retardant. That technology is still widely employed, but advances are on the way. "We are at the cusp of seeing the next wave of improvements," says the Forest Service's Becker.

Neptune Aviation, a longtime airtanker operator for the Forest Service and other agencies — but not one of the five firms chosen in May 2013 to provide the service with next-generation airtankers — plans to equip five of its BAe 146 jets with active fluid control systems by this summer. The Neptune Aviation system adjusts the flow rate based on the aircraft's speed, pitch, altitude and gravitational force, says Dan Snyder, the company's chief operating officer. "It makes sense that active control systems will provide an improvement, but right now we don't have any field results to prove it," Becker says. "Everyone is excited to see the results we get from these systems. If they offer a clear improvement, you will see future requirements reflect that."

On the military C-130Q that Coulson Aviation flies for the forest service, the company augmented the fluid control system with GPS to help the plane hit its targets. Coulson found the C-130Q — a model of the four-engine turboprop equipped with a very low frequency antenna for Navy reconnaissance and submarine communications — on display in a Wisconsin museum after it was retired from service for the Navy and NASA. Coulson bought a constant flow tank called a Retardant Air Delivery System from Aero Union, a defunct aircraft operations and maintenance company based in Chico, Calif. Coulson redesigned

MODERN AIRTANKERS

The Forest Service awarded contracts in June 2013 to convert the airframes below into seven airtankers. The private fleet could grow to 21 aircraft over the next 10 years, if all contract options are executed.



Shown to scale	Avro RJ85	C-130Q	BAe 146	DC-10	MD-87
Number	Two	One	One	One	Two
Description	Updated version of the BAe 146-200 regional airliner	Lockheed-built military transport aircraft	Regional jet airliner built by BAe Systems	McDonnell Douglas wide-body commercial airliner	Part of the McDonnell Douglas MD-80 series of commercial airliners
Contractor	Aero-Flite, Kingman, Ariz.	Coulson Aircrane, Portland, Ore.	Minden Air, Minden, Nev.	10 Tanker Air Carrier, Albuquerque, N. M.	Erickson Aero Tanker, Hillsboro, Ore.

Source: Aerospace America research

Graphic by John Bretschneider

Tradeoff: The DC-10's fire retardant capacity dwarfs that of its competitors. But the plane's size sometimes prevents it from landing at smaller airports where its rivals can operate.

U.S. Forest Service

and enlarged the 3,000-gallon tank to hold 3,500 gallons. Engineers are now working to further expand the tank to hold 4,000 gallons and linking GPS to the controller to allow aerial firefighters to plug in the latitude and longitude of their intended target and have the tank automatically open at the targeted location. The Next-Gen GPS controller is designed to vary the flow rate based on the aircraft's speed and altitude to ensure the desired coverage level is always achieved on the ground. "There's no other tanking system in the world like it," says Wayne Coulson, company president and chief executive.

Minden Air is linking its retardant delivery system with its aircraft's flight management system to gather data on ground speed as it computes the optimum flow rate.

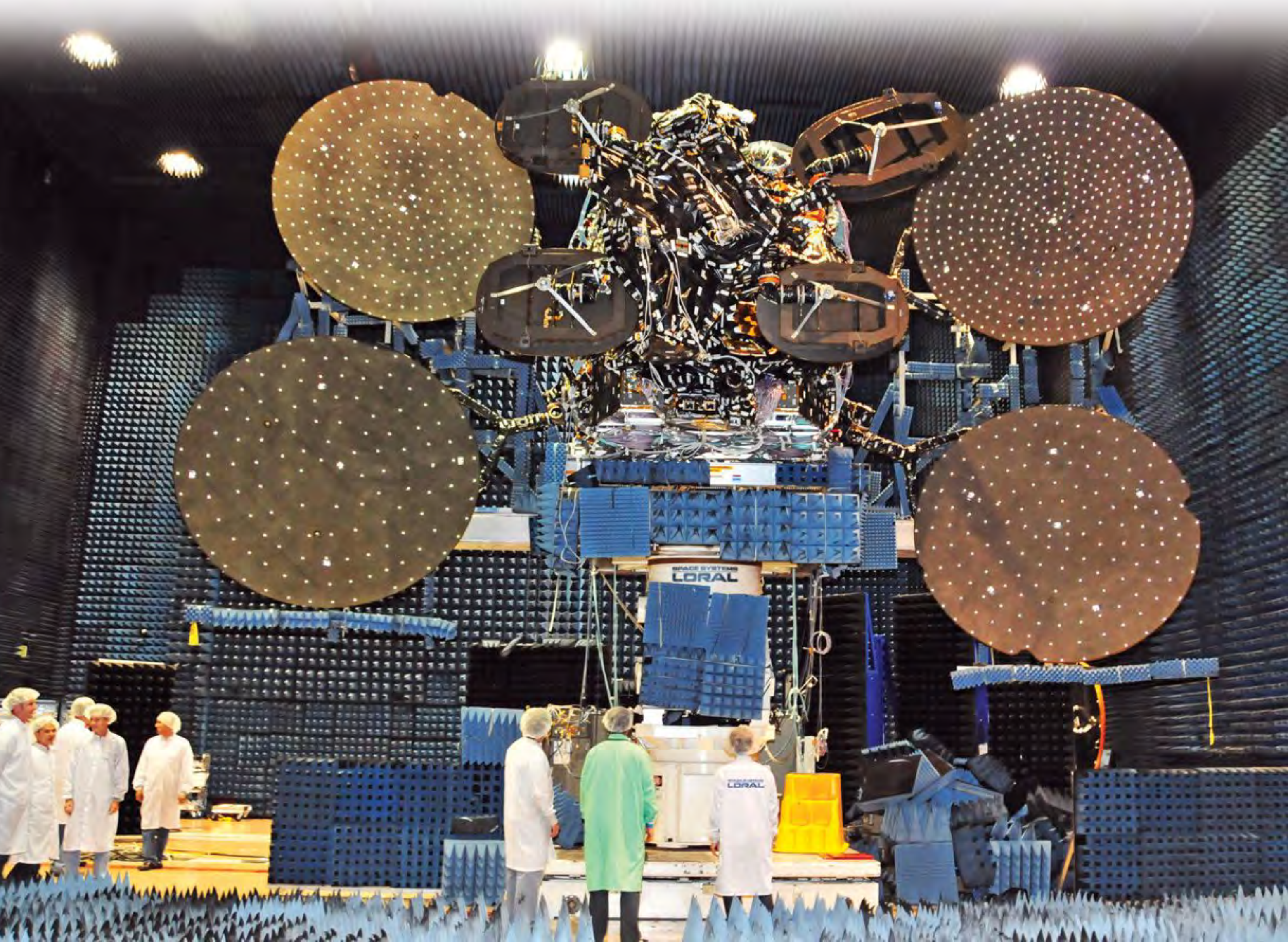
Spreading retardant in a consistent, uniform line is essential, because firefighters on the ground are counting on the retardant to slow the fire's spread and give them time to use bulldozers and fire hoses to establish wide swaths devoid of fuel to contain the flames. "You don't drop retardant on fire," McCullough says. "You drop it on the side, to create a barrier so the fire burns fuel up to the retardant line then quits. You want to build a continuous line."

Fire commanders on the ground determine the location of that line and retardant depth. They give those instructions to the crew of a command and control plane, called the air attack platform, circling over the blaze continuously. The air attack platform — typically a Beechcraft King Air 90GT — relays the ground commander's instructions via radio to successive airtankers. Since GPS is not widely used, the instructions cite geographic features, such as ridge lines and roads, to designate the beginning and end point of each drop. Air attack platforms sometimes release a puff of smoke to designate the spot where each tanker should start and stop spreading retardant.

The Forest Service has long-term plans to operate its own fleet of C-130s, but not as replacements for commercial planes. The service doesn't want to lose the mix of capabilities, innovations and sense of competition that the commercial providers bring. The retardant capacity of 10 Tanker's DC-10, for example, dwarfs that of its competitors. Each aircraft can hold 11,600 gallons of retardant in V-shaped tanks attached to the center line of the aircraft's belly. The tradeoff is that the planes can't take off and land at some of the smaller airports where its competitors can operate. Erickson Aero Tanker's MD-87s hold 4,000 gallons of retardant while taking off and landing at 99 percent of the air bases that company officials have been asked to evaluate, McCullough says.

"Fire is a very complex thing," Becker says. "There isn't ever going to be one way to fight it that's effective all the time. You have to have a lot of different ways to approach it."

WiFi



Testing the antennas on the ViaSat-1 satellite at Space Systems/Loral in Palo Alto, Calif. The satellite is beginning to provide WiFi for JetBlue passengers.

goes airborne

Time spent aboard airliners could be getting a whole lot better for those who can't live without broadband Internet. Natalia Mironova explains the satellite technology and aircraft upgrades that will revolutionize connectivity for air travelers, provided a sound business plan can be found.

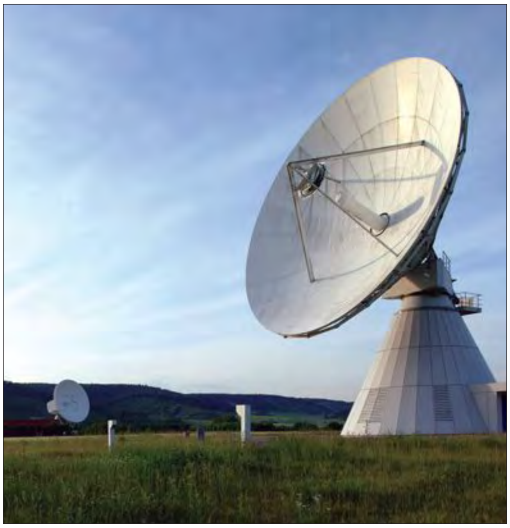
Jim Cramer, the spirited host of CNBC's "Mad Money," told his viewers he wants to watch Netflix while he is traveling by air, and he ventured an upbeat market prediction: The business of inflight WiFi is "growing like a weed," and is "expected to expand fifteen-fold over the next decade, from a $350-million business to a $5-billion business," Cramer told viewers.

While Cramer may be excited about the state of in-flight WiFi as an investor, as a customer he must be feeling quite the opposite. The current state of Internet connectivity offered to passengers on most commercial flights is expensive and slow. "They are good enough to say 'I am connected' but not good enough to satisfy the modern mobile device or modern traveler's needs," says ViaSat's Don Buchman, the vice president in charge of the California company's new in-flight WiFi service, called Exede.

Most airliners connect passengers to the Internet via antennas on the bellies of their planes and cellular towers on the ground. Because a limited amount of spectrum is allocated for those towers, the bandwidth must be shared by potentially hundreds of passengers on any planes within range of the towers. If a flyer wants to use Netflix he'll need to hope that nobody else in the air was planning to catch up on "The House of Cards."

SSL

But what if the airliner — or a cruise ship for that matter — had an antenna pointing upward toward a 7,000-kilogram geosynchronous satellite designed to do the job of many cell towers? Next-generation satellites launched recently or in development for Inmarsat, Iridium and Intelsat, among others, are designed for exactly that kind of broadband connectivity. They provide two-way communications over dozens of spot beams that dice up and reuse the radio spectrum allocated to the satellite. Interference is avoided through physical separation of the beams. A good example is ViaSat's 6,740-kilogram ViaSat-1 spacecraft positioned over North America and now starting to provide Internet to passengers on JetBlue planes. ViaSat says the satellite's 130-gigabit-per-second total capacity instantly eclipsed "all other satellites over North America combined." ViaSat is not alone in sensing a lucrative new market. Inmarsat of London has begun launching high-capacity satellites and Intelsat of Luxembourg plans to start doing so next year.



Intelsat

Intelsat's teleport at Fuchsstadt, Germany. The company sees sharply rising demand for broadband connectivity.

It will be up to the airlines and cruise ship companies to develop business models that will deliver the coveted high-speed connectivity to their customers in an effective and cost-efficient manner.

by Natalia Mironova

Battle over broadband tech

Space Systems/Loral says it will try to overturn a federal court's award of $283 million in damages to its onetime customer, ViaSat. The companies have been locked in a patent infringement dispute over broadband technology aboard the ViaSat-1 satellite, which was built by SSL and is beginning to provide WiFi to JetBlue passengers. ViaSat accused SSL of infringing patents describing how to operate multibeam satellites, avoid interference and organize ground gateways. SSL will work to "overturn the verdict in post-trial motions and if necessary, through the appeal process," President John Celli said through a spokeswoman. ViaSat wants an injunction that would prevent SSL from making or selling satellites with the technology. Expect more legal action in August. *Ben Iannotta*

The satellite operators are confident this will happen, because consumers are expecting the same kind of WiFi experience at sea or in the air as they have on terra firma: "You don't even realize you're connected to the Internet, it's kind of like breathing air," as ViaSat's Buchman puts it. And who wants to hold their breath on a cross-country flight?

If a revolution is underway, it's one that will require installation of new equipment on large numbers of airliners. Honeywell Aerospace, for example, is partnering with Inmarsat to develop, produce and distribute the radomes, antennas and terminals that will connect jets to Inmarsat's new Ka-band Global Xpress, or GX, constellation, which will consist of three new geosynchronous satellites, the first of which was launched in December with two additional launches planned by the end of the year.

Surge in demand

To gauge the market, Honeywell surveyed consumers in 2013. The survey concluded that "almost 90 percent of fliers would give up an amenity on their flight — preferred seats, extra legroom and more — to be guaranteed a faster and more consistent wireless connection." Air travelers also said they expect the same quality of the wireless connection they experience at home or in the office.

Intelsat, for one, sees the same trend: "The amount of bandwidth needed in terms of connectivity is going through the roof, and that has been the real focus of Intelsat's business: How [to] service that demand in the most appropriate way by providing the bandwidth at the right price and in the right locations," says James Collett, director of mobility services at the Luxembourg-based Intelsat.

Cruise lines operating out of range of cell towers are also struggling to keep their passengers connected. Eric Merz is the director of guest mobility services for Carnival Cruises, the world's largest cruise ship company (based on the number of passengers carried), and he says connectivity on a cruise ship is even more critical than it is on an aircraft: "For the most part you are typically on a plane for a few hours; that isn't that earth-shattering to be disconnected for that period of time. But you tell people they are going to be disconnected for a week, for some people that's a deal breaker for a vacation," he says.

According to Merz, Carnival currently offers its passengers and crew some options to connect, but they come at a price — 75 cents per minute, and the connection speed is not ideal. Carnival has resorted to tricks like cacheing the most popular sites, like CNN or ESPN, for instance, on the ship using an appliance called a "riverbed" to optimize traffic and limit the need to connect to the original IP address.

Intelsat calls its high-capacity satellite design Intelsat EpicNG. Two EpicNGs are scheduled for launch in 2015, one built by Boeing and the other by Airbus Defense and Space, formerly Astrium. Boeing also is manufacturing an EpicNG for launch in 2016, and is on contract to manufacture three

JetBlue

Partnership: Working with ViaSat, JetBlue plans to finish equipping its Airbus fleet with satellite Internet by the end of the year.

Airbus

The GX antenna, built by Honeywell for Inmarsat's Global Xpress satellite constellation, is located inside the radome atop this Airbus A350 aircraft.

more. The satellites employ frequency reuse by using the same frequency in different spot beams serving different locations. The more frequency reuse supported, the greater the total bandwidth that can be delivered through a given allocation of spectrum.

Intelsat works with cruise ships and airlines, and for both markets the strategy is to place the satellites over the most trafficked routes — the North Atlantic corridor for aircraft and the Caribbean for cruise ships. “The more you can concentrate your coverage, the more you can increase the bandwidth to the mobile users in that region,” says Collett. With its fleet of over 50 satellites, Intelsat can do just that. “We've got a very sizeable fleet, which provides a great deal of global reach, which is fundamental to a cruise ship moving around the world or to an aircraft,” he says.

The EpicNG satellites will provide C and Ka-band capacity, but also the tried-and-true Ku frequency band, which has been the standard for satellite transmissions for the last two decades. Collett says this continuity allows customers to upgrade to a higher class of service while avoiding the costly hardware upgrade. Users can tailor their networks with the frequency and application combination that best fits their needs.

Who pays

The cost of the hardware required for satellite connectivity could be a hurdle, experts say. Outfitting each aircraft with the required antenna will set the airline back several hundred thousand dollars and take the plane out of circulation for several days, perhaps a week. The cost is relative, says ViaSat's Buchman: “I would say it's not that expensive. It's probably at least 10 times cheaper than doing in-flight entertainment systems with seat-back TV devices that you have on international routes. It's really not that expensive if you look at it in the context of what you're getting [compared to] what the other available technologies and offerings are for airlines.” And the size, weight and power required for the antennas is coming down, according to Wayne Plucker, aerospace and defense industry research manager at the consulting firm Frost & Sullivan:

(Continued on page 43)

Just hit print

In the late 1950s and early '60s, a manufacturing revolution unfolded in what we now call Silicon Valley. NASA wants to work a similar magic, this time in the area of additive manufacturing and 3D printing. Edward Goldstein, a former NASA lead writer, looks at the research and the promise.

3D printing with plastic or metals could enable far bolder space exploration missions, or the technique could go down as a novel but largely impractical idea. In NASA's view, there's only one way to find out. The agency is funding research to test the feasibility of this and other additive manufacturing techniques for making aerospace components on Earth, aboard the International Space Station, in open space, or on the moon or Mars.

NASA has always been a driver and user of new technology. It was NASA's specific need for advanced integrated circuits for the Apollo moon missions that set the stage for the boom in circuitry production in Silicon Valley. Some of the 3D work is playing out there in support of the broader Obama administration-sponsored "America Makes" manufacturing initiative. Additive manufacturing refers to making 3D objects by laying down material a layer at time according to a digital blueprint. The research reflects the agency's renewed focus on technology development under administrator Charles Bolden. When NASA's Constellation human spaceflight program was on the books, NASA "just didn't have the funding or resources to be looking at lower level technologies," says Andrew Keys, the chief technologist at NASA's Marshall Space Flight Center.

With so many 3D projects underway, the National Research Council's Aeronautics and Space Engineering Board has launched a study to explore additive manufacturing for space applications. "We're specifically looking at the possibilities as well as the technical challenges of taking this technology out into space," says Dwayne Day, the board's senior program officer. "I think one of the things that we are learning is that for some applications this is a promising technology, but it's promising within a somewhat limited range. It's never going to be a complete re-

Made in Space team members monitor 3D printers aboard a Boeing 727 modified by Zero Gravity Corporation to simulate microgravity.

NASA

placement for traditional assembly and integration in space."

Parts made in space

3D printing is scheduled to be tried aboard the space station later this year when a SpaceX Dragon cargo module arrives in August with equipment for a demonstration called the 3D Printing in Zero-G Experiment. The printer was built by Made In Space, a 24-person company in Mountain View, Calif., in cooperation with NASA Marshall under a Small Business Innovative Research contract. Astronauts will use the station's Microgravity Science Glovebox to initiate the printer's production of simple plastic objects, such as wrenches or specimen containers. The printer will use extrusive additive manufacturing, in which layers of polymers or other materials are laid down according to computerized 3D patterns. They'll be returned to Earth for inspection alongside parts manufactured on the ground.

"Our goal is to help people build experiments, fix things that need fixing and give a really good go at exploration," says Michael Snyder, Made In Space's lead de-

by Edward Goldstein

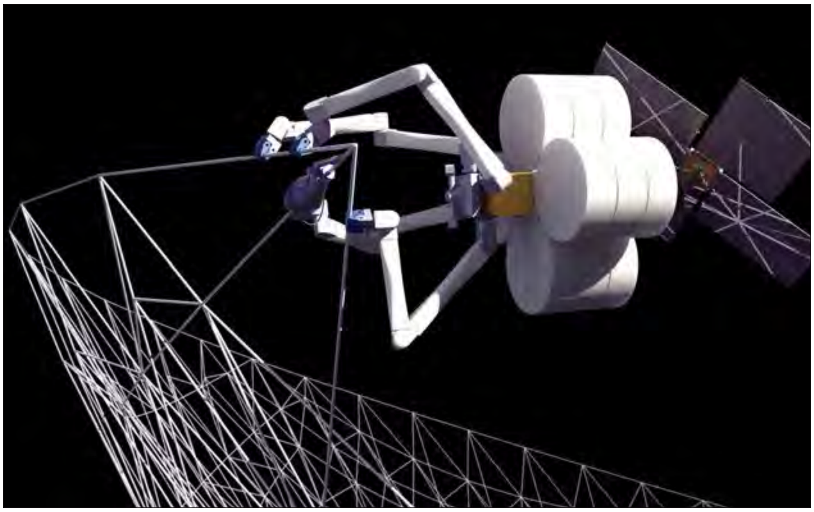
sign engineer and director of research and development. If all goes as planned, a more sophisticated 3D printer will be carried to the station in 2015, and it will become "a full-time facility that's open to anybody to make anything they want on the station," Snyder says. That could mean parts to fix or upgrade space station experiments, or parts made for educators and researchers who want to try the technology.

The Replicator could be here. NASA is watching progress under a small business grant awarded in May 2013 to the Systems and Materials Research Consultancy in Austin, Texas, to study the feasibility of 3D printing for making food in space. A likely first menu item: pizza.

The space station isn't the only option for additive manufacturing in space. Tethers Unlimited, Inc., of Bothell, Wash., has been working since 2012 under a NASA Innovative Advanced Concepts contract to develop a technique for making multifunctional spacecraft structures in open orbit. In March, TUI received a NASA small business contract to continue developing its proposed spaceborne "Trusselator," a device that would automatically extrude layers of material to form lightweight carbon fiber truss structures. These would be robotically assembled into solar arrays, antennas or other components. The Trusselator is part of the company's plan to launch what it calls "self-fabricating satellites." Raw materials would be launched, and then the Trusselator would get to work forming structures out of it. A gangly SpiderFab robot would crawl across the pieces to attach them together. The technique is described in the September 2013 AIAA paper, "SpiderFab: An Architecture for Self-Fabricating Space Systems."

TUI's CEO and chief scientist Rob Hoyt says the approach could give spacecraft designers a new level of freedom: "We're focused on being able to create space system components that are much bigger, much higher performance than could possibly fit into any of the available launch shrouds," he says. "We hope to be able to do an initial [on-orbit] demonstration mission within a couple years."

Construction help: Tethers Unlimited's SpiderFab robot, seen here in an artist's rendering, would crawl across large parts made in space, attaching them to each other to form larger structures.



Tethers Unlimited

The challenge of metals

Given the strength and temperature limitations of plastics, other researchers hope to show the feasibility of 3D printing with metal. It won't be easy. On Earth, some metals are made by spraying powder out a nozzle and melting it with lasers. "In space, you can't really use the powder, because it would float all over the place," says Day of the National Research Council.

Researchers at NASA's Langley Research Center say they might have a way around the problem. They're working on a technology they call EBF3, for Electron Beam Freeform Fabrication. An electron beam gun melts two strands of wire into a 3D shape a layer at a time. No molds or tooling dies are necessary, and the process takes hours, not days or weeks, proponents say. "The thing we like about this application for space is that it's not a powder bed [printing] system that you obviously may have difficulty with in a vacuum," says David Dress, deputy director of Langley's Space Technology Program Office.

A big challenge was the size of the system. It once took up a small room but has been reduced to the size of a table top, making it "more appropriate for space," Dress says. The system has been shown to work aboard a zero-G aircraft, and will provide "the opportunity to show the value in creating parts that could be usable in an environment like the space station and eventually on the moon and Mars," Dress adds.

Keith Belvin, Langley's chief technologist, says the technique would be applied only when required. "It's not just that we like metal 3D manufacturing. I'm actually a fan of the plastics and advanced materials systems also. But there are some parts where you need the strength of metals."


Contour Crafting

Print your house: The Contour Crafting machine developed at the University of Southern California releases quick-setting concrete to build structures layer by layer. The method could someday be used to build huge structures on the moon.

Rocket engines and satellite sensors

Many additive manufacturing advocates say great promise has been shown for Earth-based aerospace manufacturing. Last year, NASA Marshall generated a record 20,000 pounds of thrust when it tested a liquid oxygen and gaseous hydrogen injector made by laying down nickel chromium in a laser sintering process. The part, made by Directed MFG, Inc., of Austin, Texas, is similar in design to injectors for large engines, such as the RS-25 engine for the Space Launch System. "We're still going through the data on how the test progressed and what the results were, but all indications are that this is a good way of being able to reduce the cost of building engine components," says Keys, the Marshall chief technologist. "Ultimately I think additive manufacturing is going to be a substantial part of bringing engine costs down, increasing the quality of components and being able to more rapidly make them."

At NASA's Goddard Space Flight Center in Maryland, researchers are exploring 3D printing for highly customized spacecraft and instrument components, and for applications such as removing heat from spacecraft electronics, protecting circuitry from radiation, and building sensors, lighter structures and optics for space instruments. Additive manufacturing would have advantages for complex components, says Ted Swanson, the assistant chief for technology in Goddard's Mechanical Systems Division. An example might be a gamma ray sensor, which requires an insulator, conductor and very precise micro holes. "This is something you'd probably do with traditional manufacturing, but it would be very labor intensive and extremely expensive and take a lot of time too," he says. "In the additive manufacturing process, you could try something out quickly, then determine whether the basic idea works correctly or not and proceed to building the final article. That's one of the big benefits for additive manufacturing – a fast turnaround for one-of-a-kind projects. And we do a lot of that around here."

Building structures on the moon and Mars

One of the bolder in-space additive manufacturing concepts is the idea of robots fabricating large structures on the moon and Mars. Behrokh Khoshnevis, a professor of industrial and systems engineering at the University of Southern California, has received NASA Innovative Advanced Concepts funds to research this idea with the Swamp Works lab at NASA's Kennedy Space Center. Khoshnevis has developed a method he calls "Contour Crafting," in which layers of quick-setting concrete are laid down under computer control. Khoshnevis wants to use the technique on the moon or Mars to make structures including landing pads and walls to shield humans from radiation.

"The Contour Crafting machine would basically be a robotic arm sitting on some kind of rover," he says. "The rover does not have to be too big, because it can move around and also can raise itself. So therefore we can build pretty high structures and pretty large ones." He says lab tests have "demonstrated the validity" of the approach. For lunar applications, "we are proposing to take the lunar soil and melt it, much like flowing lava in volcanic situations on Earth, and extruding it directly," he explains. Next, he wants to demonstrate the fabrication process with a stationary robot to build a structure that would be four or five meters thick.

NASA's spending on 3D printing research is receiving high-level, if qualified, support. "Additive is not going to be the be-all for everything. But it's right now undergoing a revolution where it's going to be useful for many things," says LaNetra Tate, principal investigator for the Game Changing Development Program within NASA's Space Technology Mission Directorate. "We want to invest in the technology that's going to help drive our missions and support our stakeholders. We also want to be on the cutting edge and help industry and academia accelerate technology where they can't do it by themselves, and NASA can play a supporting or leading role."

When it comes to in-space applications, there are still tough questions to be answered, for example about the power requirements for large-scale manufacturing in space and whether new materials can be mass produced with adequate quality controls. The good news, advocates say, is that the planning required for future human missions will provide plenty of time to conduct test bed studies within a long-term strategy of support to NASA's mission.


Made in Space

Jason Dunn, left, and Mike Snyder of Made in Space work on the 3D printer, scheduled for launch on a SpaceX Dragon module in August.

WiFi goes airborne

(Continued from page 37)

The expense is "only marginally higher than the air-to-ground solution," he says.

Still, there is an ongoing discussion about who will end up paying for the new technology. "The passengers will [be willing to] pay, but only so much," says ViaSat's Buchman. Some airlines may choose to invest in high-speed broadband and offer it to the passengers as an amenity, like soft drinks or peanuts. "We think that model has pretty good, strong legs to it, because that's how the airline builds its brand; the airlines have gone from competing on price to competing on value, which is the value of their amenities," he explains.

Intelsat's Collett says each airline will have to figure out a business plan based on its marketing strategy and its place in the market: A regional carrier is more likely to opt for a cheaper (and slower) Internet solution and charge the passengers for it, whereas an international carrier operating trans-oceanic flights might choose to offer the high-speed broadband for free. There may also be some interest from third-party content providers like Google or Yahoo to capitalize on the "captive audience" an aircraft full of Internet users will provide.

While the specifics of how to make connectivity fit into the airlines' business models are still being discussed, "what's clear is connectivity is now very much in the mix of the criteria that passengers are applying when they are deciding who their carrier is. And therefore it certainly has the focus of the airlines right now," says Collett.

Changing the landscape

JetBlue is betting on its investment in satellite connectivity to give it an edge. The company partnered with ViaSat in a deal that will have its Airbus fleet outfitted with Ka-band aeronautical terminals — which include a modem, an antenna and radome for high-speed satellite Internet — by the end of this year. The airline's Embraer 190s will follow closely behind. Currently the Fly-Fy Internet connectivity, as the company is branding it, is offered for free under the Simply Surf plan that allows basic web browsing and limited media use. For streaming movies or other applications requiring higher bandwidth, there is Fly-Fy premium, which costs $9 per hour.

"Customers love it and offer compliments highlighting its speed, convenience, and reliability. It was important for us to ensure we offered enough bandwidth so that every customer on a flight could connect simultaneously without feeling an impact to service," says Jamie Perry, JetBlue's director of product development, in an e-mail. Being able to offer high-speed connectivity to every passenger on the plane at the same time is one of ViaSat's major selling points: "We're changing the landscape from 'it's a precious commodity,'" says ViaSat's Buchman, "to 'anyone who wants to use it should be able to use it.'" ViaSat's service is also available on some United Airlines flights, and the company is gearing up to launch a Europe-Middle East service with El Al airlines next year, working with the France-based Eutelsat.

Intelsat

Intelsat's Epic 29e satellite, scheduled for launch in 2015, will allow customers to shift to higher-grade service without costly hardware changes, the company says.

Some industry experts argue that while the airlines will have to choose which technology is worth the investment, whether or not to provide connectivity on their planes is not really much of a debate. Advocates predict in-flight WiFi will one day be standard, like an in-flight snack. "The expectation is certainly already there. And I think the challenge for the satellite industry is to deliver that capability in a simple and cost-effective manner that allows all the airlines to adopt it," says Collett. Frost and Sullivan's Plucker says it's all a numbers game: "The longer the airlines are in profitable mode, which they finally are again, the more likely they are to make this investment. If they catch another downturn — don't hold your breath.

Out of the

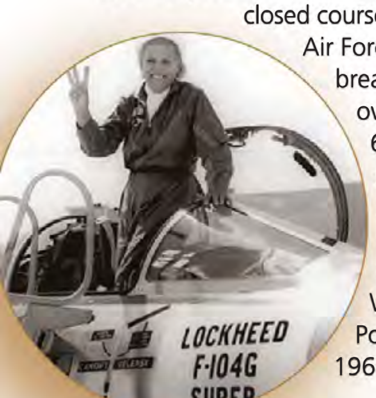
25 Years Ago, June 1989

June 14 The Titan 4 expendable launch vehicle lifts off on its inaugural flight carrying a military early warning satellite to geostationary orbit. The Titan 4 is a new generation of heavy lift rockets. NASA, Astronautics and Aeronautics, 1986-1990, Pages 219, 320.

June 19 NASA announces Voyager 2's discovery of a 6,200-mile-wide storm on the planet Neptune comparable to the Great Red Spot on Jupiter. The find occurs when the space probe is 58.98 million miles from Neptune. The following month the probe discovers a third moon of Neptune and dark atmospheric bands around the planet's south pole. Three more moons and a ring around Neptune are found by August. NASA, Astronautics and Aeronautics, 1986-90, Pages 220, 223, 227-228.

50 Years Ago, June 1964

June 3 Jacqueline Cochran claims her third speed record in less than a month when she flies an F-104G fighter at 1,135 mph over a 500-kilometer closed course at Edwards Air Force Base, breaking her own record of 680.75 mph, set over the same course in 1961. Washington Post, June 5, 1964.



June 5 The U.K. launches its Blue Streak rocket from the test range at Woomera, Australia. Initially designed as a medium-range ballistic missile, the Blue Streak has been chosen as the first stage of a three-stage launcher, Europa 1, for the European Launcher Development Organisation. The Blue Streak reaches an altitude of 110 miles and a top speed of 6,400 mph. However, the engines cut off prematurely and the rocket falls 382 miles short of the planned impact area. The Blue Streak is later canceled. New York Times, June 6, 1964; Flight International, June 11, 1964, Pages 952-953.

June 8 Valentina Nikolayeva-Tereshkova, the first woman to fly in space and the wife of cosmonaut Andriyan Nikolayev, gives birth to a daughter. Tereshkova piloted the USSR's Vostok 6 spacecraft on June 16, 1963. Flight International, June 18, 1964, Page 1039.

June 17 Ling-Temco-Vought unveils its new XC-142A vertical and/or short takeoff and landing aircraft at its Dallas plant. Built for the Army, Navy and Air Force, the aircraft has four turboprop engines that act like helicopter rotors during takeoffs and landings. But when the plane is aloft, its propellers and wings are placed in conventional positions and it can attain a top speed of more than 400 mph. U.S. News and World Report, June 29, 1964.

June 17 The experimental French two-stage Rubis (Ruby) sounding rocket is launched for the first time at the French test site at Hammaguir in Algeria. The rocket reaches an altitude of 1,118 meters, carrying scientific instruments to measure phenomena at peak altitude. D. Baker, Spaceflight and Rocketry, Page 168.

June 20 The huge M-1 liquid-oxygen/liquid hydrogen Aerojet rocket engine, designed for 1.5 million pounds of thrust, undergoes its first test firing and reaches 800,000 pounds of thrust. But the firing is cut short by a malfunction in the liquid oxygen system, attaining only 1.6 seconds instead of 3 seconds and 1 million pounds of thrust as planned. Aviation Week, June 29, 1964, Page 25; Missiles and Rockets, June 29, 1964, Page 11.

June 23 The Army Map Service announces it has completed a topographic lunar survey that is the first to show extremely fine variations in the moon's surface elevations. Considered the best lunar map to date, the survey covers an area of about 8 million square miles. D. Baker, Spaceflight and Rocketry, Page 168.

June 26 The Curtiss-Wright experimental tilt-rotor X-19 vertical takeoff and landing aircraft makes its first trial flights in a series of short tests. Aviation Week, July 6, 1964, Page 278.

June 30 The first in a series of Sikorsky YCH-54A Skycrane twin-engine heavy-lift helicopters is delivered to the Army's Aviation Materiel Command. Eventually, the Army purchases some 105 of the versatile aircraft, designating them CH-54. They are later used in the Vietnam War for transport and for retrieval of downed

Past

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

aircraft. Flight International, July 9, 1964, Page 40, and July 23, 1964, Page 123; Sikorsky YCH-54A Skycrane file, National Air and Space Museum.

75 Years Ago, June 1939

June 1 The Focke-Wulf Fw 190V-1 prototype makes its inaugural flight at Bremen, Germany. Designed by Kurt Tank, the plane becomes one of the outstanding radial-engine fighters of World War II. J. Smith and A. Kay, German Aircraft of the Second World War, Pages 173-175.

June 17-18 Flt. Lt. Nicholas Comper, creator of the Comper Swift and Comper Scamp light aircraft, is murdered during the night in Kent, England. Details are not given in the press. Interavia, June 20, 1939, Page 7.

June 20 Flying his Heinkel He 176 from Peenemunde airfield in Germany, test pilot Erich Warsitz completes the first successful flight of a rocket-powered aircraft. The plane's Hellmuth Walter HWK-RI-203 rocket motor produces approximately 1,500 pounds of thrust. The aircraft reaches a top speed of 494 mph on its initial test. Later flights increase the maximum speed to 528 mph. Heinkel Press Release, April 1939.

June 23 The Distinguished Flying Cross is awarded to Capt. Franklin C. Wolfe of the U.S. Army Air Corps for his "extraordinary achievement" in having flown medical supplies to earthquake victims in Chile the previous January. Aircraft Year Book, 1940, Page 433.

June 24 Pan American Airways' Boeing 314 Yankee Clipper flies the first North Atlantic air mail service on the northern route, via New Brunswick, Newfoundland, Ireland and England. The plane departed from Port Washington, N.Y., with 2,543 pounds of mail and 20 passengers, including observers and special guests. The total distance is 6,836 miles. Aircraft Year Book, 1940, Page 433.

100 Years Ago, June 1914

June 18 Demonstrations of the Sperry-Curtiss gyrostabilizer fitted on a Curtiss flying boat take place at a meeting on airplane safety, held at Bezons, France. This gyrostabilizer is considered the world's first automatic pilot. Pilot Lawrence Sperry, son of inventor Elmer A. Sperry, is later awarded the first prize of 50,000 francs for the invention at the international airplane safety competition in Paris. Flight, July 3, 1914, Page 712; W. Davenport, "Gyro!" Pages 104-113.

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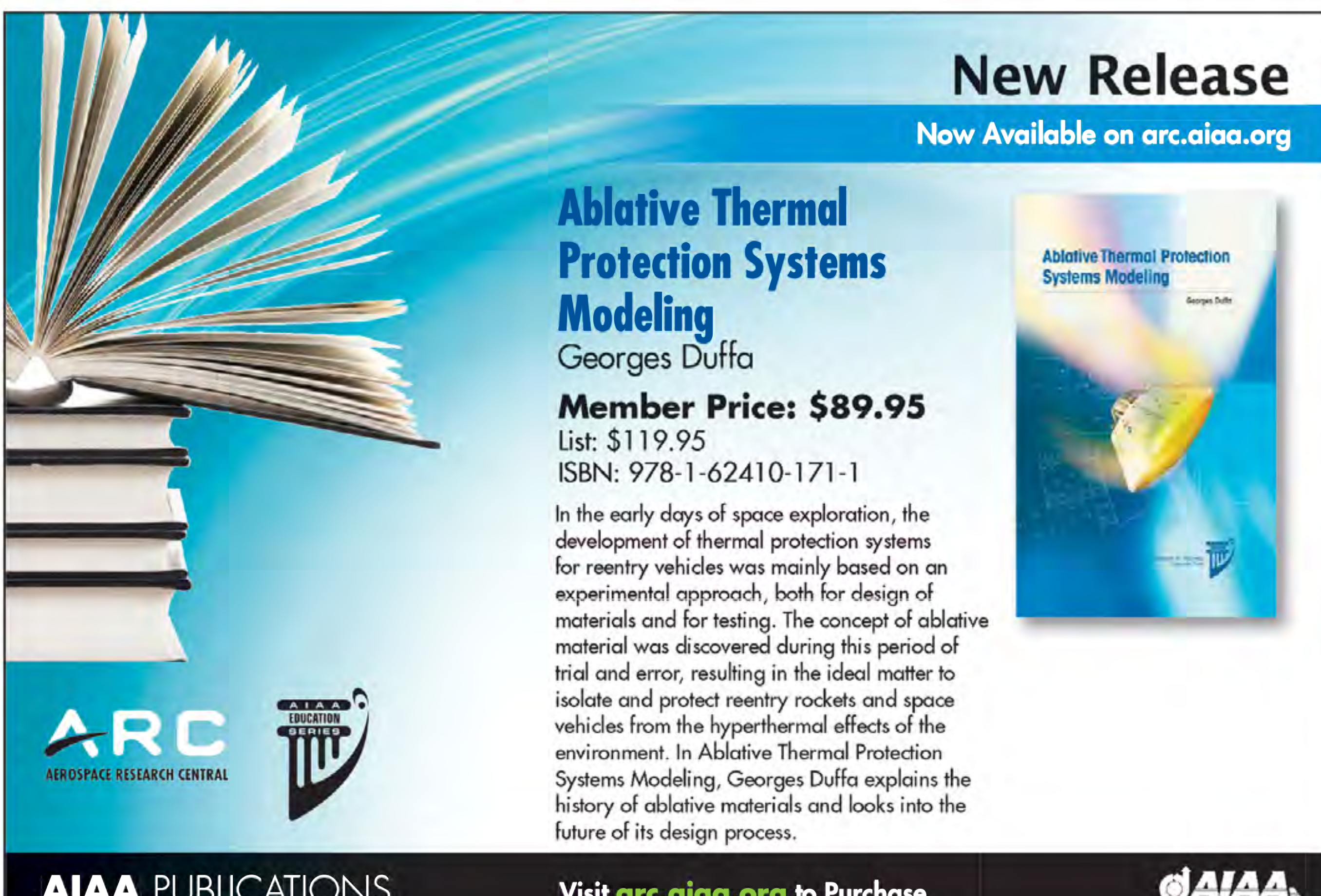

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AIAA Sustained Service Award Presented—**James McBrayer**, Professor Emeritus, Aerospace Engineering at the University of Central Florida in Orlando, FL (far left), received an AIAA Sustained Service Award during the 17 April Central Florida Section's award dinner. McBrayer was recognized "For more than 50 years of sustained, significant service and dedicated contributions to the interests of the Institute." Also pictured are (starting second from left) Jerry Lutz (Sustained Service Award, 2013), Tom Crouch (Distinguished Lecturer), Michael Yarymovych (Distinguished Service Award, 2014), and Randal Allen (Chair, Central Florida Section).

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Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2014			
2–4 Jun†	**Global Space Applications Conference**	Paris, France (Contact: Lisa Antoniadis, +33 1 45 67 68 46, lisa.antoniadis@iafastro.org)	
5 Jun	**Aerospace Today ... and Tomorrow: An Executive Symposium**	Williamsburg, VA	
14–15 Jun	**Third AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III)**	Atlanta, GA	
14–15 Jun	**Business Management for Engineers**	Atlanta, GA	
14–15 Jun	**Optimal Design in Multidisciplinary Systems**	Atlanta, GA	
16–20 Jun	**AIAA AVIATION 2014** **(AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **20th AIAA/CEAS Aeroacoustics Conference** **30th AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **AIAA/3AF Aircraft Noise and Emissions Reduction Symposium** **32nd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **6th AIAA Atmospheric and Space Environments Conference** **14th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Flight Testing Conference** **7th AIAA Flow Control Conference** **44th AIAA Fluid Dynamics Conference** **19th AIAA International Space Planes and Hypersonic Systems and Technologies Conference** **11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference** **21st AIAA Lighter-Than-Air Systems Technology Conference** **15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **45th AIAA Plasmadynamics and Lasers Conference** **7th AIAA Theoretical Fluid Mechanics Conference**	Atlanta, GA	**14 Nov 13**
22–27 Jun†	**12th International Probabilistic Safety Assessment and Management Conference**	Honolulu, HI (Contact: Todd Paulos, 949.809.8283, secretariat@psam12.org, www.psam12.org)	
13–17 Jul†	**International Conference on Environmental Systems**	Tucson, AZ (Contact: Andrew Jackson, 806.742.2801 x230, Andrew.jackson@ttu.edu, http://www.depts.ttu.edu/ceweb/ices/)	
15–18 Jul†	**ICNPAA 2014 – Mathematical Problems in Engineering, Aerospace and Sciences**	Narvik University, Norway (Contact: Seenith Sivasundaram, 386.761.9829, seenithi@aol.com, www.icnpaa.com)	
28–30 Jul	**AIAA Propulsion and Energy 2014** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference** **12th International Energy Conversion Engineering Conference**	Cleveland, OH	**14 Jan 14**
31 Jul–1 Aug	**2nd AIAA Propulsion Aerodynamics Workshop**	Cleveland, OH	
31 Jul–1 Aug	**Hybrid Rocket Propulsion**	Cleveland, OH	
31 Jul–1 Aug	**Missile Propulsion Design, Technologies, and System Engineering**	Cleveland, OH	
31 Jul–1 Aug	**Application of Green Propulsion for Future Space**	Cleveland, OH	
2–10 Aug†	**40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events**	Moscow, Russia http://cospar2014moscow.com/	**14 Feb 14**
3–4 Aug	**Decision Analysis**	San Diego, CA	
4–7 Aug	**AIAA SPACE 2014** **(AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA/AAS Astrodynamics Specialist Conference** **AIAA Complex Aerospace Systems Exchange** **32nd AIAA International Communications Satellite Systems Conference** **AIAA SPACE Conference**	San Diego, CA	**21 Jan 14**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
7–12 Sept†	**29th Congress of the International Council of the Aeronautical Sciences (ICAS)**	St. Petersburg, Russia (Contact: www.icas2014.com)	**15 Jul 13**
25 Sept†	**Acoustic Testing and Upgrade of the LLF—A Symposium Dedicated to Aero-Acoustic Testing on the Occasion of the Finalization of the Acoustic Upgrade of the DNW-LLF**	Marknesse, The Netherlands (Contact: Siggi Pokörn, +31 610 279 923; siggi.pokoern@dnw.aero, www.dnw.aero)	
29 Sep–3 Oct†	**65th International Astronautical Congress**	Toronto, Canada (Contact: http://www.iac2014.org/)	
5–10 Oct†	**33rd Digital Avionics Systems Conference**	Colorado Springs, CO (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)	
22–26 Oct†	**30th Annual Meeting of the American Society for Gravitational and Space Research**	Pasadena, CA (Contact Cindy Martin-Brennan, 703.392.0272, executive_director@asgsr.org, www.asgsr.org)	
3–6 Nov†	**28th Space Simulation Conference**	Baltimore, MD (Contact: Andrew Webb, 443.778.5115, Andrew.webb@jhuapl.edu, http://spacesimcon.org/)	
12–14 Nov†	**Aircraft Survivability Technical Forum 2014**	Laurel, MD (Contact: Meredith Hawley, 703.247.9476, mhawley@ndia.org, www.ndia.org/meetings/5940)	
2015			
5–9 Jan	**AIAA SciTech 2015 (AIAA Science and Technology Forum and Exposition 2015)** **Featuring:** **23rd AIAA/ASME/AHS Adaptive Structures Conference** **53rd AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Infotech@Aerospace Conference** **AIAA Spacecraft Structures Conference (formerly the AIAA Gossamer Systems Forum)** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **17th AIAA Non-Deterministic Approaches Conference** **56th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **8th Symposium on Space Resource Utilization** **33rd ASME Wind Energy Symposium**	Kissimmee, FL	**2 Jun 14**
11–15 Jan†	**25th AAS/AIAA Space Flight Mechanics Meeting**	Williamsburg, VA (Contact: AAS—Roberto Furfaro, 520. 312.7440; AIAA—Stefano Casotto, Stefano.casotto@unipd.it; http://space-flight.org/docs/2015_winter/2015_winter.html)	
26–29 Jan†	**61st Annual Reliability & Maintainability Symposium (RAMS 2015)**	Palm Harbor, FL (Contact: Julio Pulido, 952 270 1630, julio.e.pulido@gmail.com, www.rams.org)	
7–14 Mar†	**2015 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
25–27 Mar†	**3rd Int. Conference on Buckling and Postbuckling Behaviour of Composite Laminated Shell Structures with DESICOS Workshop**	Braunschweig, Germany (Contact: Richard Degenhardt, +49 531 295 3059, Richard.degenhardt@dlr.de, www.desicos.eu	
30 Mar–2 Apr	**23rd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar**	Daytona Beach, FL	**30 Sep 14**
13–15 Apr†	**EuroGNC 2015, 3rd CEAS Specialist Conference on Guidance, Navigation and Control**	Toulouse, France (Contact: Daniel Alazard, +33 (0)5 61 33 80 94, alazard@isae.fr, w3.onera.fr/eurognc2015)	
25–27 May†	**22nd St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia, (Contact: Prof. V. G. Peshekhonov, 7 812 238 8210, icins@eprib.ru, www. Elektropribor.spb.ru)	
22–26 Jun	**AIAA AVIATION 2015 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **21st AIAA/CEAS Aeroacoustics Conference** **31st AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **33rd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **7th AIAA Atmospheric and Space Environments Conference** **15th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Complex Aerospace Systems Exchange**	Dallas, TX	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
	22nd AIAA Computational Fluid Dynamics Conference AIAA Flight Testing Conference 45th AIAA Fluid Dynamics Conference 22nd AIAA Lighter-Than-Air Systems Technology Conference 16th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference AIAA Modeling and Simulation Technologies Conference 46th AIAA Plasmadynamics and Lasers Conference 45th AIAA Thermophysics Conference		
27–29 Jul	**AIAA Propulsion and Energy 2015 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** 51st AIAA/ASME/SAE/ASEE Joint Propulsion Conference 13th International Energy Conversion Engineering Conference	Orlando, FL	
31 Aug–2 Sep	**AIAA SPACE 2015 (AIAA Space and Astronautics Forum and Exposition)** **Featuring:** AIAA SPACE Conference	Pasadena, CA	

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

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

AIAA Continuing Education courses.

From the Corner Office

AIAA'S FUTURE

Jim Albaugh, AIAA President

It's with great respect for the Institute and its members that I write my first note to you as President of AIAA. Your support and confidence is much appreciated. First, I would like to thank Mike Griffin for his terrific leadership over the last two years. Under Mike, the Institute has focused on better serving you through the technical committees, making the hard decisions necessary to improve our financial position, supporting the industry on Capitol Hill, and bringing discipline to the area of governance.

Second, I want to comment on the many successes our industry has had in the past year: the successful flight of the X-51, the carrier landing of the X-47B, the continued success of Space-X, and the ongoing development of multiple new commercial airplanes, to name but a few. Clearly, this is a great time to be an engineer, continuing to push technology and innovation.

People often ask me how the United States, or any country for that matter, can achieve leadership in aerospace. My answer is pretty straightforward: "build the most capable aircraft or spacecraft as measured by the customer."

While that may sound easy, it's not. It takes a significant investment by government, industry, and academia in R&D. One of my concerns is that as a country the United States is not making the investments necessary and will fall behind if this trend is left unchecked. It is an area that the AIAA staff and I plan on making one of our most important issues.

At SciTech in January, you may have heard C. D. (Dan) Mote Jr., president of the National Academy of Engineering, talk about talent being the "Coin of the Realm" and it being a key to the continued success of our country. Together with increased R&D spending, AIAA must focus on what can be done to ensure the best and brightest from around the world come to the United States, just as they have done for decades past.

Another consideration is what AIAA's roll and mission should be in the years ahead and how we can continue to be relevant to our many constituencies, including students, early and mid-career engineers and technologists, technical executives, national labs, academia, and government. To that end, we have chartered a team to address this. In a sentence, we have asked this team to help us understand what AIAA should look like decades from now to better serve our members. As part of this, I believe we need to more broadly define what aerospace is. I look forward to sharing the results of this study in the future.

Once again, I am honored to serve you. I look forward to working with and supporting you over the next two years.

CALL FOR BOARD OF DIRECTORS NOMINATIONS

The 2014–2015 AIAA Nominating Committee will meet in August to review nominees and select candidates to participate in the Board of Directors (BoD) election to fill the following vacancies by election in 2015:

- Vice President-Elect, Education
- Vice President-Elect, Public Policy
- Director–Technical, Aerospace Design and Structures Group
- Director–Technical, Aerospace Sciences Group
- Director–Region II
- Director–Region III
- Director–Region VI
- Director–At-Large
- Director–At-Large, International

AIAA BoD Duties Highlights

Details to keep in mind when running for the Board of Directors:

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

AIAA members may submit themselves or other members qualified for the chosen position as nominees by submitting a nomination through the AIAA website (go to **www.aiaa.org**, log in, and select Board of Director Nomination from the left-hand navigation bar) no later than **28 July 2014**. Nominations will open 9 June.

Bill Seymore
AIAA Corporate Secretary/Treasurer

AIAA RELEASES 2013–2014 ANNUAL REPORT

AIAA has released the 2013–2014 annual report, "Shaping the Future of Aerospace," highlighting the Institute's recent achievements and giving a glimpse of the year ahead. Overall, the report addresses the importance of the Institute's continuing restructuring of AIAA's brand, products, and services to meet the evolving needs of both our members and the international aerospace community more readily.

Looking back on the year, outgoing AIAA President Mike Griffin stated, "I think everyone realized then that there were challenges and threats to our industry and to AIAA as an organization. When confronted with tough times every organization must face the choice either to hunker down and try to ride it out, or to confront the challenges on the horizon and take action. I am pleased by the steps AIAA has taken to confront our challenges, and in the process enhance our relevance."

In addition to being the report's title, "Shaping the Future of Aerospace" is also AIAA's new tagline. The tagline and our new mission and vision articulate our members' achievements, creativity, dedication, ingenuity, and passion for aerospace engineering and science.

To read the Annual Report, please go to **www.aiaa.org/Governance**.

PREMIER AWARDS PRESENTED AT AIAA AEROSPACE SPOTLIGHT AWARDS GALA

AIAA presented its highest awards at the Aerospace Spotlight Awards Gala on 30 April, at the Ronald Reagan Building and International Trade Center, Washington, DC. The event provided the opportunity for senior leaders in government, academia, and industry to recognize the “best of the best” in aerospace and celebrate those who have continuously pushed the boundaries of human achievement -- making the impossible, possible; expanding our knowledge of the universe we inhabit; and transforming how humanity grows ever closer together. The Gala brought together over 500 guests to salute the honorees, which included a new class of AIAA Fellows and Honorary Fellows and distinguished winners of AIAA’s premier awards.

AIAA President James Albaugh welcomed all to the evening’s festivities, followed by presentation of the 2014 AIAA Fellows and Honorary Fellows, all of which were congratulated for their achievements. After dinner, Albaugh presented AIAA’s prestigious awards, which are the highest awards that the Institute and AIAA Foundation bestows.

The AIAA honors and awards program is extensive, providing many opportunities for member advancement or recognition of significant contributions and technical excellence. For over 75 years, AIAA has ignited and celebrated ingenuity and collaboration, ensuring aerospace professionals are recognized for their contributions to making the world safer, more connected, more accessible and more prosperous – from the major missions that re-invent the uses of air and space, to the inventive new applications that enhance everyday living. For more information about the AIAA Honors and Awards program, contact Carol Stewart at carols@aiaa.org or at 703.264.7623.

AIAA Honorary Fellows: (from left) Edward Greitzer, Paul Kaminski, and George Muellner.

(L to R)” Joseph Vogel (The Boeing Company), George Thum (Aerojet-Rocketdyne), and Charles Brink (U.S. Air Force Research Laboratory) with AIAA Foundation President Mark Lewis and AIAA President James Albaugh, after accepting the 2014 AIAA Foundation Award for Excellence on behalf of the X-51A WaveRider Team.

2014 AIAA Fellows and Honorary Fellows with AIAA Executive Director Sandy Magnus (first row left) and AIAA President James Albaugh (first row right)

The X-51A WaveRider Team

AIAA President James Albaugh (right) with Ben T. Zinn (left) of Georgia Institute of Technology and recipient of the 2014 AIAA Reed Aeronautics Award.

Glynn Lunney, former NASA Flight Director and Program Manager/Rockwell Satellite Systems Division President/United Space Alliance Vice President, with AIAA President James Albaugh (right) after receiving the 2014 AIAA Reed Aeronautics Award.

2014 recipient of the AIAA Distinguished Service Award Michael Yarymovych (left) of Sarasota Space Associates with AIAA President James Albaugh.

Kathie Olsen (left), founder and Managing Director, ScienceWorks and 2014 recipient of the AIAA Public Service Award with AIAA President James Albaugh.

Christopher Scolese, Director, NASA Goddard Space Center, accepts the AIAA National Capitol Section Barry M. Goldwater Educator Award for A. F. "Rick" Obenschain, Deputy Director. Also pictured: Martin Fredericks (left), AIAA National Capitol Section and AIAA President James Albaugh.

Abraham Karem (center) after accepting the Daniel Guggenheim Medal from President James Albaugh (far right). Also from left to right: Vigor Yang, Georgia Institute of Technology; Bruce Mahone, SAE International; and Peretz Friedman, University of Michigan.

18TH ANNUAL DESIGN/BUILD/FLY COMPETITION

The 18th annual Cessna Aircraft Company/Raytheon Missile Systems/AIAA Foundation Design/Build/Fly competition was held 11–13 April. The engineering competition is also recognized by the Academy of Model Aeronautics. It was an exciting time for the 700 students in attendance, and the competition broke its own records yet again.

This year students were asked to build a radio-controlled aircraft that would simulate a Backcountry Rough Filed Bush Plane. The requirements were to design a plane that could take off on a rough field, which would be simulated by having the students taxi their aircraft through a pattern on corrugated plastic. The plane then had to be able to fly three specific mission types: a ferry flight, a maximum load mission, and an emergency medical mission.

The ferry flight simply asked students to fly as many laps as they could in four minutes. The maximum payload mission required the plane to carry as many 1-pound, 6-inch cubed wooden blocks as they could for three laps. The emergency medical mission required the students to fly wooden blocks simulating two patients and two attendants for three laps.

In addition to designing the plane, each team needed to prepare a report about their plane. The report had specific areas that need to be addressed, including management of the team, design, drawing package, manufacturing, and testing. The specific areas that needed to be addressed were identified on the website. The report layout was structured similarly to real-world requests that come from the government of prime contractors.

Teams that submitted the report to the contest on time were invited to bring their plane to Wichita, KS, and participate in the flyoff at the Cessna Airfield. Of the 100 teams that submitted letters of intent to participate, 80 submitted reports on time.

At the flyoff each team had to pass a safety inspection, which includes providing proof that the plane has flown and is able to perform the various missions. A signed pre-tech sheet had to be submitted by the pilot who had flown the plane. Then inspectors checked to make sure that all of the clevises were secure, and that the plane was structurally sound. A wing tip test was performed, the center-of-gravity was identified, and inspectors made sure that the plane met all contest requirements and could perform all of the defined missions. Almost all of the 73 teams successfully passed the technical inspection, and 49 teams successfully made a qualifying flight score.

The competition began flights on Friday afternoon. Flights were performed continuously through the contest's scheduled time from Friday through Sunday with only a short suspension of flying due to a thunderstorm that rolled through. As teams completed their flight missions, their scores were updated at the scoring table. Total scores for the teams were a combination of their report score, their flight scores, and their rated airplane cost—the weight of their plane.

The competition provided a lot of fun for the participants. In addition to watching the success of their own plane, many teams praised and recognized the accomplishments of other teams as well. Several teams had multiple unsuccessful flight attempts, but on their third or fourth attempt they finally completed a mission. This accomplishment was recognized by all in attendance. And, if a team was unlucky enough to have a crash, other teams offered the use of their tools to allow repairs to be done. The spirit of cooperation as well as competition was seen throughout.

The team from the University of Southern California, Los Angeles, won the event's $2,500 first-place prize, scoring 407.24 points. The team from the University of California–Irvine received the $1,500 second-place prize, scoring 352.86 points. And the team from San Jose State University received the $1,000 third-

Many teams take great pride in their entries.

MIT university going through tech inspection.

Tel Aviv University making a flight attempt.

Pictured left: Contestants and observers at the flight line. Picture right: Sandy Magnus, AIAA Executive Director (left); David Levy, Competition Director (center); Michael Thacker, Cessna Senior VP Engineering (right).

place prize, scoring 326.37 points. The team from the University of Ljubljana, Ljubljana, Slovenia, was the highest placing foreign team, placing fourth overall, scoring 256.76 points.

This year's competition director was David Levy of Cessna Aircraft. The judging coordinator was Tom Zikhur, also of Cessna. Flight line director was Chris Bovais of the Naval Research Lab, and the Technical Inspection Director was Rob Roedts of Columbia Helicopter. Russ Althof of Raytheon Missile Systems was part of the Organizing Committee of the contest and a key member in making this year's competition a success.

For a full listing of teams, the competition objectives for this year, and to find the complete listing of winners and all participants, please visit **www.aiaadbf.org**.

LANGFORD TO RECEIVE NAA HENDERSON TROPHY

The National Aeronautic Association (NAA) announced that AIAA Fellow **Dr. John Langford** has been selected to receive the 2014 Cliff Henderson Trophy. The Cliff Henderson Trophy, which is in the collection of the Smithsonian's National Air and Space Museum, was established in 1960 to honor the creator and managing director of the world-renowned National Air Races from 1928–1939. Henderson's work stimulated a generation's interest in aviation and challenged the state of the art in aviation development. In that spirit, the trophy is awarded to "…a living individual, group of individuals, or an organization whose vision, leadership or skill made a significant and lasting contribution to the promotion and advancement of aviation and aerospace in the United States."

Dr. Langford is the Chairman and CEO of Aurora Flight Sciences Corporation, which he founded in 1989. He received his Bachelor's degree in aeronautics (1979), Masters in aeronautics and defense policy degrees (1985 & 1983), and Ph.D. in aeronautics and public policy (1987) from the Massachusetts Institute of Technology.

His career has spanned numerous facets of aviation and aerospace to include a series of human-powered aircraft projects that culminated in the Daedalus Project (which shattered the world distance and endurance records for human-powered flight in 1988, with a 72-mile flight between the Greek islands of Crete and Santorini). He also worked as an engineer on the development of the F-117 stealth fighter.

Since Dr. Langford started the corporation, Aurora has been a leader in the development and manufacture of advanced unmanned systems and aerospace vehicles and has produced aircraft and air vehicles as a prime contractor. In addition, Aurora supplies major aerospace original equipment manufacturers with technologically advanced aerospace components.

In addition to being an AIAA Fellow, Dr. Langford is also a member of AIAA's Institute Development Committee and has received the AIAA National Capital Section (NCS) Young Engineer of the Year award (1989) and the AIAA NCS Barry M. Goldwater Educator Award (2000).

NAA will present the trophy to Dr. Langford on 11 June at the annual NAA Henderson Trophy Luncheon in Arlington, VA.

NEW CORPORATE MEMBERS

AIAA is pleased to welcome three new corporate members to the AIAA roster.

- **AAC Microtec**, based in Uppsala, Sweden, develops, manufactures and markets robust multifunctional electronics systems for aerospace and industrial applications.
- **Atkins**, based in London, England, is one of the world's leading design, engineering and project management consultancies.
- **Schafer Corporation**, based in Huntsville, Alabama, is a scientific and engineering company providing technical solutions to mission critical challenges in national security.

For more information on the AIAA corporate program, please contact Merrie Scott at merries@aiaa.org.

IAC 2014 TO SHOWCASE NORTH AMERICAN SPACE ACCOMPLISHMENTS

AIAA is proud to be a supporter of the 65th International Astronautical Congress (IAC), the world's premier space event, which takes place 29 September–3 October 2014, at the Metro Toronto Convention Centre in Toronto, Ontario. This event is hosted by the Canadian Aeronautics and Space Institute (CASI) and organized by the International Astronautical Federation (IAF). AIAA is a founding member of IAF and has a long history of collaboration with CASI as a sister society.

Focusing on the theme "Our World Needs Space," the IAC will promote an exploration of the relationship between Earth and space and the ways that space activities help to meet our needs on Earth. In addition, this event will showcase the global and collaborative nature of our industry, with a special focus on the capabilities and accomplishments of the two North American spacefaring nations—the United States and Canada.

Participants representing industry, government, and academia will gather to network and present their latest accomplishments and future plans, identify opportunities for collaboration, and share their opinions on the widest possible array of topics.

IAC 2014 will have a multifaceted program that features plenary keynotes and panels, technical and poster presentations, social activities, an exhibition, and various associated and side events.

Topics include:

- Space exploration
- Space science
- Space life sciences
- Space debris
- Applications and operations
- Earth observation
- Space communication and navigation
- Integrated applications
- Technology
- Astrodynamics
- Space propulsion
- Infrastructure
- Space systems
- Space transportation
- Space and society
- Space education and outreach
- Space policy, regulations and economics
- Space law

Registration is open now. For more information and to register, visit **http://www.iac2014.org**.

CALL FOR PAPERS FOR *JOURNAL OF AEROSPACE INFORMATION SYSTEMS*

Special Issue on Optimal Decision Making in Aerospace Systems

The *Journal of Aerospace Information Systems* is devoted to the applied science and engineering of aerospace computing, information, and communication. Original archival research papers are sought that include significant scientific and technical knowledge and concepts. The *Journal* publishes qualified papers in areas such as aerospace systems and software engineering; verification and validation of embedded systems; the field known as 'big data,' data analytics, machine learning, and knowledge management for aerospace systems; human-automation interaction; and systems health management for aerospace systems. Applications of autonomous systems, systems engineering principles, and safety and mission assurance are of particular interest. Articles are sought that demonstrate the application of recent research in computing, information, and communications technology to a wide range of practical aerospace problems in the analysis and design of vehicles, onboard avionics, ground-based processing and control systems, flight simulation, and air transportation systems.

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

This special issue will focus on algorithms for optimal decision making in aerospace systems. In many complex aerospace applications, systems must interact with dynamic environments, be robust to uncertainty in sensor information, and reliably balancing safety and efficiency. Recent advances in decision theoretic optimization have shown tremendous promise in addressing the challenges of engineering such systems.

Key research areas in the special issue include:

- Decision theoretic models: MDPs, POMDPs
- Multi-agent systems: MMDPs, Dec-POMDPs, POSGs, i-POMDPs
- Solution methods: dynamic programming, online planning, robust optimization
- Approximation techniques: structured approaches, Monte Carlo methods, dimensionality reduction, linearization
- Learning algorithms and adaptive methods
- Application domains: decision support for air traffic control, mission planning, unmanned aircraft, autonomous spacecraft, etc.
- Verification and validation methods for decision-making systems

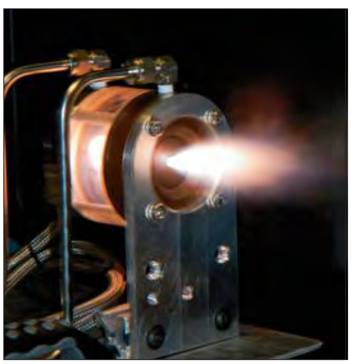
Deadline: Submissions are due by **15 December 2014**.
Anticipated Publication Date: **May 2015**.
Contact Email: Mykel Kochenderfer, mykel@stanford.edu

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.

AIAA WISCONSIN SECTION HOLDS ROCKET SCIENCE FOR EDUCATORS WORKSHOP

Todd H. Treichel, AIAA Wisconsin Section

The AIAA Wisconsin Section partnered with the Wisconsin Space Grant Consortium (WSGC) to provide a weekend workshop geared toward arming K–12 educators with skills required for high powered rocket design. Daniel Bateman, director of Spaceport Sheboygan Education Center, and AIAA Wisconsin members Todd Treichel and Randy Lutz, assisted by Frank Nobile from Tripoli-WI, combined their efforts to conduct a Rocket Science for Educators workshop specially designed to provide K–12 teachers and rocket club leaders with ideas, knowledge, and techniques for promoting math and science using RockSim design software. Rocket simulation software will enable student rocket designers to analytically size rocket components, evaluate center of gravity, center of pressure, and stability data and then simulate flight performance to scientifically predict how well a rocket will perform in flight.

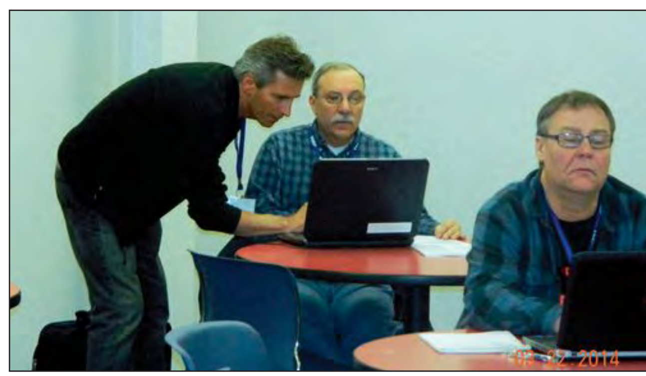


RCS thruster demonstration.

The 2014 workshop was held in April at Spaceport Sheboygan Education Center, Sheboygan, WI, where teachers and rocket club leaders were invited to attend the free workshop, receiving a software license, rocket design workbook, hands-on demonstrations, visual aids, and real-life space flight examples. An added bonus was witnessing the static firing of an ORBITEC thruster demonstrating a VORTEX reaction control system (RCS) fueled by propane and oxygen.

The goal of the Rocket Science for Educators workshop was to assist schools in implementing rocket science into respective math or science curriculums and empower rocket club leaders with skills to successfully design high powered rockets and compete in the Rockets for Schools Competition held each May at Spaceport Sheboygan. The workshop was a far-reaching program that targeted precollege students and the educators who inspire them. Learning starts with a teacher, a curious student, and fun with aerospace.

AIAA member Randy Lutz instructs class on principles of rocket design.



K-12 educators perform rocket design simulations.

AIAA-Wisconsin Rocket Science for Educators group photo taken at Spaceport Sheboygan in Wisconsin.

NATIONAL CAPITAL SECTION'S REGIONAL STEM/ SCIENCE FAIR SUPPORT

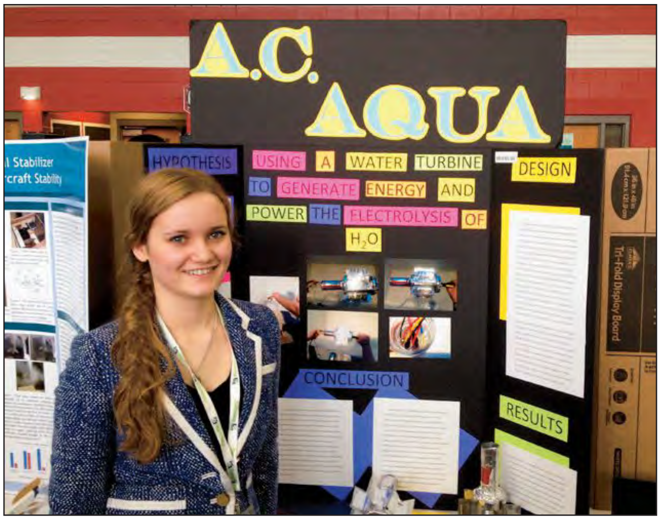
Susan Bardenhagen, AIAA Educator Associate; NCS Co-Coordinator of Regional STEM/Science Fair Judging Teams

From 1 March to 5 April, eight teams of 29 judges examined and sorted nearly 3000 projects at regional STEM/Science & Engineering Fairs, interviewed nearly 300 students from grades 6–12, and awarded 40 honors. In addition to the Washington, DC, STEM Fair, three were held in Maryland, and four in northern Virginia. Three of the 40 awards were given to team projects where the judges observed excellent collaboration and well-prepared presentations. The projects selected for consideration were drawn from nearly every one of the 17 possible categories with finalists chosen from Behavioral Science, Chemistry, Computer Science, Environmental Management, and Mathematical Science, as well as the expected Earth & Space Science, Energy & Transportation, Engineering (both Materials & Bioengineering and Electrical & Mechanical), and Physics & Astronomy.

In teams of three to five, the AIAA member judges included engineers and engineering graduate students from the University of Maryland. Being able to preview students' abstracts or titles prior to the events greatly supported the judges' efforts. In one fair the team had three hours to preview the projects before students were present and in another the team had to view, cull, interview, and select in just four hours. Dr. Joseph Gruber reflected, "It's always inspiring to attend these events and see that our future is in capable hands and this year was no exception with a difficult decision by the judges to select the top three winners. Using our various backgrounds however, we were able to adequately interview the students and analyze the projects they put forth and select the awardees along with providing honorable mentions to students who also presented outstanding projects."

In Physics & Astronomy, one student used 3-D printing to generate a series of wind tunnel models to determine "the effect of chord length of an airfoil on lift over drag ratio." A senior investigated the feasibility of a sacrificial plate equipped with an array of neodymium magnets for absorbing impacts from simulated metallic space debris. A model rocket enthusiast mixed and casted his own propellant grains using various bore designs and testing them in a homemade test stand, while a third-place student employed a phased approach using open-source model rocket design and simulation software confirming his hypothesis that an ogive nose cone shape achieved the best performance.

A Behavioral Sciences project related pilot performance to current trends in the delivery method of iPad displays. Employing a biologically-inspired approach involving vortex generation, a first-place student analyzed the downstroke phase of slow flight in bats. And the investigation of whether hydroponic plants used to clean water in a space habitat could be modified for increased oxygen production under reduced levels of ultraviolet light, resulting in lower energy consumption, earned a second place from AIAA and in her Environmental Management category.



In one of the two Chemistry projects, a team developed an innovative and portable spectrophotometer; the other examined how different types of acid reacting with baking soda would work for a bottle rocket—the judging team was impressed with the student's persistence and continuous trials.

In Earth & Space Science, a student's interest in amateur radio motivated him to pursue a backyard satellite tracking study; his persistence led him to a better understanding of frequency amplitude decay of aging satellites, while his curiosity gave him a comprehensive view of Doppler effect. Another student's interest in electronics enabled him to build a microwave transmitter system to generate power wirelessly!

Coincidentally, two students whose projects were in the Energy & Transportation category visited the AIAA booth at the USA Science & Engineering Festival on 27 April. One had been awarded third place for "The Effect of Orientation on the Power a Pinwheel Generates," where she found a simple, but effective apparatus to determine the power generated by a pinwheel as a function of incident airstream angle. The first-place awardee hypothesized that the wing tip that carried the vortex the farthest away from the wing tip would make the smallest vortex, and plans to use his prize money for next year's Science Fair.

"Mars 2.0 or Bust" presented an Engineering project on the various factors affecting a lander designed to "fly" in a Martian atmosphere. "What was more evident from the quality of her project was the level of commitment she has to further mastery of aerospace engineering," commented her judging team. After attending the AIAA-cosponsored "Humans to Mars Summit," 22–24 April, and making connections with the high-powered speakers, she made her decision to pursue engineering at MIT.

The winners were invited to attend the 5 June awards banquet to share their projects and receive their monetary awards, an AIAA student membership, and have an opportunity to participate in a three-day experiential learning visit to NASA Goddard's Space Flight Center facilities, laboratories, and clean room. Awardees will lunch with an astronaut, engage with a Nobel Laureate, and explore the Mission Lifecycle through active participation in the same critical phases used by NASA. Depending on the launch schedule, their experience may also include a day trip to visit the Wallops Flight Facility.

AIAA San Fernando Pacific chapter in conjunction with the San Fernando Valley chapter of ASME organized a tour of the Jet Propulsion Laboratory in Pasadena. Visitors saw the Mission Control Room used to communicate with the two Voyagers and Mars Science Laboratory, as well as a clean room where spacecrafts were assembled and a mock-up of Curiosity.

CALL FOR NOMINATIONS

Nominations are being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 July**. AIAA members are urged to read award guidelines to view nominee eligibility, page limits, and letters of endorsement instructions; details at **https://www.aiaa.org/secondary.aspx?id=230**.

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

Aerospace Guidance, Navigation, and Control Award recognizes important contributions in the field of guidance, navigation, and control.

Aerospace Software Engineering Award recognizes outstanding technical and/or management contributions to aeronautical or astronautical software engineering.

Children's Literature Award recognizes for an outstanding, significant, and original contribution in aeronautics and astronautics.

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

Dr. John Ruth Digital Avionics Award honors outstanding achievement in technical management and/or implementation of digital avionics in space or aeronautical systems, including system analysis, design, development, or application.

Excellence in Aerospace Standardization Award honors contributions by individuals that advance the health of the aerospace community by enabling cooperation, competition, and growth through the standardization process.

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

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

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

Information Systems Award is presented for technical and/or management contributions in space and aeronautics computer and sensing aspects of information technology and science.

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

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

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

Pendray Aerospace Literature Award is presented for an outstanding contribution or contributions to aeronautical and astronautical literature in the relatively recent past.

Structures, Structural Dynamics and Materials Award is presented for an outstanding sustained technical or scientific contribution in aerospace structures, structural dynamics, or materials.

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

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

Sustained Service Award recognizes sustained, significant service and contributions to AIAA by members of the Institute. A maximum of 20 awards are presented each year.

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

OBITUARIES

AIAA Honorary Fellow Houbolt Died in April

John C. Houbolt, whose advocacy of the lunar orbit rendezvous concept made the Apollo 11 moon landing possible, died on 15 April. He was 95 years old.

After receiving his B.S. and M.S. degrees in Civil Engineering from the University of Illinois at Urbana-Champaign in 1940 and 1942, respectively, Mr. Houbolt began his career as an engineering in the Structures Research Division at NACA at Langley Research Center. He also served in the Army Corps of Engineers from 1944 to 1946, before receiving the Rockefeller Public Service Award to study at the Swiss Federal Institute of Technology, Zurich, where he earned his Ph.D. in 1957.

Mr. Houbolt returned to Langley Research Center to work as Associate Chief of the Dynamics Loads Division and then Chief of the Theoretical Mechanics Division. And in 1961, he became the primary spokesperson for a group of engineers and scientists committed to the idea of a lunar orbit rendezvous (LOR) concept for a moon landing. The LOR concept called for a two-piece spacecraft to travel to the moon, the main craft and a smaller lunar landing module. Facing stiff resistance to the idea from his superiors, including Wernher von Braun and Christopher Kraft, Houbolt took the unprecedented step of directly appealing to NASA incoming associate administrator Robert C. Seamans Jr., who was intrigued by the idea. In 1962, after a thorough technical review, the LOR concept was endorsed for lunar landings.

In 1963, Houbolt left NASA to take a position with Aeronautical Research Associates, subsequently returning to NASA in 1976 as chief aeronautical scientist at Langley Research Center. He retired from NASA in 1985.

Houbolt's honors include the very first AIAA Structures, Structural Dynamics & Materials Award, presented in 1968, and the 1972 AIAA Dryden Lectureship in Research Award. Other honors include a 1963 NASA Exceptional Scientific Achievement Medal, the 2000 ASME Spirit of St. Louis Medal, and the 2007 Illini Achievement Award from the University of Illinois at Urbana-Champaign. Houbolt was elected to the National Academy of Engineers in 1990.

AIAA Fellow Adamson Died in May

Arthur P. Adamson died on 3 May. He was 95 years old.

After a childhood in rural Kansas and education in a one-room schoolhouse, Mr. Adamson went to the University of Southern California's School of Engineering, where he graduated at the top of the class of 1941.

He spent his entire career in engineering and engineering leadership with General Electric, working near Schenectady and at several other sites before spending the last 30 years of his career at GE's Evendale (Cincinnati), OH, plant. While with GE, he led advanced rocket and jet engine design programs, and became a world leader in jet engine design, responsible for the design of engines that remain widely used on commercial wide-body jet aircraft. Mr. Adamson received many awards for excellence in engineering leadership from GE and outside engineering organizations.

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

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

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

Business Management for Engineers (Instructor: Alan Tribble)

This course is intended to provide an overview of basic business principles used to manage a company. In particular, this course will help individuals with a strong technical background in science or engineering prepare for the transition from a role as a technical contributor to a business leader.

Key topics
- Capitalism and free markets
- Business finance
- Business structure and functions
- The relationship between systems engineering and program management
- Communicating for business impact versus technical
- Globalization

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

Design engineers and technical managers involved with preliminary or detailed design of aerospace, mechanical, and other multidisciplinary engineering systems will find this material applicable in their work environment. Advanced research students and research scholars in academia and in research laboratories will also benefit from the topics covered in this course. They would use this material as an entry point into possible areas of further research.

Key Topics
- Multidisciplinary design—components, challenges, and opportunities
- Optimization methods
- Sensitivity analysis
- Decomposition architectures in multidisciplinary design
- Surrogate modeling in design
- Soft computing methods in optimal design

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

2nd AIAA Propulsion Aerodynamics Workshop

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

Hybrid Rocket Propulsion (Instructor: Joe Majdalani)

This course reviews the fundamentals of hybrid rocket propulsion with special emphasis on application-based design and system integration, propellant selection, flow field and regression rate modeling, solid fuel pyrolysis, scaling effects, transient behavior, and combustion instability. Advantages and disadvantages of conventional and unconventional vortex hybrid configurations are examined and discussed.

Key Topics
- Introduction, classification, challenges, and advantages of hybrids
- Similarity and scaling effects in hybrid rocket motors
- Flowfield modeling of classical and non-classical hybrid rockets
- Solid fuel pyrolysis phenomena and regression rate: mechanisms & measurement techniques
- Combustion instability and transient behavior in hybrid rocket motors
- Metals, other energetic additives, and special binders used in solid fuels for hybrid rocket applications

Missile Propulsion Design, Technologies, and System Engineering (Instructor: Eugene L. Fleeman)

A system-level, integrated method is provided for missile propulsion design, technologies, development, analysis, and system engineering activities in addressing requirements such as cost, performance, risk, and launch platform integration. The methods presented are simple closed-form analytical expressions that are physics-based, to provide insight into the primary driving parameters. Sizing examples are presented for rocket-powered, ramjet-powered, and turbo-jet powered baseline missiles. Typical values of missile propulsion parameters and the characteristics of current operational missiles are discussed as well as the enabling subsystems and technologies for missile propulsion and the current/projected state-of-the-art. Videos illustrate missile propulsion development activities and performance.

Key Topics

- Key drivers in the missile propulsion design and system engineering process
- Critical tradeoffs, methods, and technologies in propulsion system sizing to meet flight performance and other requirements
- Launch platform-missile integration
- Sizing examples for missile propulsion
- Missile propulsion system and technology development process

Application of Green Propulsion for Future Space (Instructors: Alan Frankel, Dr. Ivett Layva, and Patrick Alliot)

Liquid propulsion systems are critical to launch vehicle and spacecraft performance, and mission success. This two-day course, taught by a team of international experts, will focus on the movement to green propulsion for a range of spacecraft applications. Topics include a brief history of hypergols; what is considered green and what is driving the green propulsion movement; figures of merit and lessons learned in the development of green propellants; flight experience and applications for the various classes of satellites; and challenges for current and future green thrusters and systems.

Key Topics

- History of storables
- What is green and what is driving the green movement
- Green propellants
- Green flight experience
- Applications of green propulsion

3–4 August 2014
Course at AIAA Space and Astronautics Forum and Exposition 2014 (AIAA SPACE 2014)
www.aiaa-space.org

Decision Analysis (Instructor: John Hsu)

Decision analysis is an important part of system life cycle development throughout all phases and system hierarchical levels. This course presents the trade study process as part of the systems engineering process and introduces different decision analysis methods including the traditional trade study methods, trade space for Cost as Independent Variable (CAIV), Analytic Hierarchy Process (AHV) as part of the Analytic Network Process (ANP), Weighted Sum Model (WSM), Potentially All Pairwise Rankings of All Possible Alternatives (PAPRIKA), and Decision Analysis with Uncertain information/data. The highlights are: evaluation criteria weights assignment methods including objective determination via QFD methodology; how to down-select too many alternatives; various scoring methods for evaluation criteria; how to develop decision trees; mathematical eigenvector calculations to assist the AHP analysis; how to handle billions pairwise combinations and rankings for PAPRIKA; and five methods to reach decisions with uncertain information/data, and more. Several ways of writing credible and thorough trade study report are introduced.

Key Topics

- Understand the trade study process and role in the overall systems engineering process.
- Learn the traditional trade study methods: Defining selection criteria, Identifying weights, Identifying alternatives, Defining scoring criteria, Scoring alternatives, Calculating ratings for alternatives, and Performing sensitivity analysis.
- Learn how to develop decision trees as hierarchical guidance for different levels of trade studies.
- Learn the trade study role and contribution to Cost as Independent Variable (CAIV).
- Learn how to use and apply decision analysis methods including Analytic Hierarchy Process (AHV) as part of the Analytic Network Process (ANP), Weighted Sum Model (WSM), Potentially All Pairwise Rankings of All Possible Alternatives (PAPRIKA), and Decision Analysis with Uncertain information/data.
- Learn how to write a credible, organized, structured and thorough trade study report.