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AEROSPACE AMERICA

January 2015

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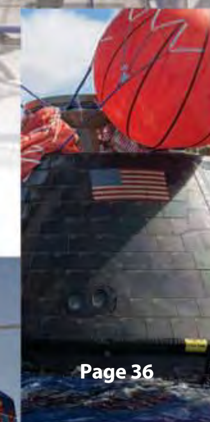

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ON THE COVER

A mesh of cells around an aircraft computer model lets CFD applications calculate complex air flows.
Image credit: CD-adapco

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AIAA
Shaping the Future of Aerospace

Editor's Notebook

Getting serious about planetary defense

Reading up about asteroids, as I did for "Planetary Defense" on page 32, always makes me more nervous than the odds say I should be.

A devastating asteroid or comet impact is unlikely to come in my lifetime or that of my children. My cerebrum knows this, but a little deeper down is my limbic system, and it subscribes to Murphy's Law: Whatever can go wrong will go wrong, and probably sooner than expected.

There's a reason our brains developed a complex emotional center. Emotions focus us. We should be doing more to protect ourselves from a collision with a near-Earth object. It's not a likely event, but the stakes are almost unimaginable. Not all of the preparations would mean spending gobs of taxpayer dollars. The White House and Congress could create an agency or assign one to lead and marshal international talents before a dangerous object pops up. We know we should do this, but it's easy to procrastinate, and that's what we've been doing for a decade now. In 2005, a NASA task force recommended establishing a Planetary Defense Coordination Office.

As it stands, the Pentagon is focused on earthly threats. Congress has directed NASA to find, track and describe dangerous NEOs. No one has the job of figuring out how to deflect dangerous objects or blow them up. For its observation mission, NASA relies on a loose, global network of ground telescopes and astronomers from other organizations. A better way would be to launch a telescope into space specifically to look for NEOs. For that, we're counting on a private group, the B612 Foundation, to raise the necessary funds to build and launch the Sentinel Space Telescope in 2017. Maybe the foundation will succeed, but in the meantime, our view of space remains disturbingly incomplete. We're trusting that someone will be looking in the right place when the big one comes. Murphy's Law says we should plan on the opposite kind of luck. History shows that objects are sometimes spotted alarmingly late. Comet Hale-Bopp, for example, was discovered in 1995 and flew through the solar system in 1996 and 1997.

Maybe the best thing that could happen would be discovery of an object on a collision course with Earth in, say, 20 years. That probably would focus us, although I half expect the warnings to be labeled junk science for a number of years.

For now, it remains the work of a small group of NASA and industry experts to push for a coordination office. "While the efforts through the NEO Observation program are laudable, an office that would coordinate planetary defense activities across NASA, other U.S. federal agencies, foreign space agencies, and international partners is still needed," said NASA's Small Body Assessment Group in an August draft report.

We should do more than listen. We should act.

Ben Iannotta
Editor-in-Chief

Particle physics breeds aerospace tech

In their quest to unlock the secrets of the universe, researchers at Europe's CERN organizaton needed a machine capable of managing temperatures of 5.5 trillion degrees Celsius — more than 250,000 times hotter than the center of the sun. That's the amount of heat CERN's Large Hadron Collider in Switzerland creates when it smashes subatomic particles together in an effort to replicate the conditions immediately after the Big Bang and identify the smallest building blocks of matter.

Experts at CERN — a French acronym for the European Organization for Nuclear Research — also see practical aerospace applications for their thermal-management and other technological innovations.

The Large Hadron Collider contains collimators — devices that narrow the high-energy beams in particle accelerators but generate intense heat in the process. To handle even-higher-energy beams that would open new avenues of basic research, CERN technology analysts have produced "the highest thermal-conductive materials ever developed," said Enrico Chesta, head of the Technology Transfer Section in CERN's Knowledge Transfer Group, in an interview. The new metal-diamond and metal-graphite composites — lightweight materials with high operating temperatures and high thermal conductivity that are resistant to thermal expansion — "could play an important role in helping to manage the high temperatures generated by equipment such as satellite electronics and could even have a role in dissipating the high volumes of heat on a re-entry capsule shield or within the combustor chamber of an aero-engine," he added.

To guide high-energy particle beams within its accelerator ring, the Large Hadron Collider relies on superconducting electromagnets, and that technology is being adapted to help protect future deep-space explorers from the effects of radiation. The European Union's Space Radiation Superconductive Shield project, known as SR2S, is researching the use of magnetic fields to protect astronauts from radiation in space. The project aims to develop a superconducting shield with an intense magnetic field — 3,000 times stronger than the Earth's magnetic field — 10 meters in diameter around a spacecraft to deflect ionizing particles.

CERN

Superconducting electromagnets like those that guide particle beams in the Large Hadron Collider might someday protect astronauts from radiation by generating an intense magnetic field.

The two high-energy particle beams within the Large Hadron Collider are guided around the accelerator ring by a strong magnetic field. In 2014, CERN researchers solved two problems facing the SR2S project: developing very long, high-temperature superconducting cables by joining short segments without losing the superconducting properties, and protecting them from sudden rapid cooling. Roberto Battiston, president of the Italian Space Agency and coordinator of the SR2S project, said on the project's website that he believes the issue of radiation protection for deep-space astronauts will be solved within three years.

CERN's contributions to space research include cooperation with the European Space Agency on several projects. Under an agreement signed in March, the two organizations are working on 12 projects, including the development of microtechnologies to be applied in miniaturized distributed sensor systems, and the development and testing of high-performance detectors for high-energy physics experiments and space payloads.

CERN was also responsible for assembling and calibrating the Alpha Magnetic Spectrometer that has been operating on the International Space Station since 2011. The particle-physics detector is looking for dark matter and antimatter in the universe. Data from the detector is analyzed at CERN's AMS Payload Operations Control Center.

Another technology CERN is bringing into service is a small AC/DC power converter that has extremely high radiation and magnetic-field tolerance. The converter, called FEAST2, was developed to handle the distribution of power in high-energy physics experiments, and the technology could be certified for use in space, according to CERN.

"For many years we have been developing technologies which have applications in areas such as medicine," Chesta said. "We are convinced that aerospace is another huge field of applications for CERN's innovation because of the many common technology development and operational challenges of working in space and the harsh environments in which our experiments take place underground."

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China, Russia boost aerospace collaboration

Russian and Chinese aerospace companies have been collaborating for many years, but developments since the Ukraine crisis and the imposition of sanctions on Russia are widening and deepening the relationships, analysts say.

In November, for example, Russia's Rostec Corp. announced that it had signed a "strategic cooperation agreement" with the state-owned Aviation Industry Corp. of China for production of helicopters, aircraft engines, avionics and radios. Rostec was founded in 2007 to develop and export Russian high-tech products. The new agreement could lead to "joint projects in Russia and China," the company said on its website.

This and other developments suggest that China is looking for technical expertise in the design and development of engines and avionics, and that it wants to acquire titanium and aluminum prefabricated products. Russia, analysts say, needs a short-term alternative source to Western suppliers for a range of electronics and components.

In the longer term, Russia has indicated a desire for China to buy Russian military jets and to work together on new civil and military aircraft designs for export in competition with Western suppliers. Russia already supplies Klimov RD-93 engines to China's Shenyang Aircraft Corp. for use in J-31 stealth fighters, which China hopes will compete on the world market against the Lockheed Martin F-35.

In the civil domain, the Commercial Aircraft Corp. of China Ltd. and Russia's United Aircraft Corp. announced in May that they will work together on a feasibility study for a widebody airliner to compete with Boeing and Airbus.

"China's aerospace industry is increasingly confident and well financed," said George Lawrence, an aerospace consultant with London-based Renaissance Strategic Advisors, by email. "Whilst it remains behind the west technologically, it has made substantial progress but the primary Chinese focus is likely to be the acquisition of technology, knowhow and experience, meaning they may be less committed to co-producing an end-item than Russia is."

November's Rostec-China announcement came just weeks after China and Russia signed a memorandum of understanding to cooperate on providing global satellite navigation services.

How far will this cooperation go? Both countries are looking to bolster their missile defense capabilities, and some experts say this could be the next area of collaboration.

Over the past few years, China has developed niche expertise in several aerospace segments, such as long-range unmanned air systems and satellite electronics, which might also be of interest to Russia.

In August, the Izvestia newspaper reported Russian space and defense enterprises planned to buy batches of electronic components from China Aerospace Science and Industry Corp., worth $1 billion in 2015. According to an industry analyst quoted in Izvestia, these agreements could be the first step toward forming a technology alliance involving Brazil, Russia, India, China and South Africa.

But many aerospace industry analysts suggest there will be substantial hurdles to closer aerospace cooperation between the two countries, even before wider global cooperation can be considered.

"Any major projects will have to navigate the country's differing agendas and the lack of trust that exists between the two parties over issues of intellectual property," said Lawrence. "Russia has previously accused China of illegally copying the Sukhoi SU-27 and such concerns may be a factor extending negotiations over a possible Sukhoi SU-35 procurement."

For the moment, the process of closer collaboration between the two countries in aerospace, energy and transport appears to be driven by politics, analysts say. But in the longer term, there might be mutually beneficial commercial reasons to cooperate as well.

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Russian Helicopters

The Ka-32A11BC multirole helicopter is produced by Russian Helicopters, part of the Rostec state conglomerate, which has entered a cooperative agreement with the state-owned Aviation Industry Corp. of China.

African farmers to get NASA, NOAA data on their phones

Molly Brown of NASA's Goddard Space Flight Center had an epiphany when she met a representative of a Ghana-based agricultural organization in Washington, D.C.

Brown had been working on satellite-based assessments of food security for years in her role as a vegetation index specialist. In front of her on this day in 2013 were representatives of a nongovernmental organization called the Alliance for Green Revolution in Africa, or AGRA. The group was in direct contact with farmers in 17 African countries and was known for distributing critical information, such as where to buy fertilizer. Rather unbelievably, Brown thought, the alliance had little or no access to environmental data that NASA and university researchers routinely cull from satellite observations.

Brown realized: "I have the data, they have the network," she told me in an interview.

The result was a collaborative effort between Goddard and AGRA, called "ACCESS for AGRA mFarms," to develop a computer program that will deliver processed information on rainfall and crops to African farmers via the simple cell phones many of them carry.

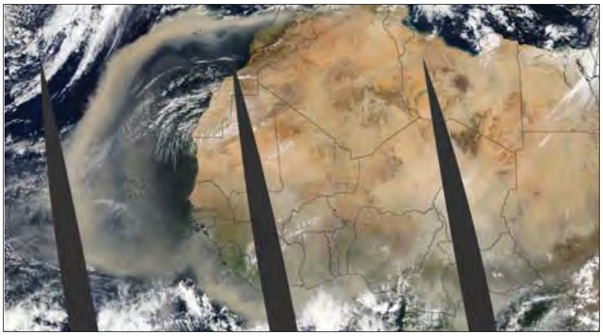
"This is the first time the data will be delivered to farmers via cell phone and text message upon demand. That's the innovation," Brown said.

Geographically specific information will be processed from a host of satellite data sets. The Moderate Resolution Imaging Spectroradiometers on NASA's Terra and Aqua satellites will provide spectral images. NOAA Rainfall Estimates, which are derived from the Meteosat spacecraft operated by NOAA's counterpart, EUMETSAT, will be incorporated in the data set. So will readings from the Tropical Rainfall Measuring Mission instruments and Advanced Very High Resolution Radiometers on NOAA's polar orbiting weather satellites. Soil moisture data will be added from NASA's Soil Moisture Active Passive satellite, or SMAP, scheduled for launch Jan. 29.

This data, along with computer modeling of the expected effects of weather on crop yields, will be tied to specific locations by scientists at the Climate Hazard Group of the University of California in Santa Barbara. The end product will be a grid of environmental data tied to specific latitudes and longitudes, updated every five days. This will be distributed to farmers who subscribe to the service via AGRA's network.

"The information [will be] sent out once every six days to the farmers through a text message or through a voice messaging system in multiple languages. There are many farmers who can't read and write, so AGRA also has a voice messaging system where they can sign up for voicemail where the information is spoken aloud in a local language," said Brown.

A large dust storm over central Africa was captured by the Moderate Resolution Imaging Spectroradiometer in a series of consecutive overpasses of NASA's Aqua satellite. Data from MODIS and other NASA instruments will be made available to African farmers via cell phone.



NASA

AGRA's network currently serves 80,000 farmers in West Africa, and the non-governmental organization is actively recruiting more subscribers. The hope is to reach 100,000 farmers across different regions in Africa in the next two years, said Brown.

The mFarms team is also developing a smart phone app that will deposit this data directly to a farmer's Android or iPhone, something that isn't very useful at the moment since most farmers in Africa have older mobile phones that can only receive text and voice mail. Brown expects that to change in the near future. "In the next five years or so, we fully expect inexpensive smart phones to massively expand there and when it does this system will be in place and those same farmers will get images and graphs and interpreted products. We need to set up those networks now so we're ready for that innovation," she said.

AGRA sees benefits to famers and also a broader U.S. mission. "On one side, you have a worldwide known organization — NASA — well equipped with a lot of biophysical and weather data on various countries in Africa. On the other side, AGRA, an African based and African led alliance is working to improve the food security and income of farmers across the continent. Information available at NASA will be useful for their strategy to [help populations] adapt to climate change. This is the perfect synergy," said Matieyedou Konlambigue, AGRA's program officer for markets access for West Africa, in an email.

For Brown, it's a breakthrough that's long overdue. "I do think this is a very important first step in getting this data that has been around for 40 years into the hands of people who really do need it," she said.

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A stitch in time for NASA airplane techies

Aircraft of the future might be stitched together rather than fastened. NASA is preparing to test a structure built that way under a six-year-old project to make commercial airliners more environmentally friendly.

The Pultruded Rod Stitched Efficient Unitized Structure, or PRSEUS, will be set up in the Combined Loads Test System, or COLTS, at NASA Langley Research Center in Virginia to see how well it tolerates the bending and internal pressure of simulated flight. The month-long test is expected to begin in March or April.

"The upcoming test will prove that the PRSEUS concept is viable for commercial transport aircraft," said lead engineer Dawn Jegley. "This is the final step in our building block process, short of a flight vehicle."

The test article is an 80-percent-scale cross-section of a hybrid wing-body aircraft fuselage, and it contains three side-by-side compartments or bays like those in which passengers would sit. Boeing Research & Technology built the 30-foot-wide, 13-foot-high structure in Long Beach, California, and NASA was scheduled to fly it to Langley in mid-December aboard its Super Guppy widebody cargo plane. NASA developed the structure concept with Boeing and the U.S. Air Force Research Laboratory.

A cross-section of a blended wing body, built at Boeing's facility in Long Beach, California, will be used to test stitched construction.

Boeing

Unlike conventional aircraft, in which thousands of fasteners tie together structures, PRSEUS is made of carbon fibers stitched together by a device that operates like a large sewing machine. The fibers are then coated with resin and heated in a pultrusion process to make them hard like plastic.

PRSEUS is lightweight but damage-resistant, making it particularly suitable for a hybrid wing-body configuration, which produces greater lift and reduced drag compared with a conventional airplane with a circular fuselage and wings, according to NASA.

"PRSEUS alone does not help with lift, drag or noise," Jegley said. "Combining it with the new shape of the hybrid wing-body is where we get the lift and drag improvements."

The structural testing at Langley is one of eight major technology demonstrations NASA is conducting under the Environmentally Responsible Aviation project. NASA launched ERA in 2009 to develop airplane technology that might cut fuel consumption, air pollution and noise. For aircraft that could enter service in 2025, ERA aims to cut aircraft drag by 8 percent, aircraft weight by 10 percent, fuel consumption by 15 percent, nitrogen oxide emissions by 75 percent and noise by 12.5 percent.

Jegley said that building an airplane to demonstrate these technologies in flight is an option for the future.

"We have discussed possibilities but no specific plans for a flight vehicle," she said. "It's just the next logical step."

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Satellite pushed by former VP Gore ready for launch

The Deep Space Climate Observatory in a clean room at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

NASA

The U.S. government's Advanced Composition Explorer, or ACE, satellite is on borrowed time. It's been watching for potentially destructive solar storms for the past 13 years, a decade longer than it was designed to last.

If all goes as planned, help will be on the way in January when the Deep Space Climate Observatory, or DSCOVR, spacecraft lifts off from Florida aboard a Falcon 9 rocket. The refrigerator-sized space weather tracker will travel to a point a million miles from Earth, where the gravitational forces of the sun and Earth are in balance. At this point, called L-1, DSCOVR will serve as a sentry for dangerous fluxes in the solar wind, the constant stream of charged particles and magnetic fields from the sun that can knock out communications and damage satellites.

Solar weather wasn't always the main mission for the 570-kilogram spacecraft. The original concept, championed in the 1990s by then-Vice President Al Gore, called for sending a climate-monitoring spacecraft called Triana to the L-1 point. NASA's Goddard Space Flight Center in Greenbelt, Maryland, built Triana, complete with a camera to snap spectral images of Earth and a radiometer to measure Earth's radiation, so fluctuations could be factored into climate models. When President George W. Bush took office in 2001, his administration canceled Triana and placed it in storage.

Fast forward about a decade. NOAA urgently needed to replace ACE, and it just so happened that Triana's secondary sensors could monitor the solar wind. Triana was pulled from storage, refurbished and given a new name and primary purpose. DSCOVR kept its climate sensors, but NOAA elevated its solar-wind observations to its main mission.

Just as with ACE, when data indicate a solar storm, NOAA will issue alerts to potentially affected parties so they can take precautions. Airplane pilots might change routes to avoid losing contact with air traffic control. Satellite operators could place the spacecraft in safe mode to protect electronics. Electric utilities could turn on more generators or shut down parts of their grids.

If DSCOVR lifts off as scheduled on Jan. 23, by May it should be a million miles from Earth and 92 million miles from the sun. NOAA expects to begin receiving data in July. DSCOVR was developed in the same technological era as ACE, so it does not represent a leap over its predecessor. But it will have some advantages, such as being able to operate during severe space weather storms. NOAA says it has developed computer models that will use DSCOVR data to create better storm forecasts.

NOAA expects DSCOVR to last five years in orbit, so efforts are underway to determine what might come after it. A lot is riding on the January launch, because there are no comparable spacecraft operated by other nations.

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Atmospheric skimming satellites

A European company has a radical idea for how to make Earth-observing satellites smaller without sacrificing resolving power. Why not have them dip into the upper atmosphere to look at their targets? The optics could be smaller on such a satellite, because the camera would be closer to the ground, and the satellites could be launched on less-costly rockets or as secondary payloads.

The concept is called Skimsat and it was developed by engineers at Thales Alenia Space UK.

The thinking is: "If you halve the altitude, you halve the optics," said Andrew Bacon, a senior space systems engineer at Thales Alenia Space UK. Bacon presented the concept at the Reinventing Space conference in London in November.

A Skimsat would be placed in a very low Earth orbit, VLEO, with a perigee, or low point, of just 160 kilometers, he explained. By Bacon's calculation, such an orbit would allow a "four times reduction in the required aperture diameter and focal length, for the same 1-meter resolution, when compared to an optical imaging satellite at 650 kilometers altitude." The transmission power for the data downlink could be reduced by 10 times, he said. The overall cost of the mission could be cut "by at least an order of magnitude," he added, implying that a constellation of 10 Skimsats could be built for the price of a single conventional satellite.

The idea of flying close to the ground to enhance resolution harkens back to the early U.S. military reconnaissance programs of the 1960s, such as the Corona satellites, which flew below 300 kilometers and, according to Bacon, produced an image resolution as good as 0.3 meters.

A key problem with these low-altitude orbits is the density of the atmosphere. A Skimsat would have to cope with the erosive effect of atomic oxygen on spacecraft materials and it would need to be designed to fight off drag as long as possible. Each Skimsat would have a wedge-shaped leading edge coated in atomic-oxygen-resistant materials. Its optical surfaces would be recessed for protection. Drag would be countered as long as possible by an electric propulsion system deriving power from a "sun-tracking tail array" protected from the atmosphere by the satellite's body. The European Space Agency's GOCE spacecraft — Gravity Field and Steady-State Ocean Circulation Explorer — provides reason for optimism, Bacon said. GOCE "demonstrated sustained operation at about 260 kilometers using a drag compensating ion engine," he said. "The spacecraft operated for 55 months before running out of fuel."

Even with those technologies, "re-entry time at these low altitudes is measured in months rather than decades," Bacon conceded. On the bright side, VLEO satellites don't hang around to pose an orbital debris problem, he added.

Skimsat would be based on the company's Omnisat bus, a "modular nanosat architecture, built like a PC with a backplane and motherboard" and designed to compete with the unmanned aerial vehicles now challenging established satellite image providers.

"Skimsat is like a UAV at orbital velocity," said Bacon, who hopes to see commercial buyers flying constellations of Skimsats before too long. "If fully funded, we could do it in three years."

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Skimsats: Atomic-oxygen-resistant materials and electric propulsion would let these proposed satellites graze the atmosphere for closer looks at the ground.

Thales Alenia Space UK

Why rocketeers fear wind

On the Beaufort scale a 20 knot wind is termed a "fresh breeze" and is welcome relief on a hot day, but not on launch day, as the Orion team twice found out before seeing their handiwork lift off on Dec. 5. A day earlier, automatic sensors detected wind speeds climbing to over 20 knots, triggering automatic holds in the launch sequence. The launch was ultimately scuttled due to what NASA called a "sticky" valve on the Delta 4 rocket. But the wind delays raised the question: Why does wind matter to a rocket that weighs nearly 500,000 pounds and generates over 700,000 pounds of thrust?

Moving-air currents affect rockets like they do airplanes. Strong winds can buffet them, slide them off course, and generally make the control systems work twice as hard to keep the craft on its intended track. There is also a slight risk of a wind gust moving the rocket into the launch tower itself — damaging both the craft and the tower — making launch impossible.

Once the rocket is aloft, wind gusts can overcome the ability of its hydraulic engine gimbals to keep the rocket on course, changing the ascent trajectory from a safe one tracking over largely unpopulated areas to "a much more risky, unintended, track over heavily populated areas which would be endangered by a launch abort scenario, or a debris fall," said Christopher Goyne, associate professor of mechanical and aerospace engineering at the University of Virginia. "High winds can also lead to forces and vibrations that can structurally destroy a rocket while it is on the launch pad."

Former NASA astronaut Wally Schirra discussed such a scenario in a 2002 interview with author Francis French, revealing that Apollo 7 launched in wind conditions that threatened to blow the craft "back over the beach," potentially creating havoc.

Wind was discussed as a potential contributor to the fatal 1986 explosion of the shuttle Challenger. While the cause of the disaster was found to be a faulty O-ring seal, the official report noted that "thrust vectoring and normal vehicle response to wind shear" could have "magnified the leakage from a degraded seal in the period preceding the observed flames."

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A Delta 5 with NASA's Orion crew capsule mounted atop lifts off from Cape Canaveral Air Force Station in Florida Dec. 5, one day after the original planned launch was postponed because of high winds.

High-flying science on ISS

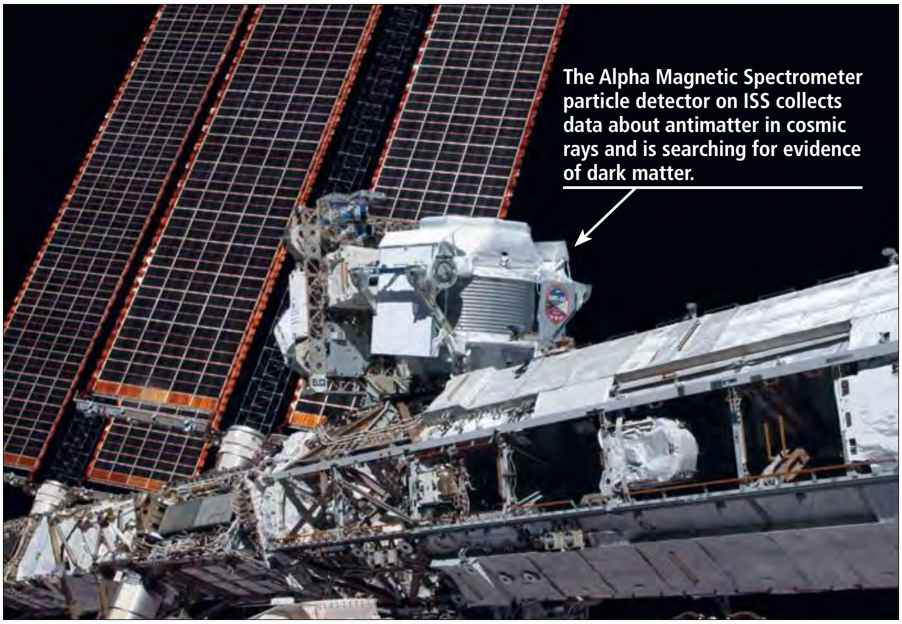
From developing more effective medicines to shedding light on dark matter, experiments on the International Space Station are growing in scope and number. Former astronaut Tom Jones looks at how the station serves as a platform for research that improves life on Earth and sets the stage for human deep-space exploration.

NASA astronaut Don Pettit took full advantage of his 2003 and 2012 expeditions to the International Space Station to convey the excitement of doing science in orbit. He reached thousands of young explorers with his "Saturday Morning Science" video broadcasts from ISS, carried on NASA TV. When Pettit talks about research aboard ISS, he sounds like a kid on Christmas morning who's describing the amazing discoveries under the tree.

"Combustion occurring at 800 degrees [Celsius] instead of 2,000 degrees C; people are scratching their heads — what's going on? It's one of these 'Wow!' discovery things," he told me by phone recently.

A broad range of basic and applied research is underway at ISS, enabled by completion of the outpost in 2011 and the productivity of its six-person crew. Discoveries are beginning to flow in on topics ranging from the mystery of dark matter to the challenge of keeping astronauts healthy on a trip to Mars.

Working in the three dedicated labs — U.S., Japanese and European — NASA and international partner astronauts together log an average of about 40 hours per week on science work aboard ISS. The crew's total weekly science output sometimes reaches as much as 70 hours, but the figure dips correspondingly when cargo vehicles arrive or the crew conducts a maintenance spacewalk. Russian crew members also participate in science investigations in the U.S. segment of the station, in addition to tending to experiments in the Russian modules. The ISS research program focuses on three areas: discoveries resulting from the station's unique location and resources, using the outpost as an exploration technology proving ground, and developing processes and insights that benefit life on Earth.



The Alpha Magnetic Spectrometer particle detector on ISS collects data about antimatter in cosmic rays and is searching for evidence of dark matter.

NASA

Fundamental science

A favorite experiment of Pettit's in the fundamental discovery category is the Alpha Magnetic Spectrometer, a high-resolution cosmic ray detector positioned on the station's S3 truss. From orbit, AMS can track the passage of high-energy nuclei and subatomic particles that are screened from terrestrial detectors by Earth's thick atmosphere. So far, physicists have only been able to catch fleeting glimpses of these exotic particles in the colliding beams of advanced particle accelerators. "With AMS, for the first time, we are taking a high resolution detector of fragments from atoms and putting it out in nature to see what's there. We can measure these particles' charge, energy and path with high resolution," says Pettit. "And we've never been able to do that before."

The AMS team announced in September that analysis of 41 billion particle detections at ISS since 2011 provides new insights into the nature of the mysterious excess of positrons (antimatter) observed in the flux of cosmic rays. The results were published in September in the journal Physical Review Letters. The positron energy spectrum observed by AMS could be explained not only by objects such as pulsars, but is "also tantalizingly consistent with dark matter particles" annihilating into pairs of electrons and positrons, the team said in a news release. Investigators hope ongoing AMS observations of higher energy particles will help distinguish whether the signal is from dark matter or a cosmic source.

Looking back at Earth is the RapidScat microwave scatterometer, delivered on September's SpaceX Dragon CRS-4 mission. Over two days, RapidScat was assembled and attached to the exterior of the station's Columbus module using the station's robotic arm and Dextre manipulator, and began operations on Oct. 1. RapidScat bounces microwaves off the ocean surface and collects the echoes to measure the global near-surface wind velocity field, refining forecasters' ability to predict weather, track hurricanes and study the changing climate.

Exploration proving ground

NASA sees ISS as the ultimate testbed for a variety of operations, technologies, and medical protocols to prepare astronauts and flight controllers for the challenges of deep space.

Crew health experts have greatly reduced astronauts' bone loss through a fitness regimen that involves exercising on two kinds of machines for a combined 90 minutes each day. For strength training and skeletal loading, a machine called ARED, for Advanced Resistive Exercise Device, uses vacuum resistance to mimic pumping iron on the ground. To maintain heart, lung and muscle health, astronauts run on a treadmill or cycle on an ergometer that records heart rate and efficiency of oxygen use.

"We've gotten to an exercise protocol that will let crew members maintain their bone mass density — not lose bone mass when they go into space," ISS Chief Scientist Julie A. Robinson said in an interview. "That was a surprise to the bone research community on the ground…. We're making some advances there that we would never have made on Earth, to help ensure we can get astronauts to Mars with bones that are strong enough to work on the surface."

Good exercise results have enabled astronauts to avoid resorting to anti-bone-loss pharmaceuticals, with their attendant side effects. Robinson says these results got attention at a conference of the American Society of Bone and Mineral Research: "We found a room packed with 400 investigators interested in finding out how to get their research on the station." ISS research promises new insights into how to treat bone loss patients on Earth — the aging, the disabled or those who are bedridden.

Astronaut Dan Burbank works out on ARED, the Advanced Resistive Exercise Device, on the International Space Station.

NASA

The exercise protocol will be put to a demanding test when NASA's Scott Kelly and Russia's Mikhail Kornienko launch in March for a one-year stay aboard ISS — twice the usual ISS duration. Their flight will investigate whether bone density, muscle mass, strength, vision and other physiological markers will remain safely stable through a flight duration comparable to near-Earth asteroid expeditions or a transit to Mars. Researchers will track the crew's health to see if, after six months, a particular function such as the immune system falls off a cliff as free fall exposure lengthens.

Monitoring equipment onboard is now much more sophisticated than when four Russian cosmonauts exceeded the one-year mark during the 1980s and 1990s.

Deep space technology is also getting a workout on ISS. Robonaut 2, the humanoid robot launched to ISS in 2011, got its first set of legs in August, equipped with handrail-gripping "feet." Robonaut's new legs span 2.7 meters (9 feet), a stance that will come in handy on its first spacewalk, planned for no earlier than 2018.

Robot assistants are part of NASA's strategy for ISS maintenance and repair, as well as the future assembly of pre-deployed elements on a deep space expedition.

NASA

Steve Swanson, left, and Reid Wiseman conduct test runs of the SPHERES-Slosh experiment, which uses soccer-ball-sized Synchronized Position Hold, Engage, Reorient, Experimental Satellites to examine how liquids move inside containers in microgravity.

Back inside ISS, astronauts now interact with hovering robots, part of the ongoing Synchronized Position Hold, Engage, Reorient, Experimental Satellite, or SPHERES, experiment. These volleyball-sized free fliers may ultimately perform as crew assistants inside the station, or act as "flying eyeballs" for exterior inspections of deep space craft.

In 2014, a SPHERES experiment coupled two of the maneuvering robots to a water-filled tank, investigating the way liquids move inside containers in a microgravity environment. The SPHERES-Slosh experiment examined the phenomena and mechanics associated with such liquid movement. Better understanding of how rocket propellants behave in free fall should improve the safety and efficiency of future propulsion system designs.

Bettering life on Earth

Laboratory work at ISS is advancing in several disciplines aimed directly at improving life on spaceship Earth. One big beneficiary has been biomedical research into what makes life tick, from microbes to astronauts.

"The station is an amazing tool that we're learning to exploit," says Pettit. "Life here on Earth has evolved over billions of years, and the environment has swung all over the map — from acid to alkaline, from hot to cold, stones hurtling in from space, lava spewing up from down below — almost nothing has been constant. Yet life survives. The one variable that has been constant through these billions of years is the magnitude of gravitational force. Now we have a platform where we can change the gravitational force by a factor of a million. Life has never had this experience before. Just try changing the temperature in an experiment down here by a factor of a million and see how long it takes the nematodes to shrivel up!

"ISS has an amazing, variable 'gravity knob' that we can now tweak. That's never been possible on Earth, and we don't know what's going to happen."

Twenty black mice, the first to experience the variable gravity at ISS, arrived in September aboard SpaceX's Dragon cargo craft. Housed in the Rodent Research Habitat System, the adult, female mice will be examined for signs of radiation damage, muscle atrophy, bone mass loss and immune system depression. Five of the mice are genetically modified "MuRF-1" rodents that lack a gene causing muscle deterioration. Because muscles exert a continual tug on the skeleton, "they will help us understand the mechanism of bone loss and the interface between muscle disuse and the loss of bone, which has incredible potential for helping treatment of patients back here on Earth," Robinson says. Tissues from the mice were returned by Dragon in late October.

The Protein Crystal Growth experiment uses microgravity conditions to generate larger crystals from a protein solution, enabling detailed structural analysis of key proteins. The technique was explored in the shuttle era, with mixed results, but commercial interest in the process has revived. In a recently returned batch of samples, Robinson says, 50 percent of crystals were of higher quality than those grown on Earth. She adds that "an outstanding result from ISS so far is a drug, now in preclinical development, that could treat Duchenne muscular dystrophy."

Robinson's favorite ISS biomedical product is a microencapsulation process able to surround a potent drug or chemical with a tiny, soluble capsule for targeted delivery within the body. The capsule shields normal cells from a toxic anti-cancer drug, for example, until it can be delivered precisely to a tumor. Experimental work on two early ISS expeditions has resulted in a practical, ground-based capsule manufacturing process. Microencapsulated compounds are now being used to mark testicular and breast cancer tumors with a dye to improve biopsy accuracy. Chemotherapy delivery is next.

"It's been exciting to watch this team make progress," says Robinson.

Accelerating science

"We're still increasing our science and increasing our users at ISS," says Robinson. "We're seeing a lot of growth on the commercial side and in these different types of biomedical models. They're seeing key experiments with rodents or fruit flies, for example, that can really benefit their own research on Earth. In a decade we'll look back and really see the value as these different applications come into their own…and make our lives healthier and better."

Pettit puts it this way: "Say you'd invented a microscope. You use it to look at things around your laboratory…man-made things. Now for the first time, we're taking it out into nature to look at a drop of pond water. And we haven't a clue what we're going to find. If that isn't going to be discovery science, I don't know what is."

Space visionary

Retired Air Force Brig. Gen. Simon "Pete" Worden, director of NASA's Ames Research Center

Back when astrophysicist Pete Worden was an Air Force officer and the technical brains behind the Strategic Defense Initiative, members of his entourage liked to say that defending Americans from missiles was but one small piece of his plans for putting space to use. Since 2006, Worden has been marshaling the talents of supercomputing experts, entrepreneurs and Silicon Valley toward creation of a space economy in which people would live and work far from Earth. Worden, in fact, joined the Air Force to become an astronaut, but NASA did not select him. Ben Iannotta spoke to Worden by phone about his second career as director of NASA's Ames Research Center.

NASA has these capability leaders coming onboard. What would you say to one of them about Ames?

We've worked very hard to do things that are on the cutting edge but that aren't focused on a lot at the other centers, and that take advantage of our unique location. We're the IT leader for the agency. We've also become the partnership lead for the emerging private sector and international partners — sort of nontraditional partners. In aeronautics, we've always been the lead on more analytical things: end-to-end analysis, safety, air traffic management. On entry-descent and landing, if you want to go to space, you talk to Marshall and Stennis. If you want to come home, you talk to us. I've gotten excited about fundamental biology. I'm convinced that biology is every bit as important for our science and exploration missions as aerospace engineering. It's going to approach about 100 million [dollars] a year. My own personal area of interest is small satellites. We're seeing in the Technical Capability Assessment that we've come up pretty well.

What do you mean by fundamental biology?

If you look at what would [be required] on Mars to enable humans to live there and live off the land, I really would like a self-replicating programmable machine. It turns out that's called biology, and we're beginning to learn how to program biology.

I hit a computer command and an apple grows?

Eventually, yes. Let me give you an example of an experiment we're doing with the German space agency, called Eu:CROPIS [Euglena: Closed Regenerative Organic food Production In Space]. On the space station, we can't test variable gravity. We don't have a centrifuge. So in about 2017, the Germans are launching a small satellite that will rotate at variable speeds and simulate gravity. Gene expression differs in space for reasons we don't fully understand. So we have an experiment that we're putting on EU:Cropsis. Cyanobacteria convert sunlight and trace elements and carbon dioxide to sugar. We're going to engineer the cell wall so that sugar can be secreted. This is basically a mechanism where we can grow sugar and pharmaceuticals and so forth. So it's a programmable factory. We want to find out: Does it work in one-sixth gravity to simulate the moon, or one-third gravity simulating Mars?

How do you take advantage of your Silicon Valley location?

We have a research park with about a hundred partners and we team with them to produce new capabilities. A very interesting one is Made In Space. They work closely with us and Marshall Space Flight Center. They just produced and launched the first 3-D printer to go into space on the International Space Station. This is another part of being able to live off the land. If something breaks, you can build a part or a tool. A good bit of the venture funding is here. Another one is the spirit of innovation: It's OK to fail. The old saying at NASA that failure is not an option doesn't really apply in Silicon Valley. Failure is not only an option, but it's expected.

Do your Silicon Valley partners use the Pleiades supercomputer at Ames?

Yes. Pleaides is number 11 in size in the world but it's the largest sort of commercial endeavor. We work closely with Silicon Graphics — SGI. It is a public-private partnership to

Interview by Ben Iannotta

NASA

Pete Worden at the Ames Research Center's hyperwall, a liquid crystal display showing historic and predicted temperature maps of the U.S.

develop this capability. One of the interesting private sector partnerships is with this company right next door to me that you might have heard of, Google, I think they're called. We and Google and USRA [Universities Space Research Association] have got one of the three quantum computers in the U.S., the D-Wave machine. That's another example of a public-private partnership to move computing forward.

One of the points people have been making is that computational fluid dynamics tools aren't ready for supercomputing and quantum computing. Are you guys addressing that problem?

Absolutely. One of our key goals is to make sure the physics understanding matches the computational tools. The quantum computer came out of our physics-based modeling group. A lot of other methods are more sort of trial-and-error, whereas fundamental physics says, "OK, what are the physics we're dealing with?" We've used [the Pleiades supercomputer] to model some of the fluid flow and aerodynamics for [NASA's Space Launch System rocket] for example. We are running up against the computational limits for some of the problems we want to solve. The quantum machine offers one interesting approach to problems we can't solve with a conventional machine.

What kind of work can you do with quantum computing?

A quantum machine — and this is a very early first order machine — has a unique capability that a conventional machine doesn't. The classic problem is the traveling salesman. I'm a salesman and I want to go to a bunch of cities and spend the least amount of time on the road. I can program this on a [conventional] computer, but when I start to get more than about 30 cities, I double the size of the machine I need. That's called an exponentially growing machine problem. But a quantum machine has a linear scaling with complexity, because each bit can be all values between zero and one and is entangled in a quantum way with the other bits. You could have hundreds of sites and in principle solve them. We'd like to optimize thousands of airplanes flying simultaneously. That's part of [FAA's] Next Generation air traffic management system. Eventually a quantum machine would enable us to do that. Suppose I send a robot into a cave on Mars. If I try to program it for all possible things, it becomes impossible. But if I start us-

(Continued on page 21)

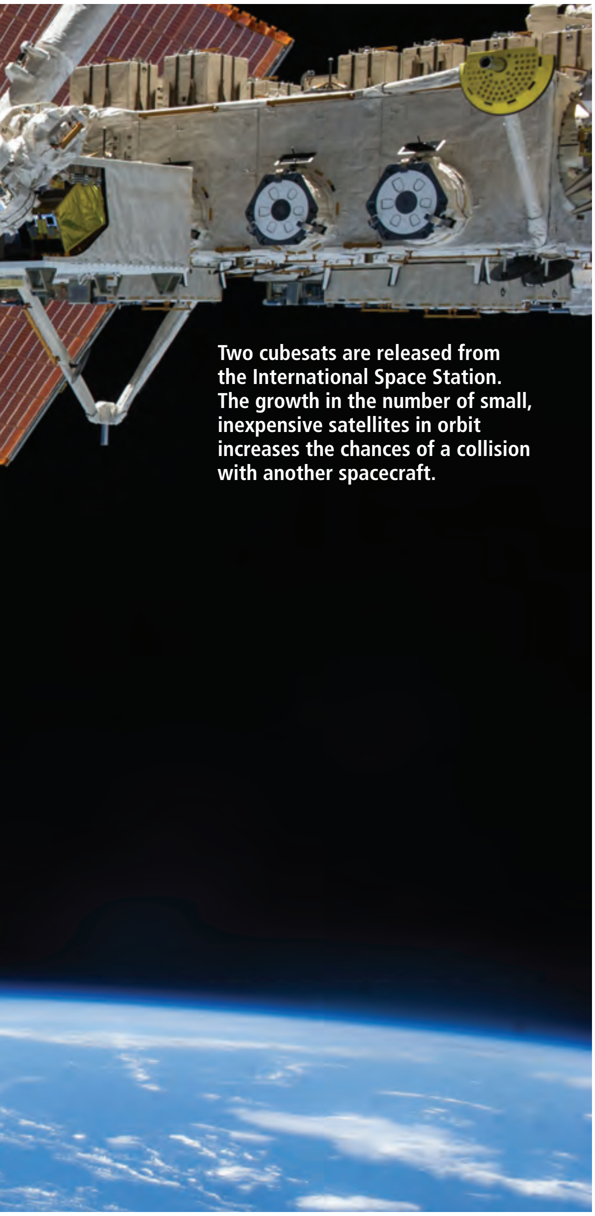
Collaborating against *space debris*

Space debris provides an incentive for commercial satellite operators, governments and universities to collaborate toward more effective use of the space environment, because all are at risk unless all participate.

Consider the biological world. When creatures spread to new locations, either on their own accord or with the help of humans, they disrupt the ecological balance and force new and often undesirable equilibria.

Invasive species can't be stopped, but their impacts can be controlled. We should adopt a similar philosophy for managing the space environment. Collaboration on space debris will mean distributing tasks among institutions to avoid redundant experiments and the tendency to do what is accessible rather than what is necessary. We also need an agreement on a more useful definition of debris. The Inter-Agency Space Debris Coordination Committee, or IADC, defines space debris as "all man-made objects...that are nonfunctional." This definition is too expansive. Only those objects that could diminish the beneficial use of space should be considered debris.

When objects do pose a risk, spacefaring nations, satellite operators and other



Two cubesats are released from the International Space Station. The growth in the number of small, inexpensive satellites in orbit increases the chances of a collision with another spacecraft.

NASA

Satellite operators and space-faring nations have a long to-do list when it comes to space debris, from understanding exactly how spacecraft break apart to updating the definition of what constitutes debris. Dave Finkleman, formerly of the North American Aerospace Defense Command, examines the issues and the potential for collaboration.

VIEWPOINT
BY DAVE FINKLEMAN

stakeholders must understand the nature of the potential impairments. Collisions and explosions that disassemble spacecraft and create more intrusions are the most serious occurrences, though extremely rare. We must assess the unavoidable and unalterable background fragment population, analyze the fragmentation consequences of any destructive events, whether accidental or deliberate, and assess the degree of potential perturbation and risk these introduce. We have not yet achieved this capability.

All satellites face the risk of collisions with the natural meteoroid background that races toward Earth at a rate of millions of kilograms per day. Every spacecraft encounters neutral and charged particles, and sometimes this alone impairs a spacecraft, no matter how diligent we are about shielding and protection. At sea, severe storms sometimes sink seemingly unsinkable vessels. We cannot prevent everything. The more satellites we launch, the more risk of failures and collisions we create. The only real solution would be to keep our presence in space low enough to minimize the risk of the most dangerous scenarios. Simply put, there is a balance between how much we launch and how much worse we make matters.

Thankfully, we are nowhere near having to stop launching satellites, but the population of objects in orbit will need to be managed eventually. Even then, we can't prevent orbital debris any more than we can prevent the introduction of environmentally invasive species. We can only mitigate the risk and diminish the probability of serious consequences.

We have a hard time defining the risk right now, partly because we do not understand how satellites disassemble through either explosions or collisions. This is not surprising, since we hardly understand how aircraft, automobiles or ships break up. The unfortunate demise of Malaysia Airlines flight 370 illustrates this. We can achieve some control with structural modifications, but more structure is more unproductive mass. Mission capability may be compromised more by excess mass than by collisions.

The explosive growth of cubesats complicates matters, partly because there are so many of them but also because their size almost doesn't matter. If a small thing hits a big thing, it's a big problem. We can add some predictive understanding by blowing up satellite mockups in controlled environments, but not much. The community must collaboratively seek greater insight.

Removing satellites at end of mission is one effective step. If a satellite isn't in orbit, it cannot explode or hit anything. An IADC guideline states that satellites should remain in low-Earth orbit for no more than 25 years after their missions end. This guideline should be reassessed. It may be too long for many orbits, while no limit may be appropriate for other orbits. In any case, estimates of orbital lifetimes for our satellites are notoriously imprecise. The atmosphere is dynamic on several time scales, not just solar cycles, which are themselves marginally predictable. As a result, there are many ways to estimate lifetime and just as many different estimates. Designers can easily underestimate how long a satellite will remain in orbit. Second, the longer a satellite is in orbit, the greater the probability of collision over its lifetime. It is wise, therefore, at the end of a mission to purge most energy stored in the satellite. This could mean residual propellants, batteries, or even flywheels that keep spinning or the tension in the outer sphere of a balloon structure. A challenge is that we often do not know how much energy remains. Residual propellant mass measurements grow very imprecise the more propellant is expended. Batteries retain latent chemical energy even when voltage is apparently low. A reason for concern about a complete purge of energy is that without energy, all control and communication would be lost.

It is also costly in terms of energy to avoid collisions. We typically don't know that a maneuver is necessary until shortly before the collision would be inevitable. Our collision estimates improve with time and more frequent observations, but the longer we wait to maneuver, the more energy we will expend and the greater the impact on the overall mission lifetime. We don't like to maneuver satellites unless we know we must. Our threshold of concern is a 1-in-10,000 chance of collision. Therefore, there is a 99.99 percent probability that there would be no collision. If there is no collision, we could never prove that it was because of the maneuver. This does not mean that we should not maneuver. It does mean that maneuver decisions are very complex and do not depend only on collision probability percentages.

We need much greater international collaboration in observing satellites and estimating their future states. Operators know much better than others where their satellites are, but they have little knowledge of where everyone else is. These are a small fraction of the challenges of space debris. We can address them only collaboratively. Technical, diplomatic and economic collaboration are all necessary. Any who resist data sharing or mutual understanding are threats to all others, and others are a threat to them.

Retired Air Force Col. Dave Finkleman is a former chief technical officer at NORAD and the former U.S. Space Command. He has a Ph.D. in aerodynamics and gas dynamics from MIT and is an AIAA lifetime fellow.

(Continued from page 17)

ing a quantum approach, this provides a new level of autonomy. We do not yet have a quantum machine that we could send on a robot to Mars, but we might in 20 years. Some people would call it AI, I just prefer to call it complicated autonomy.

What are you doing in the area of climate change?

We have the NASA Earth Exchange, which is a tool that enables people who are doing the actual modeling to get access to this data in a way that it's calibrated and linked to other data sets. Also, the Pleiades supercomputer is used by the whole agency and the whole scientific community for models, to start focusing on site-specific climate prediction. If I go to a city and say, "We think the average temperature is gonna be 3 degrees higher in the state of California and you'll have 10 percent less rainfall," what they really want to know is: "What's it going to do right here in my area?"

Do you think climate change is an area that the new Congress might not be as interested in funding?

I spent a year as a congressional fellow when I got out of the Air Force. I like to think most NASA things aren't very partisan. I think we're looking forward to some broad support for what we're doing.

Do you think the emphasis on green and climate change will have legs beyond the Obama administration?

I think understanding the environment we live in is important no matter where we are. We can argue about what's causing changes, but the climate is constantly changing for a lot of reasons. The climate changes not only on this planet but on Mars and other places we're going to be. If you're going to live someplace, you need to understand and be able to predict at a certain level the changes. This goes far beyond politics or one person's or another's view.

Our job is to collect data, to help interpret it, and make it available. I think we do it pretty well.

Where do you come down on climate change?

My interest is climates on planets that might be orbiting the nearest stars. One of the things I learned as a scientist is that I should stick to areas that I'm really an expert on. So I'll decline to give you an opinion on that.

On small spacecraft and cubesats, what kind of deorbiting technologies are in the works?

One of the interesting things about cubesats is that most of them we launch to an altitude where they deorbit in short order anyhow. That said, we are looking at ways to accelerate that. We've worked with the Marshall Space Flight Center to deploy at the end of life a small solar sail that will slow it down and deorbit it. I think if we can make these things cheap enough that it may make it possible for us to take these small sats to higher altitudes and maneuver them even if you're out of fuel or you don't have a propulsion system.

Could you foresee ever having to deploy a nuke — a nuclear weapon — against an asteroid or comet?

We don't know. I would like to think that in the long run, if you have good enough sensor systems, you can find things years or decades out so that we can use much more conventional means to move them.

When you look back on the Strategic Defense Initiative, what were the impacts?

Starting to look at defenses was a key element in ending the Cold War and coming to a peaceful end. It had to be one of the more cost-effective initiatives. So I'm happy about that. As a side benefit, we developed a lot of very exciting technologies. The nucleus of the current small satellite effort, much of it came out of the strategic defense technology program. Not that we should do efforts in national security because of the technology. But we should certainly take advantage of those. If you recall, when I was there, we sent a probe to the moon — a low-cost probe called Clementine.

I remember that.

Now that I've been here, I've sent two other probes to the moon. [*Interviewer's note: He means LADEE, the Lunar Atmosphere and Dust Environment Explorer, and LCROSS, the Lunar Crater Observation and Sensing Satellite*.] I'm a moon mission expert now. So three times to the moon and they all worked.

The other piece of history I was curious about was your chapter as director of the Pentagon's Office of Strategic Influence. That always struck me as an odd choice for a technologist, but maybe not.

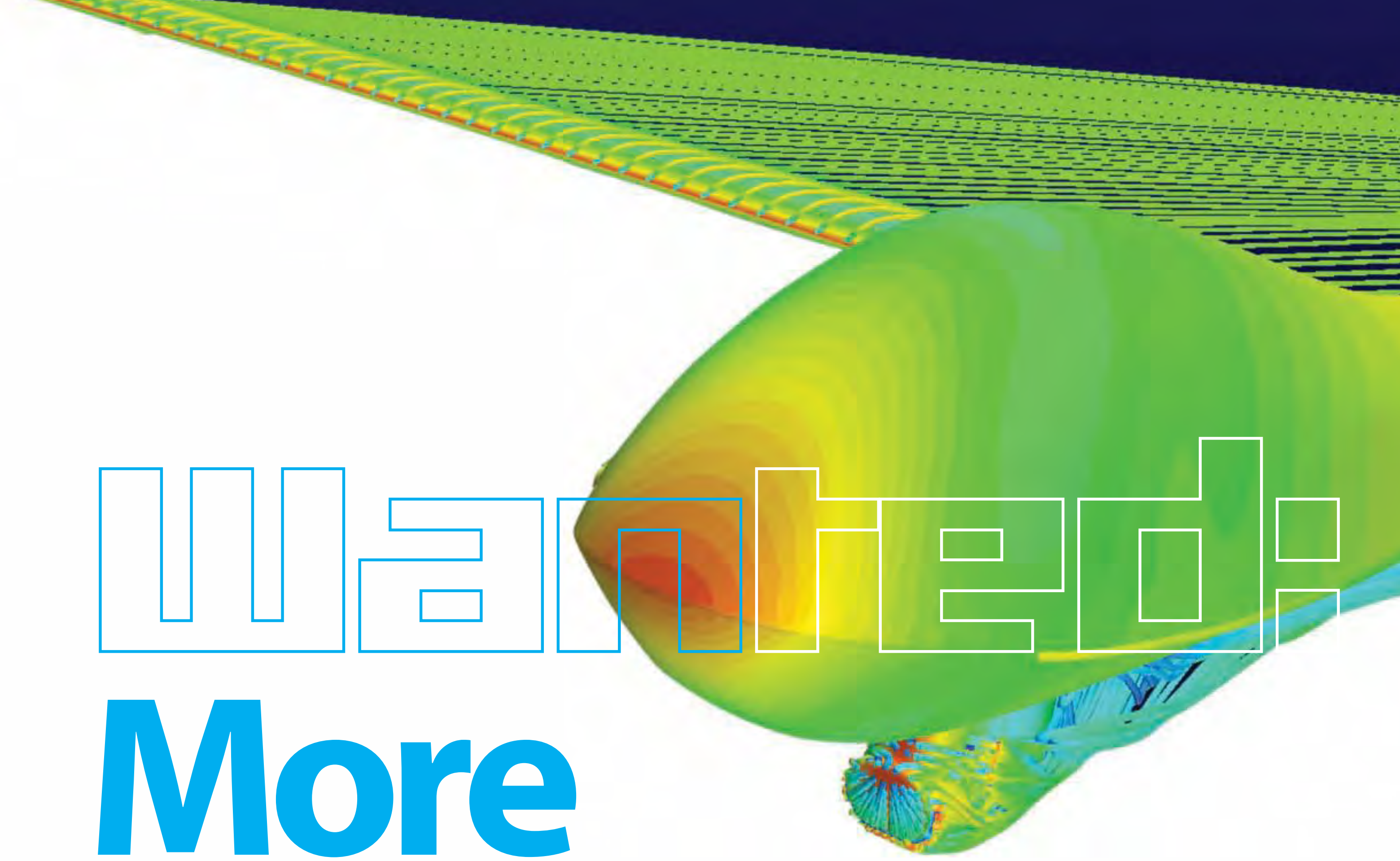
Obviously there's a lot of controversy. I will tell you that a lot of our interest was in cyber and information that goes over computers. Prior to that, I was the deputy director of operations at U.S. Space Command that had the cyber operations responsibility. I think the other thing is they were looking for somebody to look at things outside the box. But that was a short-lived job.

Can you paint a portrait of the interesting developments we'll see in the coming years?

We're at the beginning of a true space economy that's going to take us beyond Earth orbit. By the middle of this century, I expect us to be not only a multiplanet species, but a multiplanet economy. The second is biology. We are going to understand biology to make life incredibly better here on Earth, as well as to expand into the solar system. The third, and this is sort of my own pet area, is that this is the century we're going to start looking beyond our solar system. I loved the movie "Interstellar." It's time to start that — probably not using black holes, worm holes — but I'm very excited about the Kepler results.

It's science for the sake of science, but I guess what's wrong with that?

It's mankind's ultimate future. I think we're the universe's answer to entropy. And expanding into the solar system and beyond is, at least to me, the ultimate quest.



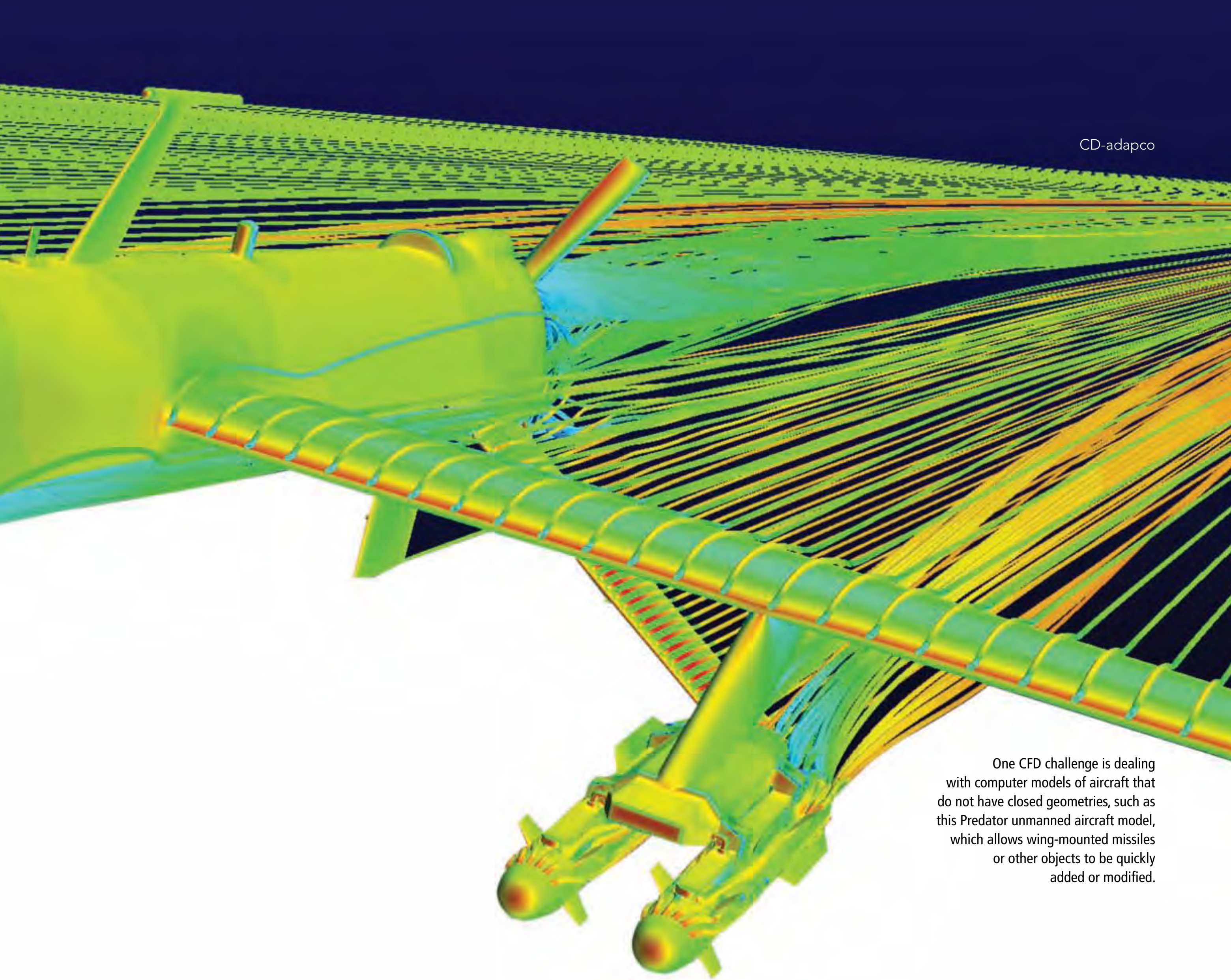
Wanted: More focus on CFD

Computational fluid dynamics has been a powerful tool for airframe designers, but American researchers are sounding an alarm about the troubles they see lurking for CFD software. Keith Button spoke to the authors of a report NASA commissioned on the topic.

By Keith Button

U.S. aircraft designers see all sorts of amazing machines in our future — airplanes with electric propulsion; with shapes that are part wing and part conventional body; with giant wingspans or with wings braced by struts and trusses.

American research is underway on some of these ideas, but aviation advocates in the U.S. are beginning to sound the alarm about a threat they see to their ability to get the best of these concepts into operation before other nations or non-U.S. corporations do. These experts warn that the U.S. does not have an adequate plan in place to improve today's computational fluid dynamics and other digital simulation tools and to get ready for exotic new computing concepts, such as circuity made from microscopic carbon nanotubes or computers that rely on quantum properties.



One CFD challenge is dealing with computer models of aircraft that do not have closed geometries, such as this Predator unmanned aircraft model, which allows wing-mounted missiles or other objects to be quickly added or modified.

Those technologies offer enormous potential because of their ability to rapidly process terabytes of data, but today's CFD algorithms and computing code would need to be rewritten for them.

There's also lots of room for improvement in the nearer term. Today's CFD products — the colorful physics-based digital simulations of aerodynamic flows — look very impressive and have assumed a larger role in aircraft development. But they are not as powerful as many designers and analysts would like.

"There's this perception in the [CFD] community and outside the community that when you see all these pretty pictures from current CFD methods that those are sufficient to design all kinds of new vehicles, but that's not the case. There are some glaring inaccuracies in many different areas," says Juan Alonso, an associate professor of aeronautics and astronautics at Stanford University.

Adapting CFD to the times will require the aerospace community to solve technical issues, win more funding and instill better collaboration among private industry, government agencies and university experts in high-performance computing, software design and applied mathematics, experts say.

"These are hard problems that cannot be solved by any one organization," says Jeffrey Slotnick, technical fellow in computational aerodynamics at Boeing in Huntington Beach, California.

Slotnick is one of the authors of a report commissioned by NASA, "CFD Vision 2030 Study: A Path to Revolutionary Computational Aerosciences." The report was completed in November 2013 and released in March. In the months since, the writers have publicized their findings in appearances at the Salishan Conference on High Speed Computing in Oregon, the AIAA Aviation Forum in Georgia, and at a user event in Kobe, Japan, put on by the RIKEN institute.

The report lays out a CFD development plan that has NASA taking the lead role by funding a base research program for simulation technologies, creating a formal structure for in-house simulation software development, making high performance computing available for CFD development, establishing testing and validation programs to assess CFD predictions, fostering collaboration, and attracting world-class engineers and scientists to the field of CFD.

From Slotnick's perspective, the key recommendation is to get a better collaborative effort off the ground: "We can't just rely on business as usual here. We have to do something fundamentally different to solve the problems."

Today, computational fluid dynamics is used to predict the aerodynamic characteristics and performance of airplanes before they are built. CFD does well at simulating air flows in cruising conditions, where an airplane operates 99 percent of the time. It's much less effective at predicting performance in other situations, such as takeoffs, landings and other low-speed, high-lift conditions in which flaps are deployed, or for simulating stalls or other conditions at the edges of the flight envelope, says Dimitri Mavriplis, professor of mechanical engineering at the University of Wyoming and an author of the report. Those flight conditions produce turbulence — the swirls and eddies created when air does not flow smoothly over the surface of the aircraft. Physical model tests in wind tunnels or real-world flight tests are used to judge performance in those scenarios because CFD lacks the accuracy needed to make credible design decisions, says Alonso, the Stanford professor and one of the report's authors. This weak spot in

POWER PLAYERS

High-performance computers are essential for advanced computational fluid dynamics applications. The Top500 project ranks the world's most-powerful computers based on a benchmark that measures the maximum number of floating-point operations per second, or flops, the computer has achieved. As of November, NASA's fastest computer ranks just outside of the top 10.

Rank	*Name*	*Performance (in petaflops)*	*Site*	*Country*
1	Tianhe-2	33.9	National Super Computer Center	China
2	Titan	17.6	Oak Ridge National Lab, Energy Dept.	U.S.
3	Sequoia	17.2	Lawrence Livermore National Lab, Energy Dept.	U.S.
4	—	10.5	RIKEN Advanced Institute for Computational Science	Japan
5	Mira	8.6	Argonne National Laboratory, Energy Dept.	U.S.
6	Piz Daint	6.3	Swiss National Supercomputing Centre	Switzerland
7	Stampede	5.2	Texas Advanced Computing Center, University of Texas	U.S.
8	JuQueen	5.0	Juelich Research Center	Germany
9	Vulcan	4.3	Lawrence Livermore National Lab, Energy Dept.	U.S.
10	—	3.6	Undisclosed government agency	U.S.
11	Pleiades	3.4	NASA Ames Research Center	U.S.

Source: Top500.org

current CFD simulation comes from reliance on mathematical models that are based on previous testing experience and approximations, instead of pure computations.

While some features of the air flow are as large as the aircraft, turbulent swirls can be smaller than 1/100th of an inch, very close to the surface of the plane. To calculate those flows with CFD, a mesh, or three-dimensional grid, is set up to account for each cube of space around the simulated aircraft. The mesh can include billions or trillions of cubes, or cells, each with calculations for velocity, density, temperature and other factors.

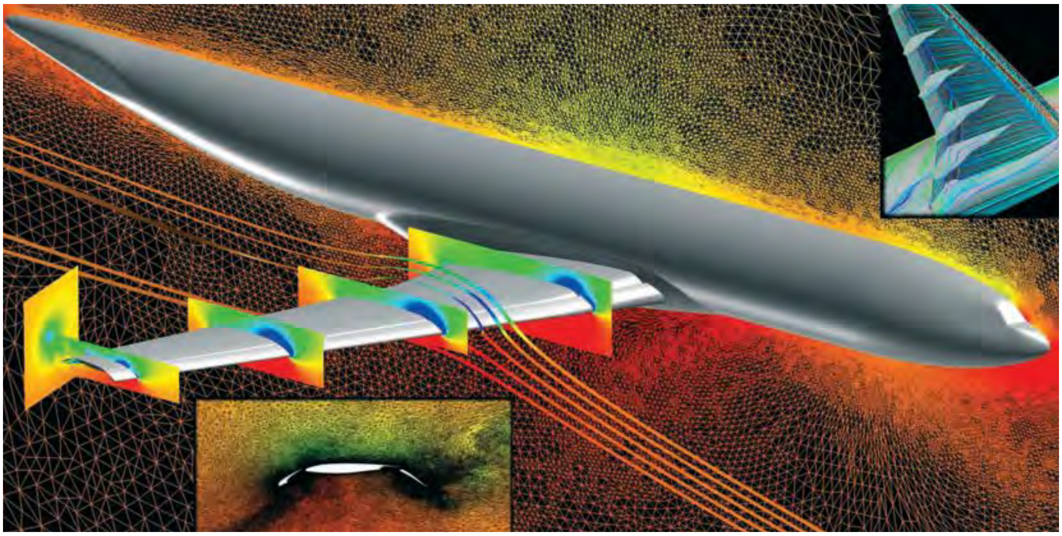
CFD calculations with today's level of computing power cannot handle the computational size of the meshes, so these mathematical models are necessary. But because the models are based on approximations, they introduce error and uncertainty into the simulation results, Alonso explains.

"We can't just rely on business as usual here. We have to do something fundamentally different to solve the problems."

— Boeing's Jeffrey Slotnick, on the future of CFD

circuitry and quantum computing bears fruit sometime after 2030. The problem, Gropp says, is that today's well-understood CFD algorithms and software will have to be rewritten or overhauled to work on massively parallel computers or quantum computers.

Some high-performance computers using massively parallel systems already have more than 1 million conventional processing cores, and within another decade some will have more than 1 billion cores, Gropp says.



The intensive calculations needed to generate this CFD visualization — a mesh adaptation simulating a transport aircraft in a high-lift configuration — were performed by a NASA high-performance computer.

NASA/Elizabeth Lee-Rausch, Michael Park

Until recently, designers of CFD tools could count on advances in computer processing cores, or chips, to run increasingly more sophisticated and larger-scale CFD models. But about eight years ago, the exponential increase in the clock speeds of computers, a measure of processing power, came to an end, explains Bill Gropp, a professor of computer science at the University of Illinois Urbana-Champaign and an author of the report.

Improvements in computing speeds in the next few years will come from massively parallel computers, in which large numbers of processing cores are combined and run in parallel. An even more revolutionary leap is expected when research on carbon-nanotube

It's also not a given that the fastest computers will be available to U.S. aerodynamicists. Since 2013, China has been the home of the most powerful computer, according to the Top500 project, which ranks the world's high-performance computers. China's Tianhe-2, or Milky Way-2, can operate at a speed of 33.9 petaflops and has a theoretical peak speed of 54.9 petaflops, or roughly 550,000 times faster than a laptop computer. With recent upgrades, NASA's most powerful computer, called Pleiades, moved up the list from 21st in June to 11th in November. Pleiades has achieved 3.4 petaflops and has a theoretical peak of 4 petaflops. The only other NASA computer in the top 100 ranks 50th.

The report amounted to a figurative blowing of the whistle about the potential effect on CFD from these computing advances. "I think [the motivation for the report] was the realization within NASA that in high-performance computing, we are not doing what we should be doing," says Mujeeb Malik, technical lead for revolutionary computational aerosciences at NASA's Langley Research Center in Virginia.

Twenty years ago, NASA was a pioneer in high-performance computing. Now, the Department of Energy has the fastest U.S. computers and most of the budget — $1 billion per year — while NASA invests a tiny fraction of that in high-performance computing, Malik says. "For aviation applications, we are falling behind."

CFD and other computational simulation tools have allowed great advances since 40 years ago, when most of the analysis was done through wind-tunnel testing, Malik says. In aircraft engine development, the number of real-life tests necessary has dropped by about 75 percent. And at Langley, since 1980 NASA has closed down 20 wind tunnels, partly because of CFD advances.

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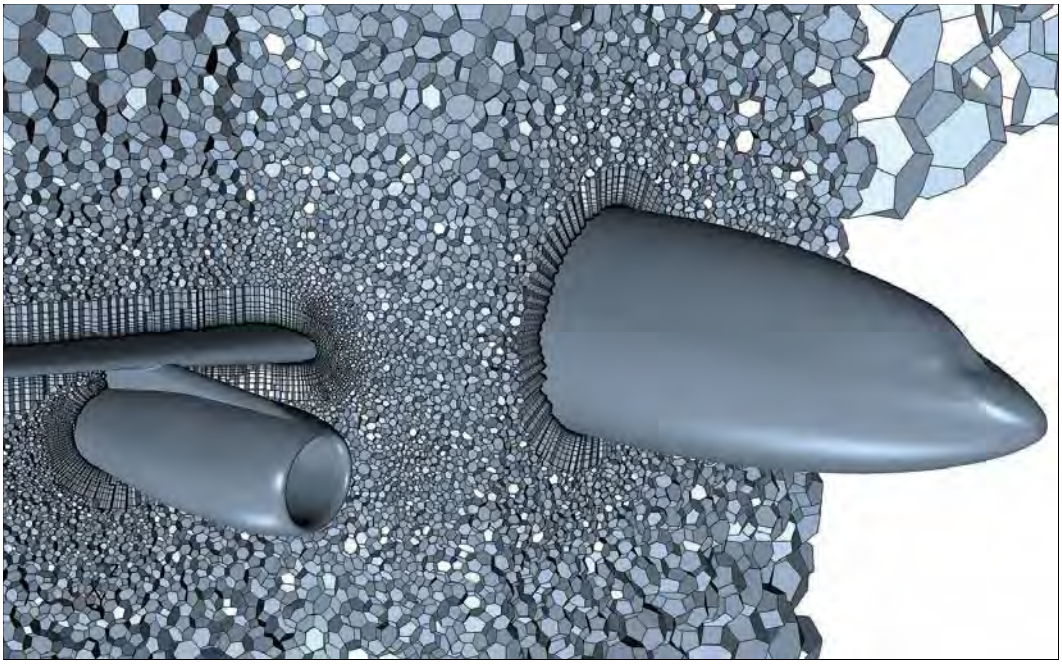


The rapid generation of 3-D meshes around aircraft models, a key step in the CFD process, will become even more important as more powerful computers enable higher-resolution simulations, according to a NASA report.

But even using today's best computers, simulation technologies can take a long time to work through complex problems. Malik says one of his colleagues, using 2,000 to 3,000 processing cores on Pleiades, took two to three months to run a CFD model calculating air flow around an aircraft's landing gear and the associated noise.

To improve its computing power, Malik predicts that NASA will use the capabilities of the Energy Department, but he says more investment in high-performance computing might also be needed by NASA.

Flight certification by analysis alone — meaning to accurately predict the aircraft's behavior under specific conditions — would be a key goal. "What we'd like to do, in a perfect world, is do all of the analysis up front and have that analysis be good enough for flight certification without doing any flight testing," Slotnick says. Even short of that ultimate goal, he says, improved computational modeling would mean less wind tunnel, and flight testing would be needed to earn a certification.

What really excites experts like Slotnick and Alonso is the potential of making more use of CFD in the design phase. Today, innovation is crimped by the cost and time it takes to build a physical model and test it in a wind tunnel. Designers tend to avoid getting too daring, because they don't want to have to ship the craft back to the factory for changes. The wind tunnel tests are mostly meant to confirm the design — not help designers innovate.

As Slotnick puts it, a physical wind tunnel model is supposed to be "prophetic" about the aircraft's performance. The model can't be changed — at least not easily — but CFD would give new flexibility. "If you have a computational process in place, where you can do design and morph geometry in the design process, then you can explore areas of the design that you might not have ever thought of before," he says.

Design is "a huge carrot out there, in terms of what we'll be able to do in the future," Slotnick says. "In 20 years, engineers will not simply be doing CFD analysis," he predicts. "They'll be sitting and doing high-fidelity design using computational methods and incorporating CFD into the design, almost in real time."

At stake could be NASA's ability to meet the design demands of the future. "For many, many years, we've squeezed out almost everything that is possible from the tube-and-wing configuration standard commercial aircraft," Alonso says. But developing cleaner, more fuel efficient or quieter planes will require more innovative configurations, he says.

Besides the Holy Grail of certification by CFD modeling, NASA space missions have a lot riding on CFD advancements, says Mavriplis, the University of Wyoming professor.

"A lot of those things you can't test. You basically have to do some sort of risk reduction, and then assume that the probability of something going wrong in flight is small enough," he explains. On the latest Mars mission, "the heat shield was quite a bit thicker than it needed to be, so that was extra weight/mass that could have been used for payload, if they had better confidence levels in what those rates would have been."

The U.S. commercial industry also risks falling behind Airbus and other non-U.S. competitors, Mavriplis says.

NASA/Shishir Pandya

The ability to create CFD simulations of unconventional aircraft designs, such as the D8 double bubble concept, is a challenge for aeronautical innovators.

How the collaboration will come together to make CFD advancements possible is not yet known, Slotnick says. "Informally, we're struggling with how to move forward a little bit, because the mechanism by which we can bring people together is really not in place," he says. "Trying to figure out how to build that mechanism, and what that mechanism is going to be, is the next step to address."

Revolutionizing AIR TRAVEL

Airliners that can be refueled without landing could be the first step toward giant planes that transfer cargo and passengers in flight. Philip Butterworth-Hayes looks at Europe's research toward dramatic fuel savings.

by Philip Butterworth-Hayes

I'm in the simulated cockpit of an Airbus A350 airliner, watching the displays as we close in on the tanker above us. By pushing a series of buttons, I have started the final, automated approach toward the refueling boom, through which 30,000 pounds of fuel will be pumped into the A350's fuel tanks. There's some turbulence, so I'm ready to push the abort button if necessary to protect the 250 passengers aboard my plane in this scenario.

The simulator is at the National Aerospace Laboratory, NLR, in Amsterdam. The tanker above me is being flown by a pilot in a simulator at the German Aerospace Center, DLR, in Braunschweig, Germany.

I was invited to observe and participate in the final simulator trials of Europe's €3.7 million ($4.6 million) Recreate study, which is short for Research on a Cruiser-Enabled Air Transport Environment. Since 2011, simulated tankers and airliners have been flying scenarios like the one I just witnessed. The missions are drawn up by researchers at nine institutes and universities with a goal of understanding the technical challenges and potentially great efficiency savings of midair refueling of airliners. Today's airline industry, of course, relies on refueling on terra firma, and midair refueling may seem like a fanciful notion. But if the industry is to reduce carbon emissions by 50 percent below 2005 levels by 2050, then radical approaches like this one might need to be found.

The findings of the Recreate program are due to be delivered to the European Commission in early 2015 but some substantive conclusions have already been announced. Researchers estimate that fuel burn could be reduced by 11 to 23 percent by equipping current technology airliners to receive fuel from tanker planes.

National Aerospace Laboratory

An airliner approaches a tanker in an artist's rendering of civil aircraft refueling.

Midair transfers

Researchers have an even bolder vision, however. They've been studying how an entirely new class of large airliners, called cruisers in their parlance, might operate alongside smaller feeder planes.

In cruiser-feeder operations, large nuclear-powered cruisers would fly fixed routes over great distances around the world while the non-nuclear feeder aircraft would exchange passengers, crew, luggage, spare parts and cargo with them in midair. Scientists at the National Aerospace Laboratory, the Technical University of Munich and the University of Bristol in the U.K. have for the last three years been studying the airworthiness challenges of introducing such a system with current technology aircraft and looking further ahead at the technical and safety certification challenges to cruiser-feeder operations.

More advanced cruiser aircraft would need an entirely new class of engine. "The concepts with the transfer of payloads and passengers based on engines burning chemical fuel have been shown not to be economically feasible," says project coordinator Stephan Zajac of NLR. That's because "the overall weight of the system and thus the total amount of fuel is too high. But if the cruiser can be propelled by a nuclear power source the efficiency of the system improves markedly," he says.

So when Lockheed Martin announced in October that it could have a prototype compact fusion reactor built within five years and a production engine in service five years after that, the news was greeted with particular interest by the European cruiser-feeder researchers. Powered by a nuclear fusion reactor, a long-range airliner could in theory stay in the air for many months, bringing cruiser-feeder operations technically and economically a step closer. There are lots of ifs, but one result could be a global airborne metro system in which passengers would hop on and off a fleet of intercontinental airlines, much as they do a metro train.

Ensuring the automatic safe delivery and return of passengers, spare parts and cargo between a feeder and a cruiser would require a wide range of enabling technologies. Nuclear-powered cruisers are still decades away, so the researchers decided to use current technology aircraft in simulators to address the fundamental technical challenges posed by an automatic air-to-air delivery system.

Raising the boom

Logic would suggest that the simplest way of introducing a civil refueling capability would be to adapt the military systems in use today. But for technical, safety and economic reasons that is unlikely to be sufficient.

put, there is a balance between how much we launch and how much worse we make matters.

Thankfully, we are nowhere near having to stop launching satellites, but the population of objects in orbit will need to be managed eventually. Even then, we can't prevent orbital debris any more than we can prevent the introduction of environmentally invasive species. We can only mitigate the risk and diminish the probability of serious consequences.

We have a hard time defining the risk right now, partly because we do not understand how satellites disassemble through either explosions or collisions. This is not surprising, since we hardly understand how aircraft, automobiles or ships break up. The unfortunate demise of Malaysia Airlines flight 370 illustrates this. We can achieve some control with structural modifications, but more structure is more unproductive mass. Mission capability may be compromised more by excess mass than by collisions.

The explosive growth of cubesats complicates matters, partly because there are so many of them but also because their size almost doesn't matter. If a small thing hits a big thing, it's a big problem. We can add some predictive understanding by blowing up satellite mockups in controlled environments, but not much. The community must collaboratively seek greater insight.

Removing satellites at end of mission is one effective step. If a satellite isn't in orbit, it cannot explode or hit anything. An IADC guideline states that satellites should remain in low-Earth orbit for no more than 25 years after their missions end. This guideline should be reassessed. It may be too long for many orbits, while no limit may be appropriate for other orbits. In any case, estimates of orbital lifetimes for our satellites are notoriously imprecise. The atmosphere is dynamic on several time scales, not just solar cycles, which are themselves marginally predictable. As a result, there are many ways to estimate lifetime and just as many different estimates. Designers can easily underestimate how long a satellite will remain in orbit. Second, the longer a satellite is in orbit, the greater the probability of collision over its lifetime. It is wise, therefore, at the end of a mission to purge most energy stored in the satellite. This could mean residual propellants, batteries, or even flywheels that keep spinning or the tension in the outer sphere of a balloon structure. A challenge is that we often do not know how much energy remains. Residual propellant mass measurements grow very imprecise the more propellant is expended. Batteries retain latent chemical energy even when voltage is apparently low. A reason for concern about a complete purge of energy is that without energy, all control and communication would be lost.

It is also costly in terms of energy to avoid collisions. We typically don't know that a maneuver is necessary until shortly before the collision would be inevitable. Our collision estimates improve with time and more frequent observations, but the longer we wait to maneuver, the more energy we will expend and the greater the impact on the overall mission lifetime. We don't like to maneuver satellites unless we know we must. Our threshold of concern is a 1-in-10,000 chance of collision. Therefore, there is a 99.99 percent probability that there would be no collision. If there is no collision, we could never prove that it was because of the maneuver. This does not mean that we should not maneuver. It does mean that maneuver decisions are very complex and do not depend only on collision probability percentages.

We need much greater international collaboration in observing satellites and estimating their future states. Operators know much better than others where their satellites are, but they have little knowledge of where everyone else is. These are a small fraction of the challenges of space debris. We can address them only collaboratively. Technical, diplomatic and economic collaboration are all necessary. Any who resist data sharing or mutual understanding are threats to all others, and others are a threat to them.

Retired Air Force Col. Dav Finkleman is a former chief technical officer at NORAD and the former U.S. Space Command. He has a Ph.D. in aerodynamics and gas dynamics from MIT and is an AIAA lifetime fellow.

between the cruiser and "the flying boom," explains NLR's Huub Timmermans. "The tanker pilots have good visibility of the passenger aircraft and all refueling workload and the required training rests with the tanker pilots, while the cruiser pilots need only maintain speed and altitude. The cruiser is not flying in the wake of the tanker — so passenger comfort is not affected — and engine thrust levels can be minimized."

Just as with today's tanking operations, engineers would have to minimize buffeting and vibrations that might damage the boom. In other words, they would have to ensure aero-elastic stability.

"A big challenge lies in the controllability and aero-elastic stability of this concept," says Zajac, "but preliminary aeroelastic analysis results show that a design space free from static and dynamic aeroelastic instabilities exists."

The boom in the civilian concept would have four ruddervators — movable airfoils at the trailing edge of the boom head designed to perform the functions of both a rudder and an elevator. This would provide greater redundancy, and therefore greater safety, than today's booms, which have two ruddervators. Within the civil concept, the entire process would be automated. The relative position between the two aircraft would be measured using four independent monitoring systems and an additional optical sensor system.

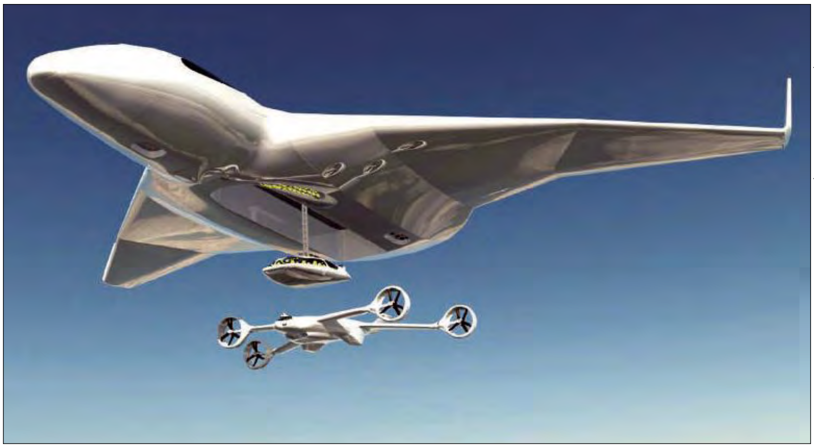
The entire civil operation will need to be automatically controlled from both the tanker and the airliner, though with both pilots able to resume manual control in the event of an emergency. The NLR researchers developed a series of cockpit displays and control mechanisms which showed how the automatic air-to-air refueling operation could be monitored and managed by the pilots. The idea was to minimize the amount of equipment and training needed for the operation. The NLR and Technical University of Munich software designers modeled the refueling operation and display on a conventional instrument landing approach procedure; deviations from the reference flight path and hold positions during the refueling process are shown on the standard pilot flight display.

One aim of the research is to minimize the amount of re-equipping of aircraft and retraining of pilots that would be needed for civil air-to-air refueling, so the graphic visualization of the progress of the docking maneuver is displayed to both crews on a standard electronic centralized aircraft monitor, which includes an "estimated safety margin" indicator. This indicates whether the refueling operation is continuing within the parameters developed to protect loads on the boom and the safety of the two aircraft. It automatically halts the operation if the display shows the operation straying too far or too long into the red zone. The amount of fuel required to complete the flight would be calculated by the flight management system and presented on the fuel progress page. Meanwhile, the crew on the feeder aircraft would view a boom status display showing the status of all four actuators and the deflection angles and the extension of the refueling boom.

The design of these displays was tested for the first time in August 2013 during a series of coordinated simulations with current technology aircraft and conventional refueling boom configurations — with the tanker above — to simplify the exercises as much as possible. The forward extending boom concept has not been simulated. Tanker pilots at DLR in Braunschweig flew the simulated feeder planes, while the passenger aircraft were operated in the Generic Research Aircraft Cockpit Environment simulator in Amsterdam, the two connected by an Internet link.

These simulations involved four crews

(Continued on page 35)


National Aerospace Laboratory

Researchers envision a day when large, long-endurance aircraft called cruisers would exchange passengers and cargo with smaller aircraft known as feeders.

An artist's concept shows two asteroids colliding and creating numerous smaller asteroids.

NASA/JPL-Caltech

Apophis caused a stir in the astronomy community when it was discovered in June 2004. For a brief period in December of that year, astronomers feared the more than 300-meter-diameter asteroid was on a collision course with Earth in 2029. Better observations of the asteroid's orbit helped scientists dispel that notion. But the fact remains that Earth would be defenseless against an object like Apophis on a slightly different course.

U.S. scientists are working quietly to solve our vulnerability to asteroids and comets, known collectively as NEOs, for near-Earth objects. Ideas range from imparting gentle tugs or nudges to objects spotted far away, to deploying nuclear devices against large objects or those discovered too late for subtler approaches. The work is modestly funded at this point and consists mainly of modeling and simulating. Success would mean the first planetary defense from rare but potentially devastating collisions.

Experts calculate that Earth will be struck on average once every 100 million years by an object like the estimated 10-kilometer-diameter

Leonid Kulik expedition

Hundreds of square miles of trees were felled by the 1908 explosion of an asteroid over the Tunguska region of Siberia. The blast is estimated to have been 1,000 times more powerful than the atomic bomb dropped on Hiroshima.

Planetary defense

Stopping asteroids from hitting Earth will require time to put a plan in place. Brian Steiner examines the options under study in universities and a national lab.

rock that slammed into what is now the Yucatan Peninsula and probably killed off the dinosaurs. A collision with a 1-kilometer asteroid could be expected once in a million years. Time would afford the best protection against such collisions.

"Our whole strategy is to find hazards years in advance," says NASA's Lindley Johnson, the agency's Near Earth Objects program executive. Scientists from NASA, the European Space Agency and other organizations, including the universities of Arizona and Hawaii, are scanning the skies for NEOs. When one is found, the coordinates are stored in a catalog at the NASA-funded Minor Planet Center at the Smithsonian Astrophysical Observatory in Massachusetts. Experts then get to work predicting the NEO's trajectory. So far, scientists have found 10 to 15 percent of the objects larger than 100 meters, Johnson says.

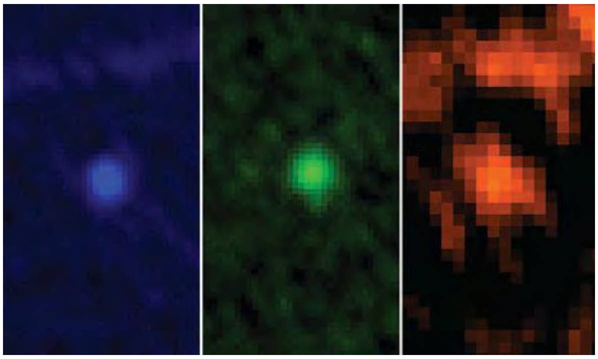
As events in February 2013 showed, the unexpected can happen. On the same day that a refrigerator-sized meteoroid flew over the Russian city of Chelyabinsk and exploded, injuring more than 1,500, an even larger object dubbed DA14 flew by Earth uneventfully, as predicted. The notable thing about DA14 was that it was discovered just 12 months earlier by a team of experienced amateur astronomers in Spain. Had it been on a different course, there would not have been much time to dodge its 2.4-megaton impact, which would have been like the 1908 asteroid explosion over the Tunguska region of Siberia that leveled trees across 820 square miles.

"One of the reasons we didn't know about the Chelyabinsk [meteoroid] is because it came from the direction of the sun. You just can't see them when they're close to the sun," Johnson says. Some scientists are working to change this. The B612 Foundation, founded by former astronauts Ed Lu and Rusty Schweickart, is raising private funds to build a space-based telescope to improve our ability to see NEOs, notes Johnson.

About 300 scientists from around the world meet every two years to discuss concepts for protecting the planet from these objects. For a relatively small object spotted far away, one idea would be to hover a plasma-powered spacecraft (sometimes called a gravity tractor) next to it and

by Brian Steiner

European Space Agency



Images captured by the Herschel Space Observatory in 2013 show the asteroid Apophis in wavelengths, from left, of 70, 100 and 160 microns. In 2029 Apophis will pass within about 20,000 miles of Earth — closer than satellites in geostationary orbits.

use the craft's gravitational pull to slowly tug the object off course.

Another option would be to steer a spacecraft, called an impactor, into the object at high speed. Jay Melosh of Purdue University has studied the options and he calls kinetic deflection "the most obvious" technique and the one that's most ready in terms of technology. The technique was tested in 2005 when the Deep Impact spacecraft plowed into comet Tempel 1. Scientists believe Tempel 1 was deflected, but the change in its orbit was too small to measure due to the very large size of its nucleus (about 6 kilometers in diameter) and the fact that its orbit constantly changes anyway due to venting gas and dust, Melosh says. NASA and ESA want to launch two probes, collectively known as AIDA for the Asteroid Impact Deflection Assessment, to further study the use of impactors on asteroids. One spacecraft would impact an asteroid and the other would observe the crater. Johnson says the plan is to launch the probes in 2020.

For larger objects closer to Earth, a bigger jolt would be required.

If the object were far enough from Earth, it wouldn't be necessary to make the entire object go BOOM, says David Dearborn, a physicist at Lawrence Livermore National Lab. "A nuclear standoff burst would vaporize a thin portion of the [NEO] to push it to a slightly different orbit. You just need about a centimeter-per-second speed change," he says, to change the object's orbit. Done 10 or more years ahead of time, the NEO would harmlessly pass us by. "Detecting it early has a real advantage," he says.

One-two punch

What if the warning time were months, as was the case with DA14? Without a notice of more than five years, the only way to stop an NEO would be with a nuclear device, says Bong Wie, a professor of aerospace engineering and founding director of the Asteroid Deflection Research Center at Iowa State University in Ames.

"In a study we did for NASA, our conclusion was the following: When we don't have sufficient warning time, we cannot gently deflect an asteroid using nonnuclear options. There's only one option: segmentation or disruption using a nuclear device," Wie says. "Whether someone likes it or not, there is no other option."

Wie and his graduate students are using computer models to simulate how such a mission might unfold and what the effect on NEOs of various sizes would be. They have a novel plan. Launch two spacecraft tethered together. The vehicles separate as they close in on the NEO, with the first one approaching at high speed until it hits the object's surface with force, making a crater 50 meters wide and 10 meters deep. The second vehicle, carrying a nuclear device, detonates just inside the crater.

"If we can do that, the efficiency of the explosion is 20 times more effective than having an explosion outside the crater," Wie says. "It's similar to removing an old building to build a new one. If you want to explode a building, would you want to put the dynamite inside the building or on the outside?"

With lead times as short as one month, Wie says it's possible to explode an NEO outside of lunar orbit. At that distance, he says, it's unlikely any debris would fall to Earth. Shorter than one month, though, and it's likely at least some incoming debris would not burn up completely in Earth's atmosphere and instead fall to the ground. But in that case, he argues, it's still better to act and destroy the NEO than to do nothing.

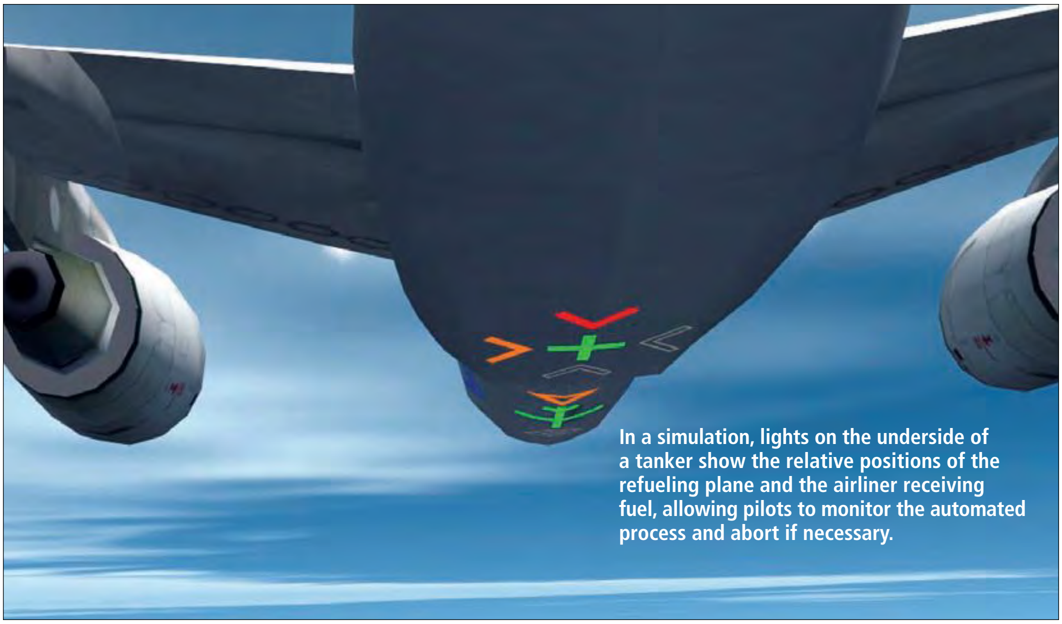
Melosh, the Purdue professor, disagrees with the nuclear option because of a broader risk he sees.

"New weapons would need to be developed because there's nothing in our arsenal big enough to do the job. I think that, of the threats to humanity, the threat from the weapons themselves is greater than the threat from the asteroids," Melosh says.

"A big asteroid could annihilate most of the people living on Earth. However, the chance of an asteroid about 1-kilometer in diameter hitting Earth is one in a million years."

Recreate

(Continued from page 31)



National Aerospace Laboratory

In a simulation, lights on the underside of a tanker show the relative positions of the refueling plane and the airliner receiving fuel, allowing pilots to monitor the automated process and abort if necessary.

of professional pilots and looked at how confident they might be in operating the system using the human-machine interface developed by the NLR and the Technical University of Munich. “All the pilots involved felt they could operate the system and that safety was assured,” says Bart Heesbeen, technical coordinator of the simulator in Amsterdam.

A second series of simulation exercises, the ones I participated in, took place in October to evaluate the improved display system and test the air-to-air refueling operation in differing turbulent conditions. The simulations focused on how and when the operation could be halted if there were a sudden loss of power or incidence of severe turbulence. The chances of in-air collisions for the developed automated control systems were investigated by Monte-Carlo simulations, a computerized mathematical technique used to quantify risk.

“We don’t see any technical obstacles,” says Zajac.

One result of the Recreate research is to outline how cruiser-feeder operations could comply with airworthiness requirements for civil aircraft. Researchers looked at near-term options for transferring fuel from feeders to cruisers adapted from existing airliner designs. They also looked at longer-term concepts for transferring payloads between feeder aircraft and nuclear-propelled cruisers. Based on a comprehensive safety analysis of air-to-air refueling operations, NLR scientist Tom van Birgelen has developed a proposed regulatory framework and corresponding means of compliance for civil certification of air-to-air refueling operations. The framework is meant for consideration by airworthiness authorities.

Meanwhile, the Technical University of Delft and the Nuclear Research and Consultancy Group NRG of Arnhem, the Netherlands, have researched possible payload transfer vehicle configurations for a feeder aircraft supplying passengers, cargo, crew and consumables to a nuclear-powered cruiser. These include detailed designs of a pressurized container exchange concept and outline designs for the nuclear cruiser itself.

There will be numerous hurdles to overcome before nuclear-powered airliners take the sky and passengers join them midair. According to Zajac some of the more pressing issues are the air traffic management challenge, establishing a regulatory framework for nuclear-powered airliners, and the political issues of adapting the technology for civil aviation use.

But in the cockpit of the simulator, another refueling trial has been completed and the two aircraft slowly move away from each other. By refueling in the air, rather than on the ground, we have been able to reduce the aircraft’s takeoff weight and add several thousand miles to its range — and perhaps been given a glimpse of the future.

Parsing Orion

by Craig Covault and Marc Selinger

Orion's first flight and splashdown looked picture perfect, but aerospace engineers know there are always lessons to be learned. In the coming weeks, NASA and its contractors will be taking Orion apart and studying reams of performance data with a goal of improving the design and opening deep space for exploration. Craig Covault and Marc Selinger explain.

With Orion now safely back on Earth, NASA and Lockheed Martin will be tearing down the capsule and analyzing data from sensors aboard the vehicle to answer some big questions, including how well the capsule's heat shield held up during the re-entry and what the ride would have felt like had astronauts been aboard during the Dec. 5 inaugural flight.

Engineers will use the findings to tweak the design of the second Orion now in development for Exploration Mission 1, an unmanned test run to the vicinity of the moon planned for 2018. Astronauts are expected to ride inside Orion for the first time on Exploration Mission 2 in 2022, a shakeout flight to the neighborhood of the moon or possibly an asteroid, if one can be pulled into range. If EM-2 goes off on time, the mission will occur 50 years after the final Apollo mission — Apollo 17.

Lockheed Martin is contractually obligated to analyze data from sensors distributed throughout the cabin and from avionic boxes in the crew vehicle and report findings to NASA within 90 days of the splashdown. The spacecraft was to be trucked back to Kennedy Space Center in Florida by Christmas for the start of teardown, Mike Hawes, Lockheed Martin's Orion program manager, told reporters. NASA plans to refurbish the spacecraft and use it in a 2018 test of Orion's launch-abort system.

"It looks like it flew very close to what we expected, but we have 1,200 sensors, thousands of pieces of data that we're going to get back, and I'm sure we're going to find some very interesting things about how it behaved," said Mark Geyer, NASA's Orion program manager. "That's really important for us as we get ready for the next mission."

For NASA veterans, Exploration Flight Test 1 bore some resemblances to the unmanned Apollo 4 mission in 1967, which marked the first time a Saturn 5 rocket launched an Apollo service module to orbit. EFT-1, however, did not carry a fully operational service module. That will happen on the 2018 Orion mission, when a European Space Agency service module provides electricity and propulsion. The new module will be developed by Airbus from the design of the Automated Transfer Vehicles that make supply flights to the International Space Station.

New recovery method: Apollo-era capsules were hoisted aboard Navy ships after the crew exited the spacecraft in open water. Orion crews will get out once the capsule is safely in the well deck of an amphibious ship.

U.S. Navy

ANALYZING THE FLIGHT

HEAT SHIELD ANALYSIS: The recorded data and structural heat shield analysis could result in significant heat shield changes, officials said. Even before the December mission, managers were not entirely satisfied with the structural strength of the shield, especially for longer flights. In this case, the shield did its basic job of getting Orion through the atmosphere in one piece. "The Orion looks in great condition," said NASA spokeswoman Amber Philman, who witnessed the descent and retrieval of the Orion from on board the recovery ship USS Anchorage in the Pacific Ocean southwest of San Diego.

On Orion, 320,000 fiberglass-phenolic cells hold a foam-like material called Avcoat, which ablates, or wears away, during re-entry to shed heat. NASA describes the material as an improved version of the recipe flown on the Apollo missions.

One factor in considering changes will be the manufacturability of the heat shield, which is 16.5 feet across. Cost and workload impacts must be weighed, NASA's Bill Gerstenmaier, associate administrator for human exploration and operations, told reporters.

VERIFY AERODYNAMIC AND THERMAL MODELS: The comparison of preflight thermal and aerodynamic wind tunnel and computer models to actual Orion data will be critical in the post-flight analysis, said Darlene Pokora, who manages Orion work at Langley Research Center. Other members of the Orion "Aero Team" are the Johnson and Ames Research Centers, she said. They all have months of Orion data analysis ahead of them, Pokora said.

While temperatures on the blunt face of the heat shield were expected to peak at 4,000 degrees Fahrenheit, the side of the spacecraft was expected to be a bit cooler, about 3,150 degrees. There, 970 black silica tiles like those used on the belly of the space shuttle were to keep the inside of the spacecraft relatively cool. How cool it stayed inside must yet be pulled out of the data.

VAN ALLEN RADIATION BELT AVIONICS DISRUPTIONS: A key element in the analysis will be how well Orion's computers and other avionics coped with two passages through the Earth's Van Allen radiation belts. Hawes noted that while the last generation of avionics was heavily shielded from radiation, the newly designed space-qualified avionics have chips designed to take radiation hits, then "fix themselves" if damage is detected.

DEMONSTRATE CRITICAL SEPARATION EVENTS: During ascent this included the separation of three 13-by-14-foot service module side panels. These protected the simulated internal components of the dummy service module during launch and provided structural support. That occurred at 6 minutes, 15 seconds after liftoff and was done to reduce Orion's weight.

The launch abort system, inactive and minus propellant for this flight, also separated as planned just after the panels.

At 3 hours, 23 minutes into the flight, just after reaching apogee, the crew module separated from the service module, which remained attached to the Delta's second stage.

The remaining critical separation events occurred at the end of the re-entry and included separation of the forward bay cover, exposing two 23-foot-diameter drogue parachutes. They deployed as the vehicle fell through 25,000 feet at 300 miles per hour, slowed tremendously by the friction of re-entry. The drogues were followed by three smaller pilot chutes that pulled out the three 116-foot-diameter main parachutes, which slowed the vehicle to 20 miles per hour at about 7,000 feet above the ocean.

DEMONSTRATE MISSION CONTROL OVERSIGHT: Monitoring of the vehicle from the Johnson Space Center in Houston was a key element of the flight. This involved oversight of all major systems in the spacecraft, including flight control during the descent using one of two redundant thruster strings. The NASA flight director in Mission Control was Mike Sarafin, while the Lockheed Martin mission director was Bryan Austin at the Cape Canaveral launch site.

Philip Butterworth-Hayes looks at the futures of the Rosetta and Philae spacecraft and what other space missions can learn about the use of social media.

Comet science

Will the sleeper awaken?

The first landing on a comet was fraught with tense moments that left the Philae robotic lander unexpectedly out of contact, and another nail-biting episode lies ahead.

The Philae lander held much of the world's attention Nov. 12 as it attempted to make history's first landing on a comet.

After its release from the Rosetta spacecraft and a seven-hour descent toward 67P/Churyumov-Gerasimenko, Philae ratcheted up the tension by contacting the comet not once, as planned, but three times. A harpoon meant to anchor the lander failed to fire, and the craft bounced twice before finally settling on the surface.

The lander contacted Rosetta, transmitting photos and other data from its instrument array. But Philae came to rest in a shadier area of the comet than anticipated, and the lack of solar energy forced the lander into hibernation on Nov. 15 when its primary battery ran out of power, according to the German Aerospace Center, DLR, which controls the lander for the European Space Agency's Rosetta mission.

A mosaic of four images from Rosetta's navigation camera shows comet 67P/Churyumov-Gerasimenko on Dec. 7.

ESA

Now the question is: Will Philae wake up?

"I'm very confident that Philae will resume contact with us and that we will be able to operate the instruments again," said Lander Project Manager Stephan Ulamec on the DLR website in November.

Ulamec predicted a spring awakening, European time. When the controllers attempt to reconnect with the lander, it's sure to be another tense moment in one of the most dramatic space science missions in recent years.

A main goal of the Philae landing was to conduct in situ analyses of soil samples to determine whether comets might have delivered water and organic compounds to Earth. A soil-sampling drill was activated on Philae during its 60 hours of operation and data was transmitted before the battery ran out of power, but scientists must analyze the data to determine whether a sample was examined in its gas chromatograph.

"We currently have no information on the quantity and weight of the soil sample," Fred Goesmann of the Max Planck Institute for Solar System Research was quoted on the DLR website as saying.

As Philae sleeps, observations of the comet will continue to arrive from the Rosetta spacecraft, which is orbiting P67 at a height of 30 kilometers.

"We will deal with some of the main aspects of Rosetta science in the next 14 or so months: examining how the comet evolves in time as it passes through perihelion — its closest approach to the sun — in

(Continued on page 40)

and *social media*

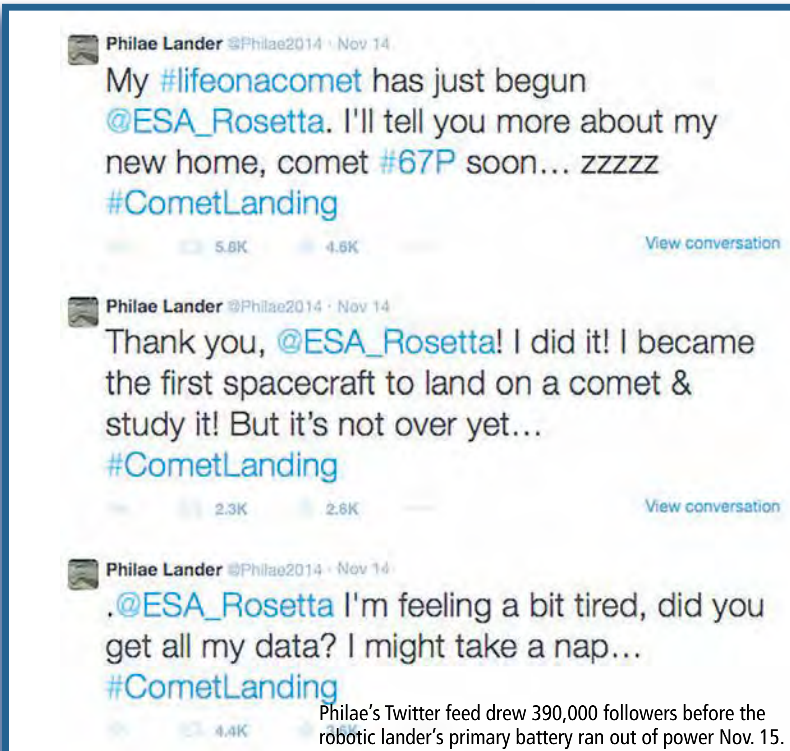
Going viral

When the Philae robotic lander was released from the Rosetta spacecraft and began its descent onto comet P67/Churyumov-Gerasimenko in November, interest on Earth extended beyond the European Space Agency's operations center in Darmstadt, Germany. On Twitter, tweets about Philae grew from fewer than 10,000 on Nov. 10 to about 60,000 the next day and peaked at over 125,000 on the 12th, the day of the landing, according to Topsy Labs, a social media search and analytics company.

Philae's social media surge was aided by the fact that the lander and Rosetta had their own Twitter feeds, which allowed their personalities — "Ready when you are, @ESA_Rosetta. Give me a little nudge?" — to shine throughout the mission. By the time Philae went into hibernation on Nov. 15, its account had nearly 390,000 followers.

Giving Rosetta and Philae their own Twitter accounts — the feeds were actually the work of teams at ESA and the German Aerospace Centre, DLR — was in keeping with a now common strategy by space agencies to engage the public in space missions. NASA's Curiosity rover on Mars, for instance, has a Twitter feed with 1.75 million followers. By raising the public's interest in space science the agencies hope to also increase support for funding future missions.

It might be an uphill struggle. In a 2014 survey of interest in science and technology issues, the U.S. National Science Board said that, while 40 percent of Americans said they were "very interested" in news about new scientific discoveries, "[i]nterest in other issues that touch on S&T ranged from a high of 58% for 'new medical discoveries' to a low of 23% for 'space exploration.'" A 2010 survey by the European Commission found that 30 percent of Europeans were "very interested" in new scientific discoveries.



Philae's Twitter feed drew 390,000 followers before the robotic lander's primary battery ran out of power Nov. 15.

Agencies are also looking beyond social media to build interest in space exploration. NASA and The Planetary Society invited people around the world to submit their names to be placed on a microchip aboard OSIRIS-Rex, the sample-return mission to asteroid Bennu in 2016. In 2013, 9-year-old Michael Puzio from North Carolina won a contest to the name the asteroid with his Bennu entry — it was previously known as 1999 RQ36 — beating more than 8,000 other entries. Industry is also trying to engage the public. In 2014, Boeing launched "Beyond Earth," an

(Continued on page 40)

Adept use of social media helped Europe's Philae scientists focus the world's attention on a 100-kilogram spacecraft more than 300 million miles away. It's an increasingly common stategy for space agencies hoping to build public support for exploration missions.

Going viral

(Continued from page 39)

online educational effort that has included live chats with astronauts and discussion pages about government funding decisions. And with important new space science and exploration missions on the horizon, agencies can be expected to look for even more ways to connect to the public.

Manned missions are likely to remain a spending priority for the largest space programs, according to a July report by Euroconsult, the space sector analytical firm. Worldwide government spending on manned spaceflight is predicted to rise from $10.99 billion in 2013 to $17.5 billion in 2023. During the same period, spending on space science and exploration is expected to climb from $5.6 billion to about $8 billion.

The Rosetta mission cost the European Space Agency $1.7 billion. To sustain that kind of spending, space agencies are working hard to inspire academics, students and the public to support continued government investments in the science of space.

Upcoming science missions that offer opportunities to ignite public enthusiasm include:

- **New Horizons** is set to begin a five-month flyby study of Pluto and its moons in summer 2015. The NASA spacecraft became active Dec. 6 after the last of 18 planned hibernation periods since its 2006 launch.
- **ExoMars**, a two-part mission by the European Space Agency and Russia's Roscosmos, is set to launch an orbiter and stationary lander in January 2016, which would arrive at Mars nine months later. That would be followed by the launch of a rover in May 2018, set to arrive in January 2019 to search for signs of primitive microbial life, past or present, on the planet.
- **InSight**, NASA's Interior Exploration using Seismic Investigations, Geodesy and Heat Transport mission to Mars, is on track for a March 2016 launch. The aim is to better understand the processes that shaped the rocky planets of the inner solar system, including Earth, more than 4 billion years ago, using a stationary lander with a robotic arm that will deploy surface and burrowing instruments.
- **Juno** will reach Jupiter in July 2016 and enter into an elliptical polar orbit 5,000 kilometers above the planet's atmosphere. Launched in 2011, the NASA spacecraft is expected to provide new information on the planet's origins, structure, atmosphere and magnetosphere, and determine whether it has a solid planetary core.
- **OSIRIS-Rex**, NASA's Origins, Spectral Interpretation Resource Identification, Security-Regolith Explorer, is scheduled to launch in September 2016 and rendezvous with the near-Earth asteroid Bennu in 2018. The mission calls for the spacecraft to approach the asteroid, use a robotic arm to retrieve a sample of material — which will have changed little since the formation of the solar system 4.5 billion years ago — and return it to Earth in 2023.
- **James Webb Space Telescope**, NASA's orbiting infrared observatory, is planned to launch in October 2018 to search for the formation of the earliest galaxies as well as exoplanets that may resemble Earth.
- **JUICE**, the ESA's Jupiter Icy Moons Explorer, aims for a 2022 launch and 2030 arrival to explore several of the giant planet's icy moons.

Sleeper

(Continued from page 39)

August 2015. We will be able to observe how the comet changes in appearance from now to then, measure volume changes," Rosetta project scientist Matt Taylor tells me in an email.

Philae managers are counting on the intensifying sunlight to get Philae functioning again. Before it powered down, DLR controllers managed to rotate the lander so that its largest solar panel is aligned toward the sun, and they expect that will help revive the craft. For the comet, the rising temperature will create a resurgence of outgassing, with streams of gases such as water vapor, carbon monoxide and ammonia pouring out of its nucleus. Mission controllers want to monitor this process, at least for a short time, from the surface of the comet via Philae as well as watching from Rosetta.

"We will see activity increase and then subsequently wane, from kilograms of material to hundreds of kilograms of material being lost per second from the comet," says Taylor. "We will be doing this from a ringside seat, starting at about 20-kilometer gravitationally bound orbits now, up to February, when outgassing will overcome gravity and we will resort to quick flybys of the nucleus."

The Rosetta mission began in 2004 with the spacecraft's launch on an Ariane 5 rocket and it is set to end on Dec. 31, 2015.

25 Years Ago, January 1990

Jan. 24 General Dynamics Corp., McDonnell Douglas, United Technologies and Rockwell International announce they will jointly develop the X-30 National Aerospace Plane as a successor to the space shuttle. NASA, Astronautics and Aeronautics, 1986-90, p. 246.

Jan. 24 Japan launches its first moon probe, Muses-A, and becomes the third country after the U.S. and USSR to send a spacecraft to Earth's natural satellite. The unmanned spacecraft is to record temperature and electrical field data. Muses-A is a dual satellite consisting of a lunar orbiter that separates from the mother craft while the smaller portion follows an elliptical path between Earth and the moon and relays tracking information on the orbiter to Earth. NASA, Astronautics and Aeronautics, 1986-90, pp. 246-247; Aviation Week, Jan. 29, 1990, p. 27.

And During January 1990

— The first airplane to fly across the Atlantic using 100 percent ethanol fuel is a modified home-built Velocity made and piloted by Max Shauck from St. John's, Newfoundland, to Lisbon. The fuel proves to be more efficient and powerful, and less expensive than ordinary aviation gasoline. Flight International, Jan. 10-16, 1990, p. 25.

— It is reported that visiting MIT scientists to the Moscow Aviation Institute become the first Westerners to inadvertently see the manned lunar and command modules that would have been sent to the moon by a giant N-1 rocket in the USSR's secret race to the moon during the late 1960s. It is not until early 1991 that the Soviet Union releases technical details of the failed N-1 program. Flight International, Jan. 3-9, 1990, p. 16.

50 Years Ago, January 1965

Jan. 1 The operations of the Syncom 2 and Syncom 3 communications satellites are transferred from NASA to the Defense Department after completing their research and development experiments. The transfers include telemetry and command stations as well as range equipment. One reason is that Syncom 3 has been useful for communications during the Vietnam War. The Defense Department has also been providing ground stations to NASA for years and will continue to furnish NASA with some telemetry and ranging data for scientific and engineering purposes. NASA Release 65-5.

Jan. 3 Semyon A. Kosberg, a leading Soviet airplane and rocket engine designer, is killed at age 61 in an automobile accident. Kosberg graduated in 1931 from the Moscow Aviation Institute and worked in the Soviet aircraft industry.
In 1941, he was appointed chief designer of an aircraft design bureau, later known as OKB-154, and remained in this position until his death. He headed the design of aircraft engines for Lavochkin La-5 and Lavochkin La-7 fighter aircraft of World War II and contributed to the Tu-2 bomber. From 1946 to his death he supervised development of liquid propellant rocket engines for upper stages of launch vehicles for the manned Vostok and Luna space probe vehicles as well as satellite launches and ICBMs. In 1960, Kosberg was awarded the Lenin Prize and a crater on the far side of the moon is also named after him. New York Times, Jan. 5, 1965, p. 12; Asif A. Siddiqi, Challenge to Apollo, passim.

Jan. 12 The first DC-9 short-haul twin-engine jetliner, capable of carrying 95 passengers, is rolled off the assembly line at the Douglas Aircraft Co. The plane makes its first flight on Feb. 25 and becomes highly popular; the final one is

delivered in October 1982. New York Times, Jan. 12, 1965, p. 72.

Jan. 14 Vice Admiral Hyman G. Rickover, known as the "Father of the Nuclear Navy," is bestowed the Enrico Fermi Award by President Lyndon Johnson for Rickover's "engineering and administrative leadership" in the development of nuclear-powered submarines and aircraft carriers. He is the first non-scientist to receive the award. New York Times, Jan. 14, 1965, p. 14.

Jan. 21 A laser beam is bounced off the Explorer 22 satellite and photographed by scientists at the Air Force's Cambridge Research Laboratories, marking a milestone in verifying the feasibility of using lasers for tracking and geodetic purposes. Also involved in the experiment is Largos, the Laser Activated Reflecting Geodetic Optical Satellite. Air Force Cambridge Research Laboratories Release 2-65-2.

Jan. 22 The TIROS 9 weather satellite is launched by a Delta vehicle from Cape Kennedy, Fla. — NASA's first attempt to place a satellite in a near-polar sun-synchronous orbit (westward drift). The primary purpose of the satellite is to test the system as a forerunner of a joint NASA-Weather Bureau operating system of weather satellites. Washington Evening Star, Jan. 22, 1965.

Jan. 24 As in the Air Force Cambridge Research Laboratories experiment of Jan. 21, French scientists bounced laser beams off the Explorer 22 satellite.

Past

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

New York Times, Feb. 4, 1965, p. 3.

Jan. 25 The SNAP 10A nuclear generator designed for space use produces electricity for the first time in ground tests at Canoga Park, Calif., conducted by its builder, Atomics International. Washington Post, Jan. 26, 1965.

Jan. 31 Japan launches its Lambda 2-2 solid-propellant three-stage rocket, the country's largest to date. Developed jointly by the Institute of Industrial Science of University of Tokyo, the Institute of Space and Astronautical Science of Tokyo University and the Prince Motor Company, the 62-foot Lambda 2-2 is launched from Tokyo University's space center at Kyushu and reaches an altitude of 620 miles. It leads to the four-stage L-4 that becomes the first Japanese rocket (the L-4S model) to orbit a satellite, Ohsumi, on Feb. 11, 1970. Missiles and Rockets, Feb. 8, 1965, p. 8; Kenneth Gatland, Pocket Encyclopedia of Spacefight, pp. 210-212.

75 Years Ago, January 1940

Jan. 1 The prototype of the Yak-1, the Yakovlev I-26, flies for the first time. It leads to a family of very successful lightweight Yak fighters used during World War II. Bill Gunston and Yefim Gordon, Yakovlev Aircraft Since 1924, pp. 66-70.

Jan. 2 Grumman Aircraft Engineering celebrates its 10th anniversary. The company was formed in 1930 after the merger of the Loening and Keystone aircraft companies, when Leroy Grumman and others from Loening decided to start their own business. Grumman and his associates rented an old shop in Baldwin, Long Island. Grumman Aircraft went on to produce highly successful planes for land and water, including the FF-1 fighter, SF-1 scout, F2F-1 single-seat fighter, XSBF-1 scout bomber, OA-9 military amphibian, and private owner and commercial models. Grumman would also play a pivotal role in the Pacific War with the development of such aircraft as the F4F Wildcat, the F6F Hellcat and the TBF Avenger. Aero Digest, January 1940, pp. 48-52, p. 174.

Jan. 3 British airship pioneer Capt. Frederick L.M. Boothby dies at age 58. In 1910 Boothby was selected to supervise the construction of Royal Navy Airship No. 1, also called Mayfly. In 1914 he was sent to Somaliland to investigate the use of balloons against the "Mad Mullah" who had been harassing pacifist tribes in British Somaliland, but Boothby was not allowed to run the experiments he suggested. Later in the war he was given commands at various naval airship stations. Flight, Jan. 11, 1940, p. 26; The Aeroplane, Jan. 12, 1940, p. 34.

Jan. 18 The Mitsubishi A6M Zero prototype makes its maiden flight. The A6M would soon prove itself one of the greatest fighters of all time, ruling the skies over the Pacific and China until finally confronted by superior numbers of better Allied designs later during World War II. A. van Hoorebeeck, La Conquete de L'Air, p. 7.

Jan. 20 Congress is given a special exhibition of Army Air Corps planes at Bolling Field, Washington, D.C. The show is designed to demonstrate how aviation appropriations are spent and to highlight U.S. air power. The planes are brought in from every U.S. military air base and feature, among others, the Curtiss P-40 and P-37, Bell XFM-1 Airacuda, Vultee YA-19, Boeing B-15 and B-17, and Douglas B-18. Aero Digest, January 1940, p. 116.

And During January 1940

— A new radio facsimile transmitting and receiving machine, intended primarily for use by airplanes, is developed and placed on the market by Finch Telecommunications of New York. The machine, designated Model DM, is intended to automatically transmit weather maps, routine messages, and other data between ground stations and aircraft. Aero Digest, January 1940, p. 163.

100 Years Ago, January 1915

Jan. 5 Americans J.C. Carberry and A.R. Christie set an altitude record of 11,690 feet with their Curtiss OXX-2 powered biplane. A. van Hoorebeeck, La Conquete de L'Air, p. 111.

Jan. 19 In a portent of future strategic bombardment attacks against cities and civilian populations, two German dirigibles, the L.3 and L.4, drop bombs on King's Lynn in Norfolk, England. Several hours after the attack, the royal family visits the town. A. van Hoorebeeck, La Conquete de L'Air, p. 111.

And During January 1915

— The first aircraft developed by Geoffrey de Havilland as chief designer for the Aircraft Manufacturing Co. Ltd, the D.H. 1 pusher biplane fighter, completes its first flight. A.J. Jackson, De Havilland Aircraft Since 1909, pp. 44-46.

AIR FORCE RESEARCH LAB

The Air Force Research Lab (AFRL) invites applications for Chief Scientist of the Munitions Directorate at Eglin AFB, FL.

We are seeking exceptional applicants to serve the Munitions Directorate and conduct U.S. Air Force research, exploratory and advanced development activities relative to warheads, fuses, explosives, seekers, navigation and control, image signal processing/algorithms, munition integrations, and assessment for conventional weapons. The Chief Scientist provides scientific advice and guidance throughout AFRL on research plans and programs in core areas and related technologies. The Chief Scientist also advises on the status of scientific and technical competence within the Directorate; the employment of consultants and experts; and plans and conducts AFRL efforts leading to symposia, colloquia and technical training.

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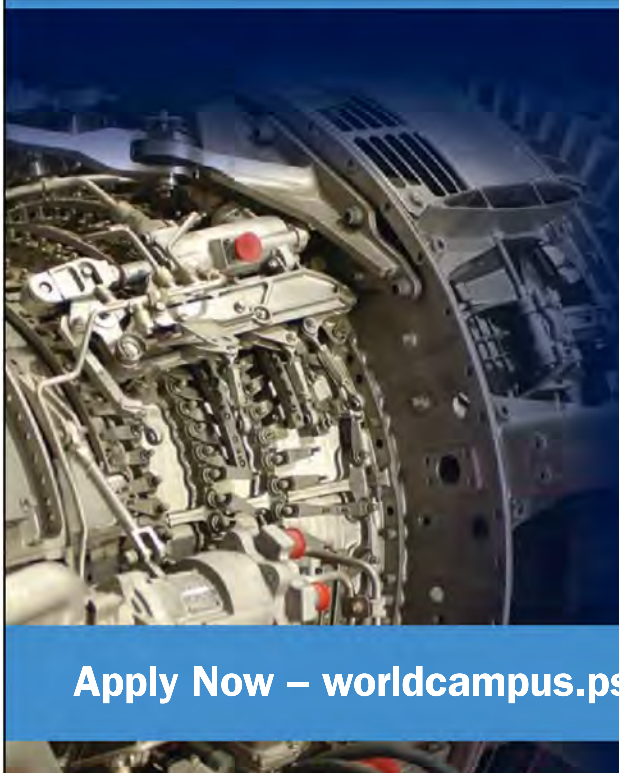

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Assistant Professor of Engineering Mechanics United States Air Force Academy

The Department of Engineering Mechanics at the United States Air Force Academy anticipates filling an Assistant Professor position beginning in late spring 2015.

Required: an earned doctorate in Mechanical Engineering, Engineering Mechanics, or an earned doctorate in Astronautical or Aeronautical Engineering with a Mechanical Engineering focus. Preference is given to those with demonstrated scholarly expertise in thermal/fluid systems courses, a record of undergraduate teaching, relevant work/life experiences, quality of education, and relevant technical contributions to include (but not limited to): publications, conference papers, patents, innovative industry designs, etc. The professor will mostly instruct in thermal/fluids systems courses.

For more information about the position and how to apply contact:

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or **cody.rasmussen@usafa.edu**

Applications must be received by **February 1st, 2015**.

U.S. citizenship required.

VirginiaTech
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Department of Mechanical Engineering Faculty Positions

The Department of Mechanical Engineering at Virginia Tech invites applications for four faculty positions: one in the area of Mechanical Systems and three in the area of Fluid Dynamics and Thermal Sciences. These positions will be at Assistant, Associate, or Full Professor levels. Exceptional candidates will be considered for named professorships.

The successful candidate for the Mechanical Systems position will have expertise in fields related to robotics, dynamics and control, mechatronics, machine learning, human-machine interaction, bio-robotics and medical robotics, robotic exoskeletons, or other emerging applications of robotics or autonomous systems.

The Fluid Dynamics and Thermal Sciences positions are targeted towards (1) Experimental combustion science and technology in novel propulsion and energy applications; (2) Fundamental and applied experimental fluid dynamics using advanced measurement techniques in emerging applications such as, but not limited to, energy harvesting, biological and bio-inspired systems; (3) Experimental or computational multiphase flow and heat transfer at the micro-nano scales in emerging energy and thermal management systems. Applicants in other emerging areas such as data analytics and uncertainty quantification in fluid-thermal engineered systems are also encouraged to apply.

Blacksburg is located in the Blue Ridge Mountains and is widely recognized by national rankings as a vibrant and desirable community with affordable living, world-class outdoor recreation, an active arts community, and a diverse international population. The Department of Mechanical Engineering which includes a Nuclear Engineering Program, has over 50 faculty, research expenditures in excess of $17M, and a current enrollment of over 170 doctoral, 130 masters, and over 1200 undergraduate students. The Department is ranked 16th and 17th out of all mechanical engineering departments in the nation in undergraduate and graduate education, respectively, by the 2014 U.S. News and World Report. The Department includes several research centers and its faculty members are engaged in diverse multidisciplinary research activities. The mechanical engineering faculty also benefit from a number of university-wide institutes such as the Institute for Critical Technology and Applied Science (ICTAS), College level centers such as the Rolls-Royce and the Commonwealth of Virginia Center for Aerospace Propulsion Systems (CCAPS), the recently established Rolls Royce University Technology Center (UTC) in advanced systems diagnostics, and the Virginia Center for Autonomous Systems (VaCAS, www.unmanned.vt.edu).

Applicants must hold a doctoral degree in engineering or a closely related discipline. We are seeking highly qualified candidates committed to a career in research and teaching. The successful candidate will be responsible for mentoring graduate and undergraduate students, teaching courses at the undergraduate and graduate levels, and developing an internationally recognized research program. Candidates should apply online at www.jobs.vt.edu to posting number TR0140100 for the Mechanical Systems position and to posting number TR0140101 for the Fluid Dynamics and Thermal Sciences positions. For the Fluid Dynamics and Thermal Science positions please indicate the research area you would like to be considered for in your cover letter. Applicants should submit a cover letter, a curriculum vitae including a list of published journal articles, a one-page research statement, a brief statement on teaching preferences, and the names of five references that the search committee may contact. Review of applications for all positions will begin on December 10, 2014 and will continue until the positions are filled.

Virginia Tech is committed to diversity and seeks a broad spectrum of candidates including women, minorities, and people with disabilities. Virginia Tech is a recipient of the National Science Foundation ADVANCE Institutional Transformation Award to increase the participation of women in academic science and engineering careers (www.advance.vt.edu).

For assistance submitting the application please contact Ms. Brandy McCoy (brandy07@vt.edu), (540) 231-6661. General inquiries about the positions should be addressed to the search committee chairs: Prof. Andrew Kurdila (kurdila@vt.edu) for Mechanical Systems and Prof. Francine Battaglia (fbattagl@vt.edu) for Fluid Dynamics and Thermal Sciences

JAMES WORTH BAGLEY
COLLEGE OF ENGINEERING
MISSISSIPPI STATE UNIVERSITY
AEROSPACE ENGINEERING

Head and Endowed Chair

Department of Aerospace Engineering

The Bagley College of Engineering at Mississippi State University (MSU) is seeking candidates for the Head of the Department of Aerospace Engineering (ASE). The ASE Head also holds the Bill and Carolyn Cobb Endowed Chair. The primary aim of the Department Head of Aerospace Engineering is to advance the national stature of the department. The Department Head is under the administrative supervision of the Dean of the Bagley College of Engineering and is responsible for the overall administration of the department. The successful candidate must possess an earned doctorate in aerospace engineering or a closely related field, must have earned national recognition by a distinguished record of accomplishments in aerospace engineering education and research, and must qualify for the rank of professor. A record of excellence in teaching and scholarly publications in archival literature and funded research is required. In addition, a baccalaureate degree in engineering is desirable.

The Department of Aerospace Engineering is one of eight academic departments in the Bagley College of Engineering. The department offers an ABET-accredited undergraduate program in aerospace engineering, as well as graduate studies leading to MS and PhD degrees. The department is composed of approximately 245 undergraduate and 36 graduate students, 13 tenure-track faculty members, 5 instructors, and 3 staff members. Faculty includes a member of the National Academy of Engineering and 10 faculty that are Fellows and/or Associate Fellows of national technical organizations. Faculty members have developed strong research programs in materials and structures, fluid dynamics, computational simulations, and unmanned aerial systems and play a vital role in several college and university research centers such as the Raspet Flight Research Laboratory (http://www.raspet.msstate.edu/), the High Performance Computing Collaboratory (HPC^2) (http://www.erc.msstate.edu/), and the Center for Advanced Vehicular Systems (http://www.cavs.msstate.edu/). The undergraduate program offers concentrations in aeronautics and astronautics. The department actively engages students in research, as well as extracurricular experiences such as the Association for Unmanned Vehicle Systems International Student UAS Competition, at which they placed first in 2008 and second in 2010. In 2013, the "Space Cowboys" Rocket Design Team received the NASA University Student Launch Initiative Best Project Review Award and the AIAA Community Outreach Award.

MSU, a Carnegie Foundation Very High Research University, is a comprehensive public institution with more than 20,000 graduate and undergraduate students and nearly 1,200 full-time faculty members, located in Starkville, Mississippi. The Bagley College of Engineering has an approximate enrollment of 3,200 undergraduate and 600 graduate students. For 2013, the Bagley College of Engineering ranked 51st nationally in research expenditures, which totaled \$39.2M for the college and \$2.4M for the ASE department, according to the American Society for Engineering Education.

The position is available beginning July 1, 2015, but the starting date is negotiable. The screening of candidates will begin November 15, 2014 and will continue until the position is filled. Applications must be submitted online at www.jobs.msstate.edu/ for PARF #7762. Nominations or questions should be directed to Dr. John M. Usher, Search Committee Chair, Bagley College of Engineering, Mississippi State University, Email: usher@ise.msstate.edu, Phone: (662) 325-7624.

Mississippi State University is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability status, protected veteran status or any other characteristic protected by law. Females and minorities are encouraged to apply.

AIAA Bulletin

On 30 October, Arnold Engineering Development Complex's (AEDC) Historian Christopher Rumley gave a talk on AEDC's namesake, Gen. Henry Harley "Hap" Arnold at a luncheon meeting of the AIAA Tennessee Section. The talk covered Gen. Arnold's life from his early days just starting out as a pilot in the new Army Air Corps and being taught to fly by the Wright Brothers themselves, to his role in the development of a strategic U.S. Air Force, and finally to his late career when he founded an aerospace test center, AEDC, to ensure the United States remained the world leader in aerospace technology. (*Photo credit: Rick Goodfriend of AEDC*)

JANUARY 2015

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

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

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2015			
3–4 Jan	**Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-On Training Using CIFER®**	Kissimmee, FL	
3–4 Jan	**Best Practices in Wind Tunnel Testing**	Kissimmee, FL	
3–4 Jan	**Third International Workshop on High-Order CFD Methods**	Kissimmee, FL	
4 Jan	**Introduction to Integrated Computational Materials Engineering**	Kissimmee, FL	
5–9 Jan	**AIAA SciTech 2015** **(AIAA Science and Technology Forum and Exposition)** **Featuring:** **23rd AIAA/AHS Adaptive Structures Conference** **53rd AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Infotech@Aerospace Conference** **2nd AIAA Spacecraft Structures Conference** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **17th AIAA Non-Deterministic Approaches Conference** **56th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **8th Symposium on Space Resource Utilization** **33rd Wind Energy Symposium**	Kissimmee, FL	**2 Jun 14**
8–9 Jan	**Fundamentals and Applications of Modern Flow Control**	Kissimmee, FL	
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)	**15 Sep 14**
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)	
4 Mar	**AIAA Congressional Visits Day**	Washington, DC	
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)	
8–9 Mar	**Overview of MIssile Design and System Engineering**	Laurel, MD	
10–12 Mar	**AIAA DEFENSE 2015** **(AIAA Defense and Security Forum)** **Featuring:** **AIAA Missile Sciences Conference** **AIAA National Forum on Weapon System Effectiveness** **AIAA Strategic and Tactical Missile Systems Conference**	Laurel, MD	**4 Nov 14**
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**
30 Mar–1 Apr†	**50th 3AF Conference on Applied Aerodynamics – Forthcoming Challenges for Aerodynamics**	Toulouse, France (Contact: Anne Venables, +33 1 56 64 12 30, Secr.exec@aaaf.asso.fr, www.3af-aerodynamics2015.com)	
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)	
13–17 Apr†	**2015 IAA Planetary Defense Conference**	Frascati, Italy (Contact: William Ailor, 310.336.1135, william.h.ailor@aero.org, www.pdc2015.org)	
6 May	**Aerospace Spotlight Awards Gala**	Washington, DC	
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)	
4 Jun	**Aerospace Today ... and Tomorrow—An Executive Symposium**	Williamsburg, VA	
16–19 Jun†	**7th International Conference on Recent Advances in Space Technologies – RAST 2015**	Istanbul, Turkey (Contact: Capt. M. Serhan Yildiz, +90 212 6632490/4365, syildiz@hho.edu.tr or rast2015@rast.org.tr)	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
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** **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**	Dallas, TX	**13 Nov 14**
28 Jun–2 Jul†	**International Forum on Aeroelasticity and Structural Dynamics (IFASD)**	Saint Petersburg, Russia (Contact: Dr. Svetlana Kuzmina, +7 495 556-4072, kuzmina@tsagi.ru, www.ifasd2015.com)	
6–9 Jul	**20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference**	Glasgow, Scotland	**8 Dec14**
12–16 Jul†	**International Conference on Environmental Systems**	Bellevue, WA (Contact: Andrew Jackson, 806.834.6575, Andrew.jackson@ttu.edu, www.depts.ttu.edu/ceweb/ices)	
27–29 Jul	**AIAA Propulsion and Energy 2015 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **51st AIAA/SAE/ASEE Joint Propulsion Conference** **13th International Energy Conversion Engineering Conference**	Orlando, FL	**7 Jan 15**
9–13 Aug†	**2015 AAS/AIAA Astrodynamics Specialist Conference**	Vail, CO (Contact: Dr. W. Todd Cerven, william.t.cerven@aero.org, www.space-flight.org/docs/2015_astro/2015_astro.html)	
31 Aug–2 Sep	**AIAA SPACE 2015 (AIAA Space and Astronautics Forum and Exposition)**	Pasadena, CA	**10 Feb 15**
7–10 Sept†	**33rd AIAA International Communications Satellite Systems Conference and Exhibition (ICSSC-2015)**	Gold Coast, Australia (Contact: Geri Geschke, +61 7 3414 0700, Geri.geschke@emsolutions.com.au, www.satcomspace.org)	
12–16 Oct†	**66th International Astronautical Congress**	Jerusalem, Israel (Contact: www.iac2015.org)	
2016			
4–8 Jan	**AIAA SciTech 2016 (AIAA Science and Technology Forum and Exposition)** **Featuring:** **24th AIAA/AHS Adaptive Structures Conference** **54th AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **15th Dynamics Specialists Conference** **AIAA Guidance, Navigation, and Control Conference** **AIAA Infotech@Aerospace Conference** **AIAA Modeling and Simulation Technologies Conference** **18th AIAA Non-Deterministic Approaches Conference** **57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **9th Symposium on Space Resource Utilization** **4th AIAA Spacecraft Structures Conference** **34th Wind Energy Symposium**	San Diego, 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 SECTIONS: THE VALUE OF MAKING LASTING CONNECTIONS

Jim Albaugh, AIAA President

Recent communiqués from the Corner Office have covered important broad-level topics such as AIAA's strategic plan, the future role of aerospace engineers, and updates on AIAA's Foundation and Forums.

This month, I'd like to focus on the significance of region and section activities to our Institute's growth and success. As you may know, AIAA divides itself geographically into seven regions. Regions I–VI encompass the United States, while Region VII includes the rest of the world. Within those regions are 59 sections, two of which are in Region VII. What you may not know is that if you live in the United States, or in the Australian Capital Territory, or the states of New South Wales and Victoria—you are automatically a member of a local section. Those local sections provide a critical link between you and AIAA at large.

The dedicated volunteer leaders of our sections work tirelessly on your behalf to support your work or student experience with local events and programs where you can exchange ideas, network, and build lifelong connections within the aerospace community. In any given week, there are a dozen or more events where AIAA members meet each other, share experiences, learn something new, and celebrate the amazing and inspiring world of aerospace.

As I write this in early December, here are just a few of the dozens of events that happened over the last few weeks:

- The San Gabriel Valley section hosted AIAA Distinguished Lecturer Richard Graham, who spoke on "The SR-71 Blackbird: An Engineering Marvel"
- The Southern New Jersey section combined with four other engineering societies in their area to host their annual awards banquet
- The Tennessee section held the first of many section breakfasts, discussing topics from lasers to gardening to tornadoes
- The Sydney section supported the Region VII Student Paper Conference, held this year at the University of Sydney
- The Greater Huntsville section tested aerodynamic theories and raised money for a local school while earning second place with their pumpkin trebuchet at the Huntsville Pumpkin Blast (see page **B8**)

You may be asking yourself, as fascinating as all this is, why should I be involved? You should be involved in your section because participation is power. When members are engaged, AIAA and the whole aerospace community benefits. *Why?*

Because AIAA sections promote excellence. Your section holds events on a wide variety of topics to provide value to you (their colleagues), student members, the aerospace community, and to give back to society at large. Events such as the Educator Associate Workshop, aimed at K–12 educators, sponsored by the Tucson section, enhance the quality of Science, Technology, Engineering and Math (STEM) education for our future engineers. Many sections also sponsor or participate in STEM precollege events throughout the year. The Delaware section, for example, invites students from local middle schools to Introduce a Girl to Engineering Day.

Because AIAA sections value their community. Sections share a common goal of serving their members. They provide you with the opportunity to meet with your fellow members, hear about their work, discuss their challenges, and discover what excites them. They also recognize the importance of outreach in their area. Networking events are always a good opportunity to find out more about your colleagues, and you never know who you might be sitting next to—a NASA Center Director, a company vice president, a renowned professor, or even a former astronaut.

Because AIAA sections foster leadership. Section chairs and officers are volunteers who work together on supporting the section's vision. They learn skills that range from bookkeeping to project management to event planning, with some statistical analysis, legislative knowledge, and public speaking thrown in. They also learn to recruit and manage fellow volunteers, and when you have mastered that, you are ready to manage anything.

Because AIAA sections expand our knowledge. Section officers understand that their members need to expand their knowledge and connect, collaborate, and exchange ideas to excel in their jobs and advance in their careers. Not only do sections invite enlightening speakers on a wide variety of topics, several sections, such as the Pacific Northwest, Rocky Mountain (see pages **B6–B7**), and Dayton/Cincinnati also organize annual technical symposia.

And finally, ***because AIAA sections demonstrate integrity***, not only within their section but as a part of the aerospace community as a whole. Their activities are conducted in a fair and honest manner, and are nonjudgmental and nonpartisan. All members of the section are welcome, and in fact are strongly encouraged to participate. The passion of the section members to help their colleagues succeed is apparent in everything they do—showing how much they care about us.

I wish that we had AIAA sections everywhere around the world, and someday perhaps we will. We do have student branches at more than 190 universities worldwide, where similar activities take place to encourage students in lifelong learning, involvement, and leadership. I know that you care about aerospace because you're reading this magazine. I encourage and challenge you, to participate in your section—attend a meeting, have coffee with your colleagues, listen to a lecture, present a paper at a technical symposium. Your section colleagues care about you; please, care about them.

Because it's best for all of us.

IMPORTANT UPDATE: 2015 CVD DATE CHANGE

The U.S. House of Representatives and the U.S. Senate recently released their legislative calendars for 2015. We had initially selected March 11, 2015, as our date for the AIAA 2015 Congressional Visits Day, but the incoming House Leadership has decided that the House will not be in session that week. Rescheduling the upcoming year's CVD is in AIAA's best interest to ensure an effective and successful outcome. The 2015 Congressional Visits Day will now take place **Wednesday, 4 March**.

For more information about CVD, visit **http://www.aiaa.org/Secondary.aspx?id=4343**. To register for the 2015 CVD, visit **https://www.aiaa.org/CVD2015**.

ROCKY MOUNTAIN SECTION'S ANNUAL TECHNICAL SYMPOSIUM 2014

Pamela Burke

The AIAA Rocky Mountain Section (RMS) held its third Annual Technical Symposium (ATS) on 24 October, at the University of Colorado, Colorado Springs (UCCS). As in past years, this symposium focused on a wide variety of topics of interest to the AIAA membership and the local industry community. There were four parallel technical sessions throughout the day as well as four panel discussions, and a main room for networking, speakers, and meals. After the sessions, there was a reception featuring munchies and Red Rocket Ale from Bristol Brewery—the official beer of Spaceport Colorado.

The ATS, hosted by UCCS College of Engineering and Applied Science, with participation from the U.S. Air Force Academy and the U.S. Air Force Academy STEM Club, attracted a wide variety of industry sponsors and exhibitors including Lockheed Martin Space Systems Company as the primary (Diamond) sponsor and Ball Aerospace as the Platinum sponsor. Other sponsors and exhibitors included United Launch Alliance, Global Design Solutions, Ares Corporation, TMC Design, Engineering Solutions Inc., Red Canyon Engineering and Software, Surrey Satellite Technology US, and the Colorado Space Business Roundtable. In addition, academic institutions were sponsors and exhibitors—Webster University, UCCS Online Graduate Programs in Engineering and Applied Science, and, of special note, the Department of Mechanical Engineering, University of Wyoming. The RMS covers a large geographic area—Colorado, Wyoming, and Montana; the participation in the ATS by the University of Wyoming was especially welcome to the RMS Council and ATS team.

Dr. Taylor Lilly, RMS Southern Vice Chair and ATS Chair, welcomed the attendees, speakers, and panel members and introduced the sponsors and exhibitors. Opening remarks were made by Dr. Merri Sanchez, Chief Scientist and Technical Advisor for the Headquarters Air Force Space Command, Peterson Air Force Base. In her remarks, she recognized the student participants and emphasized the importance of maintaining connections and networking—specifically through participation in events such as the ATS.

Throughout the day, the four technical sessions ran in parallel and included presentations on Systems Engineering, Satellites, Policy, Education, Dynamics, Propulsion, Environment,

Dr. Merri Sanchez delivering ATS Opening Remarks

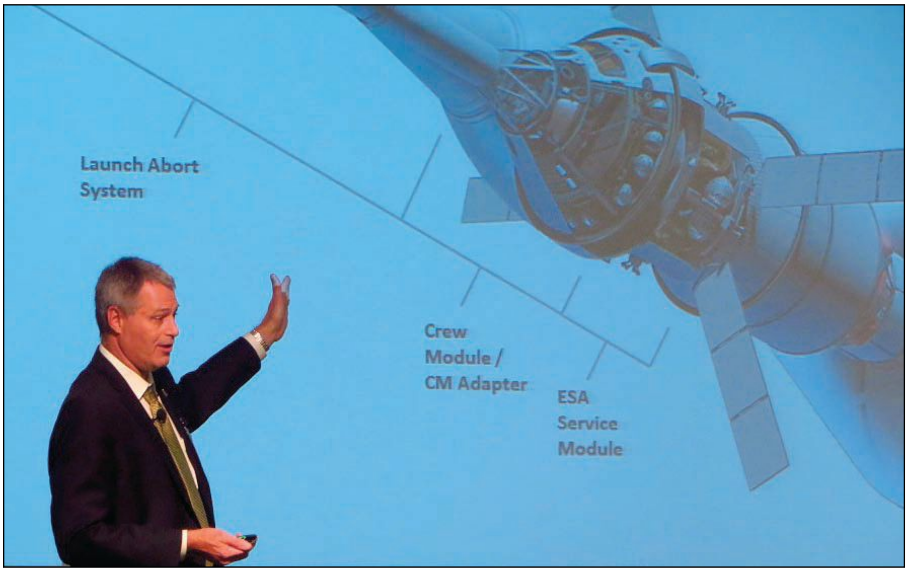
Software, Aeronautics, Space Exploration, Health Monitoring, Manufacturing, Laser Applications, Combustion, Computational Fluid Dynamics, Thermophysics, and Risk. Many of the presentations were from educational institutions such as the Colorado School of Mines, University of Wyoming, UCCS, and the Air Force Academy. As there were more abstract submissions than could be managed within time allocations, the ATS had a Poster area to give those authors an opportunity to present their activities. There were four panel discussions moderated by members of the RMS Council—Career, moderated by Heather McKay, Programs Chair; Colorado Initiatives, moderated by Arthur Hingerty, Public Policy; STEM, moderated by John Eiler, STEM Outreach Chair; and Direction of the Industry, moderated by Chris Zeller, Section Chair.

The keynote speaker was Dr. James Reilly, three-time space shuttle astronaut, who gave an engaging and inspiring discussion of why we should explore space and how the space program benefits life on Earth and impacts daily life. He introduced and peppered this discussion with details of his experiences and insights as a Shuttle and ISS astronaut.

Paul Anderson, Lockheed Martin Orion Program Director of Avionics, Power, and Wiring, was the luncheon speaker. He presented the history, current status, and future of the Orion Vehicle as part of the Exploration Missions for human space flight. He also spoke of the impending test flight (EFT-1) on 4 December

Chris Zeller, RMS Chair (right) presenting University of Wyoming Sponsor Plaque to RMS Wyoming Vice Chair Dr.Michael Stoellinger

USAFA cadets C2C Tyler Hudson (right) and C3C Gareth Price demonstrate a hybrid rocket during the afternoon break.



Luncheon Speaker Paul Anderson discussing the Orion Program


Keynote Speaker Dr. James D. Reilly

that would demonstrate the Orion capabilities to return from deep space missions, thus fulfilling NASA's role for exploration and advancing the transition for LEO operations to commercial space providers. [A successful EFT-1 flight occurred on 5 December.]

The technical sessions closed with remarks from Dr. Lilly and a hugely successful networking social to close the day. By the numbers, there were 48 sessions, 4 panel discussions, 180 registrants (which included 44 students), and 17 sponsors, exhibitors, hosts and participating organizations.

Many compliments were received from presenters and attendees. For example, one attendee emailed, "I just want to thank you and your team for putting on an excellent meeting! I greatly appreciate it. This is actually one of the better AIAA meetings I have been to in a very long time." Merri Sanchez provided this assessment: "It was my pleasure to attend the symposium and provide remarks. The section did an outstanding job putting on the technical symposium and the kudos go to your team! Having participated in organizing section level symposium I know that it takes a whole lot of work by a team. Your team is an example for all of AIAA to follow."

Of course, there were lessons learned as well and these will be incorporated into the 2015 ATS, currently in development, which will be hosted further north in the Denver-metro area in accordance with the RMS geography, and with a new chair—Tyler Franklin from Lockheed Martin.

Additional details (including biographies and presentation materials) about the ATS can be found on the RMS site at **www.aiaa-rm.org**; click on Annual Technical Symposium on left side of the home page.

PUMPKIN CHUCKING—WHERE AERODYNAMICS, SCIENCE, AND GOURDS INTERSECT

Duane Hyland

In November, Team AIAA Greater Huntsville, composed of intrepid aerospace professionals, took to the fields of Tate Farms in Meridianville, AL, to participate in the "Pumpkin Blast 2014" competition, or as it's colloquially known "some pumpkin chunkin." At the end of the day, AIAA's band of "pumpkin chuckers" placed second in the event's Adult Division, and earned the event's Outstanding Spirit and Blastmanship award from the judges.

Team members, a mix of young professional, student, and professional members, were the Launch Crew: Brandon Stiltner, team's captain; Eric Becnel, Daniel Colty, and Michael Dunning. Team Members: Nathanial Long and Colin Moynihan. Other contributors were: Anthony Bartins, Ali Butt, and Tia Ferguson. Kenneth Philippart, chair of the AIAA Greater Huntsville Section, served as the team's program manager. Each team's propulsion device had to be capable of propelling a pumpkin weighing two to four pounds over a distance of at least 75 yards, with possible propellant systems including air cannons, catapults, slings, slingshots, or trebuchets. The team decided that a trebuchet, a medieval siege weapon used to fling heavy stones at the walls of cities, would be their "chunkin" device of choice. "Once we had an idea of what the trebuchet was going to look like, we went to drawing sketches in computer-aided-design CAD," explained team leader Brandon Stiltner. The analysis allowed for precision in the building process.

Each of the event's teams were provided with five pumpkins to "chunk," and 30 minutes in which to chunk them at a target some 95 yards distant. Team AIAA Greater Huntsville's longest chunk was 80 yards. Teams started the day with 350 points, from which the judges deducted one point per foot that the pumpkin finished away from the target. Teams earned bonus points if their pumpkins weighed more than four pounds, with the maximum weight limit being 10 pounds. Other bonus awards included 50 bonus points for using trebuchet designs, and another 50 bonus points for the team finishing with the day's longest "chunk, and another 50 points for winning one of the event's special awards. The starting points, minus deductions, combined with any bonus points, determined the team placement in the event.

Team AIAA Greater Huntsville also aided the next generation of engineers during the event. "When one of the youth division teams had a major equipment failure, our team grabbed their tools and spare lumber and without hesitation, helped the high school team repair their machine," said Philippart. "The event organizer, students and parents came up to us after the event and thanked AIAA for helping their kids. We couldn't have asked for a better way to give a favorable first impression of AIAA and a practical application of STEM in action!"

The best part of the process, according to the team, wasn't watching the pumpkins soar or the application of practical engineering skills, but rather the teamwork and camaraderie that resulted from working on the device and competing. Philippart is already looking toward next year, stating: "I have no doubt that through this competition, our section planted the (pumpkin) seeds for the next generation of AIAA leaders. They did AIAA and the Greater Huntsville Section proud!"

AIAA Huntsville chapter visiting the United Launch Alliance rocket factory in Decatur, AL

AIAA GREATER HUNTSVILLE SECTION ATTENDS 100TH ANNIVERSARY OF WORLD WAR I DAWN PATROL

In late September, the AIAA Greater Huntsville Section traveled to Dayton, OH, to attend the 100th anniversary of World War I Dawn Patrol Flying Rendezvous, visit the National Museum of the U.S. Air Force, and tour sites on the historic Aviation Trail. The AIAA group spent a Saturday morning at the Dawn Patrol encampment area where they talked to World War I re-enactors, examined replica biplane fighters, and witnessed aerial demonstrations including simulated dogfighting.

The group spent the afternoon touring the National Museum of the U.S. Air Force where they learned about the history of military aviation from the Wright Brothers' first flying experiments to the cutting-edge technology of the 21st-century air force. Veterans within the group provided their personal perspectives on operating some of the systems in the museum including a detailed presentation on Cold War missile operations.

That evening, the group attended an informative presentation on Air Force Research Laboratory (AFRL) hypersonic propulsion research, including the X-51 hypersonic demonstrator. Bob Mercier, AFRL's Deputy for Advanced Technology, gave the AIAA members the same presentation that was used for the X 51 program's Collier Trophy nomination briefing.

On Sunday morning, the group toured sites on Dayton's historic Aviation Trail, including Huffman Prairie where the Wrights conducted their first flying experiments, the Wright Cycle shop, the Dunbar Interpretive Center, the Parachute Museum, the Wright Brothers Memorial, and the Wright Brothers gravesite.

First Place: Michael Dunning for his image of the Fokker Triplane.

Second Place: Richard Jozefiak for his image of the Spad fighter

The results of a photo contest held during the trip were announced in December. Over 250 pictures of the trip's activities were uploaded. The first and second place pictures appear above; there were selected as best representing the weekend's events and spirit.

At their November dinner meeting, the AIAA Los Angeles-Las Vegas section honored **Gene Haberman**, a 60-year AIAA Associate Fellow.

From left to right: Greg Larson (Programs Co-Chair), Rick Garcia (Membership Co-Chair), Jane Hansen (Director, Region VI), Nicola Sarzi-Amade (Chair, Los Angeles-Las Vegas Section), Gene Haberman, Barbara Haberman, Carl Meade (three-time Space Shuttle astronaut and dinner guest speaker).

AIAA AWARD RECIPIENTS ANNOUNCED!

AIAA is pleased to announce that Sustained Service Awards will be presented to the following members during 2015, and sincerely thanks each of them for their dedication and service.

Region 1

J. Philip Drummond, AIAA Hampton Roads Section, "For 35 years of service to AIAA and the Hampton Roads Section including Council Member, Technical Chair, and Associate Editor."

Jeffrey D. Flamm, AIAA Hampton Roads Section, "For over 30 years of service to AIAA at the section and Institute levels."

Stephen A. Rizzi, AIAA Hampton Roads Section, "For over 30 years of sustained service to the AIAA Hampton Roads Section, Region 1, and the AIAA Technical Activities Committee."

Christopher L. Rumsey, AIAA Hampton Roads Section, "For over 25 years of service to AIAA at the section and Institute levels."

Region 2

Arloe W. Mayne, AIAA Greater Huntsville Section, "For over 40 years of AIAA service as a leader, mentor, educator, technical expert and professional role model."

Region 6

David H. Klyde, AIAA Los Angeles-Las Vegas Section, "For nearly two decades of service to AIAA including technical committee leadership, distinguished lecturer, journal associate editor, and corporate member advisory committee."

The Sustained Service Award recognizes significant service and contributions to AIAA by members of the Institute. Nominations for the AIAA Sustained Service Award may be submitted to AIAA no later than **1 July** of each year. For more information about the AIAA Honors and Awards program or the Sustained Service Award, please contact Carol Stewart at 703.264.7623 or carols@aiaa.org.

NEW CORPORATE MEMBERS

AIAA is pleased to welcome the following corporate members:

Crean & Associates is a top team of leading, proven engineers, scientists, and managers with over 2000 years of combined aerospace industry experience.

Taia Global help aerospace companies and other industry verticals identify and defend their most valuable data from being stolen by hackers, competitors, and foreign intelligence services.

Higher Orbits is a non-profit organization that connects aspiring students with NASA leaders, astronauts and scientists through leadership and team-building programs focused on Science, Technology, Engineering & Math.

For information about the AIAA Corporate Membership Program, please contact Merrie Scott at 703.264.7530 or merries@aiaa.org

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.

CALL FOR PAPERS FOR *JOURNAL OF AEROSPACE INFORMATION SYSTEMS*

Special Issue on Intelligent Systems for Space Exploration

Space missions are faced with numerous challenges where the thoughtful application of automation and autonomy and the integration of artificial intelligence (AI) techniques can contribute significantly and directly to mission success. Among these challenges are operating in uncertain and extreme environments, managing scarce resources such as power, communications and computation under severe constraints, grappling with light-time delays, accomplishing unprecedented functions such as precision landing on planetary surfaces, achieving science return supportive of discovery, and all the while grappling with the intricate complexity of systems engineering tied to strong requirements for reliability, robustness and safety.

The *Journal of Aerospace Information Systems* (*JAIS*) announces a special issue to examine topics pertaining to intelligent systems for space exploration. This special issue is inspired by the iSAIRAS conference series. The most recent International Symposium for Artificial Intelligence, Robotics and Automation in Space took place in Montreal, Quebec, Canada, in June 2014.

The special issue is being organized by the following Guest Editors: Richard Doyle, Jet Propulsion Laboratory; Steve Chien, Jet Propulsion Laboratory; David Kortenkamp, TRACLabs; and Mark Woods, SCISYS UK. Guidelines for preparing your manuscript can be found in the full Call for Papers under Featured Content in Aerospace Research Central (ARC); arc.aiaa.org. The journal website is **http://arc.aiaa.org/loi/jais**.

Specifically, *JAIS* invites papers on:

- Space-based demonstration or application of intelligent systems concepts
- Ground-based demonstration of autonomous space systems concepts
- Ground-based demonstration or application of mission operations automation
- Laboratory demonstration of AI-based concepts for space missions

Relevant topics for the special issue include:

- Space systems autonomy: Onboard software for mission planning and execution; resource management; fault protection; science data analysis; guidance, navigation and control; smart sensors; testing and validation; and architectures
- Mission operations automation: Decision support tools (for mission planning and scheduling, anomaly detection and fault analysis), innovative operations concepts, data visualization, secure commanding and networking, human-robotic teaming

Papers for this special issue are expected to provide technical descriptions of systems and results and analysis of experimentation. Lessons learned in development and operations, including as relates to systems engineering, testing and validation also are pertinent to discuss.

We encourage papers addressing any operating regime for space exploration from Earth orbit to deep space (including planetary and small body orbital environments and surfaces), both robotic and human-robotic mission concepts.

Deadlines: Submissions are due by **16 February 2015**; initial reviews complete by **23 March 2015**; authors notified by **11 May 2015**; final manuscripts due by **15 June 2015**

Contact Email: Interested authors may discuss submissions with the special issue editors: **Richard Doyle**, rdoyle@jpl.nasa.gov; **Steve Chien**, schien@jpl.nasa.gov; **David Kortenkamp**, korten@traclabs.com; **Mark Woods**, Mark.Woods@scisys.co.uk

CELEBRATIONS AT MIT AND UNIVERSITY OF MICHIGAN MARK 100 YEARS OF AEROSPACE EDUCATION

Lawrence Garrett and Duane Hyland, AIAA Communications (with contributions from Thomas Mirowksi, AIAA Senior Member)

If Orville and Wilbur Wright are the fathers of flight, then Jerome C. Hunsaker of the Massachusetts Institute of Technology (MIT) in Cambridge, MA, and Felix Pawlowski of the University of Michigan in Ann Arbor, MI, could be considered the fathers of U.S. aerospace education. Hearing a clarion call for formally trained aeronautical engineers, both Hunsaker and Pawlowski established the nation's first aerospace engineering departments at their respective institutions in 1914, and this fall both institutions marked 100 years of aerospace education exellence.

The **University of Michigan's School of Aerospace Engineering**, the first aerospace undergraduate program established in the United States, held celebrations to mark its centennial milestone with alumni and guests on 18–20 September in Ann Arbor, MI. During the first day, a group of approximately 70 alumni ventured out to the aerospace department's radio telescope that was recently transferred from the physics department. The aerospace department has been recommissioning the dish and sensors, designing upgrades for the system while students have been learning how to operate it. The group then returned to the Aerospace Atrium where student groups displayed their aerospace-related projects and shared lunch with alumni. Approximately 200 alumni and students attended two afternoon sessions: "Panel on the Future of Aerospace Academics and Research" followed by "Women of Aerospace." The aerospace department staff also led alumni on a tour of the facilities where they discovered that the magnitude of change was directly proportional to the number of years since graduation. According to AIAA Senior Member Thomas Mirowksi, a University of Michigan alumnus, and a design engineer at Williams International in Walled Lake, MI, "Many of us enjoyed the delightful feeling of returning to a familiar place of our youth to see it transformed and improved by energetic educators and students." The evening was capped off with the Alumni Reunion Reception and Dinner, which "afforded us the opportunity to share personal stories of the path that our careers have followed and reminded us that the people we know who have a passion for aerospace make up a tight-knit community," according to Mirowksi.

On 19 September, the University of Michigan faculty gathered three distinguished panels to discuss the "Future of Aircraft," "Future of Space Exploration," and "Green Aviation." Approximately 400 alumni, guests and students attended these events. Capping off the day, Al Romig, AIAA Associate Fellow, and vice president of Engineering and Advanced Systems at Lockheed Martin Aeronautics, gave a tribute to one of Michigan's notable alumnus, Kelly Johnson, founder of the Lockheed Skunk Works.

One of the highlights of the centennial celebration was the Gala Dinner and Recognition Awards that took place at the Yankee Air Museum, which preserves the heritage of the Willow Run aircraft plant that produced B17s during World War II. Gemini astronaut and University of Michigan alumnus James McDivitt provided remarks and State Senator Patrick Colebeck, also a University of Michigan aerospace alumnus, presented a citation from Governor Rick Snyder to Dean Daniel Inman to recognize the University of Michigan's contributions to the development of aerospace over the last century.

Wrapping up the celebrations on 20 September, aerospace alumni gathered for a tailgate party at a University of Michigan football game, before enjoying the game. The crowd of nearly 104,000 were privileged to receive a flyover of 15 aircraft and helicopters representing the evolution of aviation. According to Mirowksi, "The AERO100 Weekend was a tremendous success to celebrate a century of achievement and innovation looking forward to a bright future 'standing on the shoulders of giants.'"

The **MIT Department of Aeronautics and Astronautics** threw their own celebration of aerospace education on 22–24 October 2014. The three-day event featured keynote addresses, panel discussions, and videos—all hailing the genius of Hunsaker, and the contributions that the department has made and continues to make to the world of powered flight, both in the Earth's atmosphere and above it.

Tom Crouch, AIAA Fellow, and senior curator, Aeronautics Department, National Air and Space Museum, kicked off the festivities on 22 October with a keynote address that discussed the history of MIT aerospace and the many contributions its program has made. Crouch's speech was followed by a series of panel discussions on the Apollo missions, which featured an array of legendary astronauts including Buzz Aldrin, Michael Collins, and James Lovell. The astronauts spent time discussing the prospects for a crewed Mars mission, with the idea that risk adversity was holding progress back. "In the risk-averse society we've become, we need to find a way to take a risk … to cross that boundary and go to the next frontier," Apollo 7 Astronaut Walter Cunningham told the gathering. Rusty Schweikert, the lunar module pilot for Apollo 9, however, took an optimistic view, proclaiming his belief that commercial space firms are energizing the business of space exploration, and that we would see a mission take place.

On 23 October, the event analyzed the current status of aeronautics with panels looking at future aircraft design, the future of air transportation, and intelligent and autonomous systems—both as they exist now and as they will exist. In the afternoon there were panels on space science, small satellites, and the importance of STEM education to aerospace. A banquet at the John F. Kennedy Presidential Library and Musem capped the second day.

The celebration's third and final day opened with a nod to the future of aerospace with a unique set of "Lightening Talks," very fast talks provided by MIT students focusing on their areas of research. This was followed by a panel of seven astronauts, all MIT alumni, who discussed their experiences on their missions—and with 37 missions between all of the participants, the audience came away with a greater understanding of what the Space Shuttle program accomplished, and what it was like to be part of that undertaking.

The event closed with a presentation by Elon Musk, founder of SpaceX. In a conversation with Jaime Peraire, the H.N. Slater Professor of Aeronautics and Astronautics, Musk discussed a wide range of topics including Mars exploration, advanced rocket technology, and advanced recapture technology—involving "floating platforms" that would allow for a rocket to splashdown and be usable again. According to MIT news reports, Musk also defended the rapid pace of development that smaller space companies seem to accomplish, noting, "Our pace of innovation is much faster than the big aerospace companies," while adding, "that has to be true from a Darwinian perspective, because small companies would die otherwise."

Throughout the celebration, tours were provided of MIT's Aero Astro laboratories, the MIT Museum, and the Draper Labs facilities—all key to creating and preserving MIT's rich aerospace history. From the past to the future, it was evident that the department of aeronautics and astronautics was celebrating a long legacy of success coupled to a shining future of innovation and discovery.

Congratulations to both programs! The nation and the world owe a debt of gratitude to Pawlowski and Hunsaker for their pioneering spirits in helping to create the first aerospace engineering departments at the University of Michigan and MIT.

OBITUARY

AIAA Fellow Jacobson Died in November

Ralph A. Jacobson, retired U.S. Air Force major general and former president of Draper Laboratory in Cambridge, MA, died 1 November at the age of 82 years.

Jacobson served 32 years in the Air Force, joining after graduating from the U.S. Naval Academy in 1956 with a bachelor's degree in engineering. He served as a tactical airlift pilot in Vietnam, an Air Force project officer for the Draper-developed Titan II Inertial Guidance System, and later in a series of space-related positions before capping his military career as director of special projects for the Secretary of the Air Force.

During his time as Draper president beginning in 1987, Jacobson led the Laboratory through a difficult period of funding challenges, as its work on the Fleet Ballistic Missile Trident II missile reached its planned end, and the end of the Cold War resulted in a sharp decline in defense spending. Jacobson helped the Laboratory diversify its work beyond defense and NASA programs, and increased spending on internal research, leading to the development during his tenure of technology that helped to create the market for microelectromechanical systems (MEMS) and multichip modules. The 1995 Space Shuttle/Mir Space Station docking was successful utilizing Draper's guidance and control technology. Jacobson's legacy at Draper also includes the endowment in 1988 at his recommendation of The Charles Stark Draper Prize for Engineering, which is administered by the National Academy of Engineering.

After he left Draper, Jacobson served as a consultant for various corporations, most recently Space Systems Loral and to Loral Corporation. He had been a consultant to Boeing Satellite Systems, Booz/Allen/Hamilton, Cymer Corporation, and Northrop Grumman previously. He was a member of the Board of Directors of Education Systems, Inc., and of Fairchild Controls Corporation. Jacobson also was a member of Sandia National Laboratories National Security Advisory Panel and of the NASA International Space Station Advisory Committee.

CALL FOR NOMINATIONS

Nominations are being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 February**. Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines to view nominee eligibility, page limits, letters of endorsement, etc. AIAA members may submit nominations online after logging into **www.aiaa.org** with their user name and password. If preferred, a nominator may submit a nomination by completing the AIAA nomination form, which can be downloaded from www.aiaa.org.

Aerospace Power Systems Award is presented for a significant contribution in the broad field of aerospace power systems, specifically as related to the application of engineering sciences and systems engineering to the production, storage, distribution, and processing of aerospace power.

Air Breathing Propulsion Award is presented for meritorious accomplishment in the science of air breathing propulsion, including turbomachinery or any other technical approach dependent on atmospheric air to develop thrust, or other aerodynamic forces for propulsion, or other purposes for aircraft or other vehicles in the atmosphere or on land or sea.

The industry-renowned **Daniel Guggenheim Medal** honors persons who make notable achievements in the advancement of aeronautics. AIAA, ASME, SAE, and AHS sponsor the award.

Energy Systems Award honors a significant contribution in the broad field of energy systems, specifically as related to the application of engineering sciences and systems engineering to the production, storage, distribution, and conservation of energy.

George M. Low Space Transportation Award is presented for a timely outstanding contribution to the field of space transportation. (Presented even years)

Haley Space Flight Award honors outstanding contributions by an astronaut or flight test personnel to the advancement of the art, science, or technology of astronautics. (Presented even years)

J. Leland Atwood Award is given to an aerospace engineering educator to recognize outstanding contributions to the profession. AIAA and ASEE sponsor the award. Nominations should be submitted to ASEE (**www.asee.org**) no later than **15 January**.

Missile Systems Award—Technical Award is given for a significant accomplishment in developing or using technology that is required for missile systems.

Missile Systems Award—Management Award is presented for a significant accomplishment in the management of missile systems programs.

Propellants and Combustion Award is presented for outstanding technical contributions to aeronautical or astronautical combustion engineering.

Space Automation and Robotics Award recognizes leadership and technical contributions by individuals and teams in the field of space automation and robotics. (Presented odd years)

Space Science Award is given to an individual for demonstrated leadership of innovative scientific investigations associated with space science missions. (Presented even years)

Space Operations and Support Award is presented for outstanding efforts in overcoming space operations problems and assuring success, and recognizes those teams or individuals whose exceptional contributions were critical to an anomaly recovery, crew rescue, or space failure. (Presented odd years)

Space Processing Award is presented for significant contributions in space processing or in furthering the use of microgravity for space processing. (Presented odd years)

Space Systems Award honors outstanding achievements in the architecture, analysis, design, & implementation of space systems.

von Braun Award for Excellence in Space Program Management gives recognition to an individual(s) for outstanding contributions in the management of a significant space or space-related program or project.

William Littlewood Memorial Lecture, sponsored by AIAA and SAE, focuses on a broad phase of civil air transportation considered of current interest and major importance. Nominations should be submitted by **1 February** to SAE at **http://www.sae.org/news/awards/list/littlewood/**.

Wright Brothers Lectureship in Aeronautics emphasizes significant advances in aeronautics by recognizing major leaders and contributors. (Presented odd years)

Wyld Propulsion Award honors outstanding achievement in the development or application of rocket propulsion systems.

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

AIAA Aviation and Aeronautics Forum and Exposition

Pushing the Boundaries of the Imaginable: Leveraging the Aviation Ecosystem

22–26 June 2015
Hilton Anatole
Dallas, Texas

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Program Overview

The global aviation ecosystem is broad, constantly evolving, and a driver of economic growth. AIAA AVIATION 2015 will celebrate its diversity by engaging participants throughout the value chain—legislation, regulation, research, design, manufacturing, suppliers, and users—to explore topics that build on the theme, Pushing the Boundaries of the Imaginable: Leveraging the Aviation Ecosystem:

- **Globalization**—Working in an International Landscape
- **Voice of the Customer**—Designing the Right Aircraft
- **Operations**—From NextGen Implementation to UAS Integration
- **Policy**—Promoting a Healthy Global Economy
- **Cybersecurity**—Getting Ahead of the Threat
- **Technology**—Driving the Future

AIAA AVIATION 2015 combines the best aspects of technical conferences with insights from respected aviation leaders, providing a single, integrated forum for navigating the key challenges and opportunities affecting the future direction of global aviation policy, planning, R&D, security, environmental issues, and international markets.

Confirmed Speakers
Edward L. Bolton Jr., Assistant Administrator for NextGen, FAA
Bill Ayer, Chair of the NextGen Advisory Committee

Technical Program

Nowhere else will you get the depth and breadth of sessions focusing on aviation and aeronautics topics than at AIAA AVIATION 2015! Featuring 16 technical conferences, AVIATION 2015 will deliver a strong technical program addressing the broad spectrum of applied science and aviation technologies. More than 1,500 papers will be presented on more than 125 specialized topics.

AIAA Programs

Technical conferences meeting as part of AIAA AVIATION 2015 include:

- 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
- 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

Courses and Workshops

Stay at the top of your game with AIAA's continuing education offerings. You will leave with invaluable improvements and solutions that you can put to immediate use.

Optimal Design in Multidisciplinary Systems (20–21 June 2015)
This course introduces you to methods and tools that have been developed over the years for the design optimization of engineering systems. You will be presented with a review of the state-of-the-art methods for design optimization that exploit the modern computer technology for applications with large numbers of variables, and design constraints.

FUN3D Training Workshop (20–21 June 2015)
This workshop will provide participants with guidance on how to install and execute the NASA Langley Research Center FUN3D computational fluid dynamics software for common aerospace applications. The objective of this workshop is to provide engineers and scientists with sufficient instructions to apply a large-scale Navier-Stokes solver to their analysis and design applications of interest. Detailed instructions will be provided for topics including analysis of steady and unsteady flow, boundary conditions, application to dynamic and overset mesh simulations, adaptive gridding, aerospace computations, geometry parameterization, and adjoint-based design optimization.

Plan Your Trip

Dallas is centrally located and within a four-hour flight from most North American destinations. A visitor will enjoy the best shopping in the southwest, four-and five-diamond/star restaurants, the largest urban arts district in the nation, and 14 entertainment districts. Dallas-Fort Worth is home to the headquarters of American Airlines and Southwest Airlines, and facilities for companies such as Bell Helicopter, Boeing, Bombardier, General Dynamics, Gulfstream, Lockheed Martin, Mitsubishi, Pratt & Whitney, and hundreds more aviation manufacturers.

Accommodations

AIAA has made arrangements for a block of rooms at the:

Hilton Anatole
2201 North Stemmons Freeway
Dallas, Texas, 75207, USA
Phone: +1.214.748.1200 • FAX: 1.214.761.7520

Room rates are $215 for a standard room (single or double occupancy). Applicable taxes will apply. These rooms will be held for AIAA until **1 June 2015** or until the room block is full, then released for use by the general public. AIAA has arranged for a limited number of rooms at the government rate. If you reserve a government room you will need to present a government ID upon check-in. To make a reservation, go to https://resweb.passkey.com/Resweb.do?mode=welcome_gi_new&groupID=30268256.
Any issues making reservations please contact Melissa Mulrine at 703.264.7847.

Exposition (2015 Exhibitors, as of 11/25/14)

Book your exposition space today. Contact Chris Grady at chrisg@aiaa.org.

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Learn more and sign up to get program updates: **aiaa-aviation.org**.

Upcoming AIAA Continuing Education Courses

Course at AIAA Science and Technology Forum and Exposition 2015 (AIAA SciTech 2015)
www.aiaa-scitech.org/ContinuingEd

8–9 January 2015

Fundamentals and Applications of Modern Flow Control

Instructors: Daniel Miller, Louis N. Cattafesta III, and Tony Washburn

Modern passive and active flowfield control is a rapidly emerging field of significant technological importance to the design and capability of a new generation of forthcoming air-vehicle systems, spawning major research initiatives in government, industry, and academic sectors of aeronautics. This completely revised two-day short course will address introductory fundamentals as well as several emerging air-vehicle applications of modern aerodynamic flowfield control techniques. The first day will cover a brief overview of the fundamentals of flow control, including basic concepts, terminology, history, strategies/techniques, actuators, sensors, modeling/simulation, and closed-loop control. The second day will cover applications of flow control to current and next-generation air vehicle systems, including vehicle propulsion integration, airfoil control, noise suppression, wake control, and some forthcoming non-aeronautical applications. A multi-institutional team of eight researchers from government, industry, and academia will cooperatively teach this course.

Key Topics
- Concepts, terminology, and history of flow control
- Flow control strategies
- Actuators and sensors
- Modeling and simulation techniques
- Closed-loop flow control
- Air vehicle applications: propulsion, airfoil, dynamic flowfield, non-aero apps

Course at AIAA Defense and Security Forum 2015 (AIAA DEFENSE 2015)
www.aiaa-defense.org/ContinuingEd

8–9 March 2015

Overview of Missile Design and System Engineering

This course provides an overview of missile design and system engineering. A system-level, integrated method is provided for missile design, technologies, development, analysis, and system engineering activities in addressing requirements such as cost, performance, risk, and launch platform integration. The methods presented are generally 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 as well as guided bombs. Typical values of missile parameters and the characteristics of current operational missiles are discussed as well as the enabling subsystems and technologies for missiles and the current/projected state of the art. Videos illustrate missile development activities and performance. Attendees will receive a copy of the course notes.

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


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