May 2015

AEROSPACE AMERICA

Composites vs. Metals

THE BATTLE FOR DOMINANCE ON AIRLINERS

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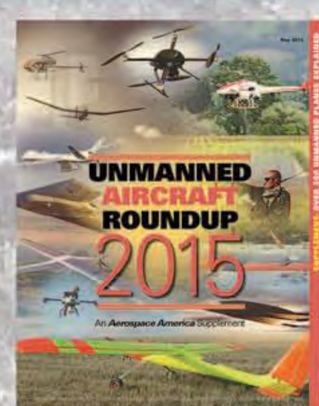

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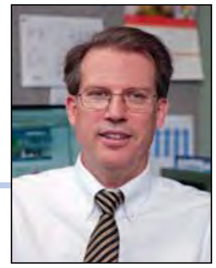
AIAA
Shaping the Future of Aerospace

Editor's Notebook



The future of air travel

When I board a plane and see a pilot and co-pilot preparing for takeoff, I wonder what air travel will be like a century from now.

My guess is that the planes of the 22nd century will fly largely autonomously, probably with a human pilot aboard as a teammate. This won't happen by magic. It will require humans to make many discrete decisions that over decades will amount to momentous change.

In the wake of the Germanwings crash in March, the industry should begin to embrace this high-tech future. Manufacturers and airlines could start small, for example, by having a remote pilot on the ground, or perhaps computer algorithms, maneuver a troubled airliner into the equivalent of a satellite's safe hold mode. Aviation authorities and the crew on the plane could then assess the situation. [*See related story on page 24.*]

It's true that the industry's overall safety record remains laudable even with the Germanwings crash, the downing of MH17 by a missile and the disappearance of MH370 last year. But statistics can't capture the frustration of a crash that might have been avoided. In this age of technology, passengers shouldn't have to worry about vanishing over the ocean or finding themselves at the mercy of an apparently mentally ill co-pilot.

Airlines that modernize to address these problems will gain a market edge. Once that happens, safety technologies that seemed exotic will become the norm, like the auto industry's hands-free Bluetooth systems and side-curtain airbags. Customers will expect them.

Of course, this isn't the first time a tipping point seemed to be at hand. In the months after the 2001 terror attacks, retired engineer Seymour "Sy" Levine pushed a patented concept called Safelander in which a remote pilot at a secure site would be empowered to take control of an airliner. Authorities decided to reinforce cockpit doors instead. Maybe that was the right answer in 2001, when the assumption was that terrorist sleeper cells were everywhere and a fast solution was needed. But in the years since, the U.S. Air Force set up networks of terrestrial fiber and satellites to remotely pilot drones half a world away, although not with the safety performance that would be demanded by airlines and regulators. Great strides were also made on autonomous control, which could liberate aircraft from vulnerable radio links to the ground.

Turning these technologies into an operational system would require investment. This spending would be justified, because an emergency system would apply to scenarios far beyond hijackings or suicidal pilots. The system could take control of a plane whose pilot has made a grave error, such as the case of Asiana Flight 214 whose pilot inadvertently deactivated the automated airspeed control, sending the plane into a seawall at San Francisco International Airport. Four years earlier, Captain Chesley "Sully" Sullenberger made a miraculous landing on the Hudson, but if a powerful computer had been aboard, it might have orchestrated a less risky landing at Teterboro Airport in New Jersey.

None of this is to say that computers are perfect. As planes become smarter and more connected, it's going to be critical for pilots to stay sharp for those moments when they do need to take charge. In the case of Air France Flight 447 in 2009, the autopilot threw up its digital hands and turned matters over to the pilots who lost control of the plane.

Twenty-second century air travel will require skilled pilots and powerful computers. The journey should begin now.

Ben Iannotta
Editor-in-Chief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China's soaring plans for new airports

Western observers expect China's next five-year economic plan to call for over a thousand new airport development projects — a mix of expansions and entirely new airports — when it is released in October. These would be mainly small airfields rather than major commercial hubs. But the blueprint will increase the number of airports open to civil traffic from around 230 today to as many as 1,500 within the next six years — a pace analysts say would be the most extensive airport construction and development program in history. Fulfilling this vision and developing current airports into more commercial operations, however, will require attracting more foreign investments.

The projects are expected to be concentrated in smaller towns and cities in remote areas to meet the growing demand for business and leisure air travel. Experts with interests in China said the country needs airports quickly to connect its northern and western provinces with the industrial cities of its eastern seaboard — the main area of economic growth for the last two decades — and with new markets in Europe and the Middle East. China is now looking to expand its trade and energy links with the West, which observers say likely will mean building airports in Tibet, which borders India, and Xinjiang province, which shares a frontier with Pakistan, Kyrgyzstan, Tajikistan, Kazakhstan and Afghanistan.

"A lot of development will take place around the one belt, one road development policy," says Peter Budd, head of the U.K. engineering company Arup's Global Aviation Business, referring to China's plan to re-invigorate trade along the historic Silk Road route that once linked Asia to the Middle East and Europe.

Until recently, many in the West were skeptical of the speed and size of China's national airport construction goals. Not anymore. The last five-year economic plan, 2011-2015, called for constructing 82 airports and expanding 101 others by the end of this year, taking the total number of civil airports in China to 230. Many industry observers expect China to make good on that target.

Zaha Hadid Architects

Artist's rendering of the planned Daxing Airport near Beijing.

"Our 20-year passenger forecast envisages 5.5 percent [annual] growth in China, leading to it becoming the world's largest air travel market around 2030," Tony Tyler, director general of the International Air Transport Association, said in a speech in Shanghai in March.

More than two-thirds of all airport construction in the world is in China, according to a 2013 article in Ascend magazine, published by the airline consulting firm Sabre Airline Solutions. The Centre for Asia Pacific Aviation in Sydney estimates China is currently building or expanding 56 airports at a cost of nearly $60 billion. Some of those are huge. When it opens in 2018, Beijing's second airport at Daxing will have four runways and an annual capacity for 45 million passengers — about the number who pass through San Francisco International Airport each year. Long-term planning for Daxing calls for capacity for 100 million travelers, which would edge out Hartsfield-Jackson Atlanta International Airport, currently the world's busiest.

Demand for domestic, not international, air services is fueling China's growth. For many cities in China's vast interior, it's cheaper and quicker to build airports than highways and high-speed train links. Seventy per cent of all airline travel in China is now domestic.

So even if China's economy were to slow, analysts say, demand for new airports should remain robust, especially as domestic air services continue to liberalize and allow aircraft operators to develop new routes. China's current five-year plan calls for doubling the number of general and business aviation aircraft in China. According to Hong Kong-based aviation consultants Asian Sky Group, the number of business aircraft based in China rose from 64 in 2007 to 371 at the end of 2013. This growth in business and general aviation is likely to accelerate if outlined plans to liberalize the airspace below 15,000 feet for civil aircraft operators are adopted in the next five-year plan. Much of this airspace is currently managed by the military but the government is looking at proposals for opening up lower airspace levels for general aviation aircraft.

China is also now looking to refine its operating practices and attract foreign investment into its airport development programs, experts say.

In October 2012 China Investment Corporation, the state-run investment fund, bought a 10 percent stake in Heathrow Ltd, the company that owns and operates London's Heathrow airport. In contrast to China's investments abroad, Budd says, foreign investment in Chinese airports so far has been limited: Germany's Fraport has a major stake in Xi'an Xianyang International Airport, and Hong Kong International Airport also has interests in airports in the south of China.

But given the current growth forecasts, these are unlikely to be the only investors in Chinese airports for long.

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Microdrones

Germany's Deutsche Bahn has used MD4-1000s to deter trespassers and graffiti artists on railroad tracks.

Algorithms, new aircraft keys to French rail monitoring

Lots of countries are starting to use unmanned aircraft to watch railways and other infrastructure for trespassers or maintenance problems, but France's unmanned aircraft initiative appears to be unique for its scale — 30,000 kilometers of rail lines — and a desire to spark innovation in aircraft design.

Efforts in such countries as the United Kingdom, Australia and the Netherlands have mainly involved small unmanned aircraft operated locally by pilots on the ground. France aims to deliver a comprehensive surveillance network based on autonomous unmanned planes. Researchers will initially work on algorithms to allow the automatic surveillance of tracks and overhead power cables but will also prioritize the development of surveillance systems to deter thieves from removing valuable cables, which costs the state rail companies several million euros a year.

"The big challenge is to develop drones which can monitor several thousand kilometres of track — which means long-term endurance, autonomous modes of operation and the ability to operate in harsh weather conditions including high winds and rain," according to Florent Muller, a systems and surveillance expert at the French Aerospace Lab, ONERA. "Such a platform does not yet exist," he says in a French-language podcast on the website of ONERA, short for Office National d'Études et de Recherches Aérospatiales

France plans to incorporate these still-to-be built planes into a monitoring network that will include sensors and communications aids to survey building interiors, including stations and maintenance centers.

ONERA and the French state railway company Société Nationale des Chemins de Fer, or SNCF, signed an agreement in February that will have the agencies invest a total of €4 million ($4.4 million) over the next five years to explore the use of unmanned aircraft to monitor the rail system.

SNCF's 30,000 kilometers of track includes 2,000 kilometers of high speed lines with an additional 800 kilometers under construction. The company runs safety trains along the track every morning before passenger services start, to ensure the line is clear — an expensive and lengthy process that an unmanned air system could one day replace, according to ONERA experts.

French officials have used unmanned aircraft for such localized tasks as inspecting electrical stations and bridges. The February agreement marks a shift toward a strategic research program.

Other countries are interested in unmanned planes, too. In January, the U.K.'s National Rail company signed a three-year agreement with Cyberhawk Innovations, a company that conducts umanned aerial inspections and surveys of utility lines and facilities, tracks and embankments. In Australia, rail freight operator Aurizon has begun testing unmanned craft to monitor the high voltage electrical system along its central Queensland coal network. It is operating two German Microdrones MD4-1000s equipped with Sony A6000 digital cameras with a resolution of 24 megapixels and infrared cameras. In the U.S., Union Pacific has tested the use of Aurora Flight Sciences unmanned craft for track inspections. In April 2014, Germany's Deutsche Bahn used MD4-1000s to deter trespassers — especially graffiti artists — on the track. ProRail in the Netherlands has used Altura Zenith ATX8s with infrared sensors to check the switch point heating systems on its tracks. Polish freight transport company PKP Cargo is using unmanned planes to prevent coal theft during transport . Light rail operators in Jerusalem have used Bladerworx unmanned craft to monitor the damage to infrastructure during recent riots.

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Make-or-break time for Airbus A380

This looks like a pivotal year for the A380, the double-decker plane that for more than a decade Airbus has billed as a key to airline profitability in the 21st century.

Airbus won no airline orders in 2014 for the $428 million aircraft. In fact, since the first order in September 2001, Airbus has received only 317 or-

In December, Etihad Airways became the 13th airline to receive an A380 double-deck jetliner, and the third operator from the Middle East to do so.

Airbus

ders against its original forecast of a demand for 1,250 planes of more than 400 seats (the A380 has 500) through 2023. The A380 was designed to capture that market, but the market hasn't taken off as expected. Of the existing orders, 40 percent came from a single airline, Emirates.

Airbus executives are waiting to see whether more airlines this year will commit to buying the A380 before making tough decisions about its future. Analysts told Aerospace America that the company has two choices: Continue with the current configuration and hope the market picks up or spend several billion dollars on a new version of the plane called the A380neo, with more fuel-efficient engines, a redesigned wing and perhaps a longer fuselage.

Airbus

If new orders aren't received, production would end within the next six years. That prediction is based on a production rate of 28 to 30 planes annually, the rate that added up to deliveres of 154 planes at the start of the year.

The A380 rolled out slower than expected, which is not unusual for a new aircraft type. The first revenue earning flights came in 2007, 18 months later than planned, mainly as a result of having to deal with wiring complexities and incompatible production software among the major partners. Then, the global economic crisis of 2008 hit many airlines in North America and Europe just when many were considering ordering the aircraft.

On top of that, the operational benefits of carrying 500 passengers on a single plane have not played out as expected. National and international regulators have ruled that separation distances between the A380 and following aircraft should be greater than those for Boeing 747s, as the A380 is heavier and generates a more powerful wake vortex. This means that capacity-constrained airports that had hoped the A380 would allow them to increase passenger throughput without increasing aircraft numbers have not been able to increase their capacity as much as they had planned.

And in May 2013, Boeing began selling a higher passenger version of its 777 airliner, called the 777 9X, a development that posed a new challenge to the A380 on long-haul routes. The 777 9X will have 400 seats, a \$388.7 million price tag and two engines compared to the A380's four.

What should become clear this year, aircraft industry officials predicted, is whether the underlying business case for the A380 is valid, despite its slow start.

One industry watcher suggested that Airbus's calculations could eventually prove correct.

"I don't think they were entirely wrong," said Thomas Saquer, a London-based consultant for Frost & Sullivan. "When they developed the A380 they thought that [long-haul] business aviation routes would fly hub to hub, which has been the case but maybe has not developed as fast as they thought. The financial crisis has also put airline operating margins under pressure, which has meant they have been struggling to raise capital to buy this size of aircraft."

The good news for Airbus could be the emergence of new hubs in the United Arab Emirates, Turkey and China. This could create demand for the A380 beyond the legacy hubs of London, Dubai and Singapore.

Airbus will need new orders and new customers soon if it is to forge ahead with development of the A380neo. Emirates and Turkish Airlines are reportedly negotiating with Airbus for A380s but the question is whether the numbers involved would be enough to warrant spending several more billion dollars on a re-engining program, when Airbus has other projects to weigh.

"Even though they still have five more years of production, Airbus is going to have to take a decision on re-engining quite quickly," said Saquer, the consultant.

Analyst Jacob Markish of Renaissance Strategic Advisors in Virginia said that developing a new design of the A380 with more fuel-efficient engines "will get [Airbus] some incremental volume but would also tie up resources perhaps better spent on further strengthening the A350 line, introducing the A320neo" — an upgraded version of the A380's smaller cousin — "into service and developing the long range version of the A321, all of which may have more of compelling, positive business case than the A380."

In February Airbus Chief Executive Tom Enders announced to financial analysts that the A380 program will break even this year, meaning that from 2016 the company will produce each A380 at a profit. In one view, money alone has never been the underlying justification for the A380.

"In many ways Airbus was almost forced to build the A380 regardless of how strong the business case was for it. The primary rationale was arguably to develop a product portfolio which could finally compete toe to toe with Boeing across the entire breadth of product range," said Markish. "The design point which Airbus came in at was, perhaps, slightly larger than ideal, because they had to differentiate its product from that of the competition."

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'Terraforming in a bottle' on Mars

Future human explorers working in the harsh climes of Mars could find easy breathing and comfy living inside biodomes — that is, if research by a small Indiana company succeeds.

Scientists at Techshot, Inc., of Greenville, Ind., want to test the concept of ecopoiesis, in which specialized bacteria generate oxygen from soil and create a mini-ecosystem. In an experiment on Mars, Techshot's sensor-laden container would corkscrew into the landscape and release ecosystem-pioneering organisms inside the container. These cyanobacteria and other microorganisms that live in extreme conditions on Earth would interact with a soil sample of Mars drawn into the container to make metabolic byproducts, especially oxygen for human explorers to breathe.

The scientists hope such an experiment can hitch a ride on a future NASA rover sent to Mars.

Eugene Boland, chief scientist at Techshot, is working on the idea with grant money from the NASA Innovative Advanced Concepts Program, under the space agency's Space Technology Mission Directorate.

Techshot exposed microbes to simulated Mars conditions for five weeks earlier this year, Boland says.

"We're impressed that our microbes still survived under the atmospheric pressure of Mars, the full solar radiation that reaches the planet's surface, along with the day-night temperature swings," Boland said. Using simulated Mars soil provided by NASA's Jet Propulsion Laboratory, water was injected into the sample of Mars dirt to mimic subterranean ice already shown to exist on the planet.

Once planted on Mars, perhaps 1 1/2 inches to 2 inches deep, the hardware would use Martian ice as its phase changes into liquid water, Boland says.

Mars is not completely devoid of oxygen. So the test bed equipment would be outfitted with a sensor to assure that the transplanted-from-Earth microbes are indeed churning out oxygen. Data gleaned by the experiment would be relayed to a Mars orbiting spacecraft for transmission to Earth.

Boland says, "The two biggest challenges we have right now [are] building the device small enough that we can drill into sandy Martian regolith" and using "a low-torque drill that can be mounted on a rover's robot arm, one that doesn't take up too much space or power."

"This idea of terraforming in a bottle is pretty ambitious…but I think it's a good idea," says Chris McKay, an astrobiologist at NASA Ames Research Center in California. McKay is part of an advisory team on the project.

"If we want to know how life can survive on Mars, we have to use life as the probe," McKay says. "No amount of chemical or geological 'context' is a substitute for actually growing life forms. This seems like a good way to start it," Boland stated by email.

Boland says his goal is limited and achievable: Make biodomes housing bacterial or algae-driven systems that convert Martian regolith into useful oxygen.

"I think we can actually use biological oxygen factories on Mars, essentially to grow the supplemental oxygen that will be needed," Boland said. "That's what my vision of this system really becomes…kickstarting it with microbes."

Leonard David
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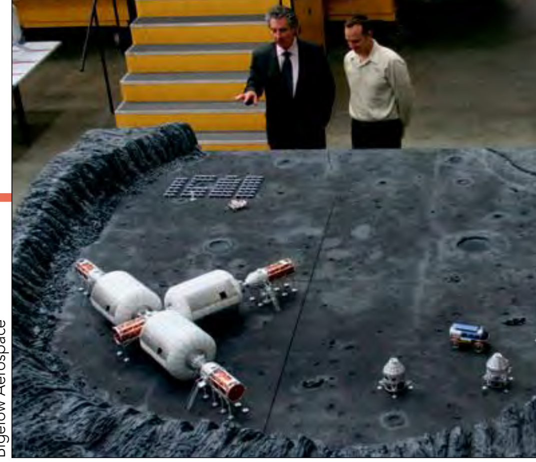
Eugene Boland/Techshot, Inc.

In a test chamber that simulates Mars conditions, scientists at Techshot, Inc. examine how Earth-sent microbes interact with Mars soil to create an ecosystem capable of supporting life.

Inflatable modules aim for room in space habitats


Bigelow Aerospace

Bigelow Aerospace wants to put expandable habitation modules on the Moon for scientific exploration and commercial enterprise.

What will the space habitats of the future look like? The answer could be something like the privately-built and NASA-funded Bigelow Expandable Activity Module, or BEAM, scheduled for delivery to the International Space Station in September by a Dragon cargo module.

BEAM is made by Bigelow Aerospace out of a flexible Kevlar-like weave material that will be tucked unpressurized inside Dragon. Outside the space station, BEAM will be removed from the unpressurized pallet of the Dragon by an astronaut operating the station's Canadian-built robotic arm. The arm will hold BEAM while a built-in pressurization system inflates the structure with air carried to space in pressure canisters. The arm will steer BEAM to berth at the station's Tranquility module.

NASA wants astronauts to hang out inside BEAM and inspect it periodically so the agency can assess whether to incorporate the technology in its long-term plans for human exploration of asteroids and Mars. Greater safety will be one of the key advantages of inflatable technology over rigid structures, according to Bigelow Aerospace.

"In a broad sense, the same kind of materials that are used for the BEAM are used in bulletproof vests, which is why expandable habitats are so much safer than traditional metallic structures," says Michael Gold, director of D.C. operations and business growth for Bigelow. "If you were getting shot at, what would you rather have for protection: a Kevlar vest or a piece of aluminum? I'll take the Kevlar vest."

The Kevlar-like material also will be covered by a micrometeoroid and orbital debris protection layer.

BEAM is scheduled to remain attached to the space station for at least two years, but Gold hopes it will stay much longer than that. When and if NASA decides to eject BEAM from the space station, it will burn up on reentry into the atmosphere.

BEAM's makers also say the technology promises larger volumes with less cost and weight.

Gold says Bigelow is withholding some technical details for BEAM, both because of proprietary concerns and export-control reform issues. Sharing technical information related to most space systems requires a license from the U.S. Department of Commerce or the U.S. Department of State, and in many cases the information cannot be made public without violating federal export-control laws.

BEAM is the creation of Robert Bigelow, an entrepreneur who made his wealth in real estate and construction. In 1999, he founded Bigelow Aerospace in a cluster of facilities on a 50-acre site in North Las Vegas.

From the start, Bigelow viewed expandable habitat technology as the anchor for private-sector space commerce in low Earth orbit and deep space exploration. To that end, Bigelow Aerospace underwrote the fabrication and testing in orbit of two subscale pathfinder expandable spacecraft, Genesis 1 and Genesis 2 in 2006 and 2007. Both were boosted into orbit from ISC Kosmotras Space and Missile Complex near Yasny, Russia, aboard converted Russian intercontinental ballistic missiles. With 406 cubic feet of usable volume, the Genesis modules tested technologies for Bigelow's larger expandable structures.

In 2013, NASA awarded a $17.8 million contract to Bigelow to provide BEAM for attachment to the space station in 2015.


NASA/Stephanie Schierholz

William Gerstenmaier, NASA's associate administrator for human exploration and operations (left), views the Bigelow Expandable Activity Module at the Bigelow Aerospace facility in Las Vegas.

The inflated structure will add 565 cubic feet of volume — about the size of a large family camping tent. The space station crew will periodically float into BEAM to inspect the module and collect performance data.

Bigelow has set its sights beyond just the space station. The company is developing a full-scale system, the BA 330, a larger expandable structure that would yield roughly 12,000 cubic feet of internal space for up to six crew members. Bigelow intends BA 330s to support zero-gravity research including scientific missions and manufacturing processes An even larger spacecraft, the Olympus, is in planning stages that would provide 2,250 cubic meters of internal volume.

"We have done conceptual work and have even constructed a full-scale model of Olympus," Gold says.

Once BEAM proves itself on board the space station, Gold says, the intent is to someday deploy the larger volume Bigelow space modules in Earth orbit, eventually setting the stage for their use on the moon, Mars and other deep space destinations.

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Flying Tailless

Cargo hauler faces demo

Necessity breeds innovation, and during the wars in Iraq and Afghanistan it looked like a good idea to make a truck that could go airborne to avoid improvised explosive devices. The flying jeep never took off, but engineers are hard at work on its progeny. Henry Kenyon explains.

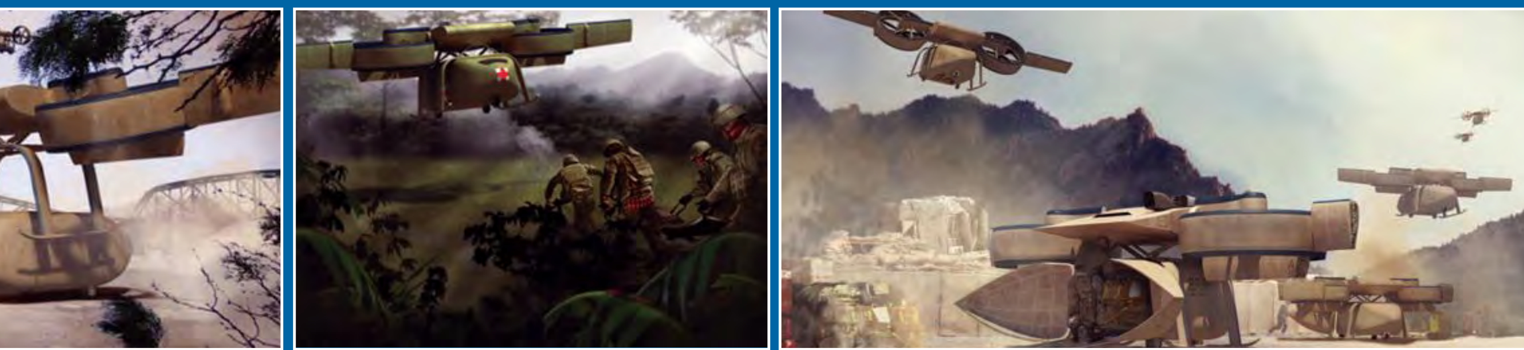
Engineers from DARPA and Lockheed Martin Skunk Works plan to fly an unusual prototype cargo carrier later this year, one whose roots can be traced to the bloodiest days of the wars sparked by the 2001 terror attacks.

Most aircraft that take off and land vertically have tails with rotor blades to counteract the main blade's torque, or as in the case of the V-22 tiltrotor, a tail with multiple flight surfaces to keep the plane stable in forward flight. The Aerial Reconfigurable Embedded System, ARES, won't have a tail of any kind. That was Lockheed Martin's solution to a challenge from the Defense Advanced Research Projects Agency in 2013: Make a robotic aircraft that could squeeze into tight spaces without having whirling blades or long tails endanger troops. ARES will get thrust from ducted fans — propellers housed in two protective nacelles — and it will be steered by control algorithms inspired by the vertical landing/short takeoff version of the F-35 joint strike fighter. The prototype must show it can carry a variety of cargo and sensors in easy-to-swap pods, with its central body housing propulsion systems, avionics and fuel. On either side will be a single engine nacelle, which will tilt up for vertical landing and rotate forward for flying like a conventional aircraft.

DARPA, Lockheed and its design partner Piasecki Aircraft feel good about the design because the craft tested well on simulation software and in a wind tunnel. But no one can say for sure what will happen when ARES takes off and lands for the first time at the Army's Yuma Proving Ground in Arizona. The craft's onboard computer must orchestrate the control surfaces to keep the craft under tight control. The idea is to demonstrate how an operational version might someday land at a small combat outpost or on the crowded deck of a ship. If the tests show promise, the Army, Navy or Marine Corps could someday have a robotic aircraft capable of hauling ammunition, food, light vehicles, sensors, weapons or wounded troops. The Coast Guard might use it to drop life rafts. Civilian applications could include resupplying remote oil and gas sites.

Flying jeep to cargo hauler

With IEDs killing coalition troops in Iraq and Afghanistan in 2010, DARPA started a program called Transformer that called for building a four-passenger ground vehicle that could, when needed, take to the air. The original idea was to transport ground troops over rough terrain or battlefields studded with improvised explosive devices. The Pentagon, however, ultimately was not interested in a flying jeep because battlefield resupply missions became a higher priority, says Ashish Bagai, an aerospace engineering Ph.D. and the ARES program



DARPA

DARPA hopes to show how a tailless craft might someday land in tight spaces with cargo pods tailored for specific missions.

manager. DARPA shifted the mission to coming up with a multipurpose robotic aerial cargo hauler.

Lockheed designers kept the core of the original aircraft but added a connection point for cargo under the center section. Piasecki Aircraft, Lockheed's ARES partner, helped develop the flight module's core.

Going tailless is a major design challenge. Vertical and horizontal stabilizers on the tails of conventional aircraft keep them flying in the direction intended by the pilot or autopilot. Without a tail, an aircraft becomes inherently unstable, explains Doug Welch, a conceptual design engineer at Skunk Works. ARES must compensate for its inherent instability by applying control power from its effectors — wings, fan ducts, a central trim tab, and veins located behind the ducted fans. Skunk Works engineers used software tools to design the control system and its aerodynamics before verifying the arrangement in wind tunnel tests, Welch says. Flight control software, a Lockheed Martin specialty, determines the best control surface and fan arrangements needed for stability and aircraft response, he says.

The ducted fans also help control the aircraft. In hover flight, the fans mainly provide vertical thrust, and the craft's position can be adjusted by moving vane flaps positioned downstream of the propellers. When the ducts rotate forward for cruising, the flight computer changes the rotor blade pitch angle on one side to vary the thrust and turn the aircraft, a process called differential collective.

With so many control surfaces, the ARES flight computer can produce the same effect by mixing and matching configurations, Bagai says. That will help the aircraft compensate for any battle damage it might receive.

ARES could also haul more load at higher altitudes than conventional helicopters, because helicopter rotor blades cannot generate adequate lift in thinner air. When it is in horizontal flight mode, ARES' winglike control surfaces will allow it to operate like conventional aircraft, which rely on their control surfaces for greater lift. The Pentagon wants to solve the high altitude supply problem because of its experience in mountainous Afghanistan. With an expected flight ceiling of 15,000 to 20,000 feet, ARES should avoid many of the problems faced by helicopters in high combat zones. Bagai notes that conventional helicopters must often travel through valleys and other low points, making their movements predictable to enemy forces.

Flight tests

Before the flights, Lockheed plans to check the aircraft's hovering and vertical takeoff capabilities while the craft is tethered to the ground with safety cables. The engines, ducted fans and power train were tested in 2014.

The plug-and-play cargo modules will be a major focus for engineers between now and the flight. These will be attached to an adaptor plate beneath the center of the wing. The same adaptor could also potentially carry an ordnance rack to arm the aircraft with missiles or other weapons and sensors. ARES weighs 7,000 pounds to 7,500 pounds fully loaded, with the cargo pod accounting for roughly half of the weight.

Then there are the ground handling procedures. The ARES team must still determine the best ways to swap out payloads at a forward base. This might entail using forklifts at larger facilities or putting cargo on inflatable/deflatable bladders or crank-driven devices in more remote locations, Bagai says. Some of the services want ground handling to be as automated as possible, while others see it as a potential mother ship for smaller drones that could be dropped or deployed on the ground and then recovered.

"It's quite conceivable that in each of these uses, the handling of the mission pod is specialized," Bagai says.

It all depends on a good showing in Yuma.

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Cosmic archaeologist

John Mather, senior project scientist for NASA's James Webb Space Telescope

What do you do for an encore after you win the Nobel Prize in Physics for a satellite experiment that helped confirm the Big Bang theory? For astrophysicist John Mather, his second act will be to look at the universe as it existed 100 million to 250 million years after the Big Bang, when clouds of gases first coalesced and began emitting light.

Mather, who earned a Ph.D. in physics from Berkeley in 1974, is in charge of milking as much science as possible from the James Webb Space Telescope, which NASA plans to launch in 2018. He spoke to Aerospace America contributor Edward Goldstein at Mather's office at NASA's Goddard Space Flight Center in Maryland.

What do you hope to discover or better understand through the James Webb Space Telescope?

Where did the first stars, and black holes and galaxies get formed after the Big Bang? This is hard because you have to look at things that are really faint and far away, and redshifted because of the expanding universe, so you have to have an infrared telescope.

How do the galaxies grow? The Milky Way wasn't always gigantic. We have simulations from computers that say it probably grew from hundreds or thousands of little things pulling together under the force of gravity. It relates to when the chemical elements of life were first liberated. The Big Bang gave us hydrogen and helium and what we see around us is mostly other things, except for the hydrogen in the water. So where did that all come from? When [did] the universe come alive with pond scum, bacteria, etc? That's a big question. Probably pretty quickly is my guess. But it will be hard to tell that.

How are stars born ? When I was a college student people knew in general that gravity pulls gaseous material together. Well, that's still where we are. The details mostly happen inside gas clouds where you can't see. The infrared light will go around the dust grains instead of bouncing off, and we can see inside the clouds where the stars are being born.

The last big question is about exoplanets. [With Webb] we can look at everything from Mars outward in our own solar system to see how this place works. One of the big questions is why Earth is different, and that relates to whether we're the only ones here. Earth might be especially lucky in the sense that it has water, and it has continents and oceans. It has a big magnetic field for a little guy. It has a big moon. It has this amazing history of being bombarded by comets and asteroids for hundreds of millions of years. It has about the right temperature and pressure to have life. It's the only one in the solar system. Are we really alone? The Webb telescope probably can't tell us that, but it can tell us a little more about how unusual our situation is.

Can Webb help us find an Earth-analogue planet?

If astronomers can tell there's a planet going in front of a star at a certain time of day, then we'll point over there and look and see the star get fainter for a while and we'll analyze the difference. We'll spread out the light with a spectrograph and measure the chemical constituents of the atmosphere of that planet. We're pretty sure we can see if there's water vapor – enough to have an ocean underneath. We should be able to tell if there are clouds and various other things. In good cases, we should be able to look at Earthlike objects. Now, please somebody tell us where there is a good [candidate]. Kepler has given us a lot of good candidates but they're all pretty far away, so there's only a limited amount that you can learn from those. We have a small observatory called TESS [Transiting Exoplanet Survey Satellite] that will launch in 2017. Maybe they can give us dozens or hundreds of candidates. That would be cool.

How would you determine if there's life on another planet?

That is one of the hardest problems we can imagine, but also one of the most interesting. It will probably take either one of two things. Either you will have to have a really big

Interview by Edward Goldstein

telescope with perfect optics and a coronagraph that is able to block the starlight so you can see the little fuzzy dot next to it and say, "Oh that's like Earth." Then you can do all the things astronomers do: measure the color, measure the orbit, and measure the constituents of the atmosphere by reflected light, which is different from the transit spectroscopy method. You can even maybe pick up some of the heat of the planet if you have long enough wavelength coverage and you are lucky and it's bright enough.

John Mather in his office at NASA's Goddard Spce Flight Center, with an Albert Einstein figurine and bobbleheads from TV's "The Big Bang Theory."

Photo by Edward Goldstein

The other method involves putting up a star blocker. You've probably seen the star shield pictures that look like a pointy sunflower, but you have to put it tens or hundreds of thousands of kilometers away from the telescope. It casts a shadow of the star so you can see the planets orbiting. And it's a very wonderful thing to do and it requires great mechanical engineering as opposed to great optical engineering. We probably should try both [methods]. A lot depends on how hard the problem is. How many stars do you have to look at before you strike gold?

Congress has prohibited NASA from actively supporting SETI, the search for extraterrestrial intelligence. What is your personal view of that search?

It seems to me fairly clear that the universe is enormous and civilizations are likely to be pretty far away. On the other hand, we don't know what civilizations are up to out there. Listening in is a pretty cheap way to find out. As it happens, developing the technology for SETI has led to pretty interesting technologies for a lot of other areas. The SETI people need to listen to the radio transmissions coming from planets around little stars so that's pretty fancy stuff. They need the best receivers and they need the best analysis process. They've even enrolled the public in helping analyze [data]. I think that's pretty cool.

There's an international observatory being planned called the Square Kilometre Array. They calculate that if there's a planet out there with airport radars like what we have, they'd be able to pick it up out to a distance of 50 light years, which is pretty spectacular. There are not many likely civilizations within 50 light years, but it might not be zero. It seems likely to me that a lot of civilizations would still have airport radars even if they were a million years old or 10 million years old as long as they have airplanes and they need to get them safely around. They'll use radar because it's a pretty good way. No guarantee there. But I think we should try this. It's a pretty inexpensive way to find out about pretty amazing things. I'm not worried about whether they are coming here. Space is too gigantic and traveling at the speed of light it takes you forever to have a conversation.

What have you learned about the origin of the universe since the Cosmic Background Explorer satellite mission?

The COBE satellite discovered that the Big Bang theory is basically right, although it should be called the Expanding Universe theory. People misinterpret the word. They say, "Big Bang," and they should say, "Infinite Bang." "Big" just isn't big enough. We've had two additional satellites, the NASA Wilkinson Microwave Anisotropy Probe and the European Planck mission that have extended the discoveries we made and said we got it right the first time. Now, we have the most amazing ability to calculate with tremendous precision from the conditions of the early universe to now. I had no clue that would be possible when we proposed that project back in 1974.

What other wild ideas and concepts have you been playing around with?

A wild idea that was developed [by] Stanford University and others is called atom wave interferometry. When I read about it in the New York Times, I said, "We need to be in that business." And I got some really bright engineers in this hallway that are working on the Webb telescope and said, "Let's find the people who are originating this work and get in and help." Now it looks likely that two things can happen. We should fly two different missions that apply this technology. One is to observe the shape of the Earth gravitationally. We've already done that beautifully with the GRACE [Gravity Recovery and Climate Experiment] mission. What we can do is so much better with this new method, with about twice the spatial resolution, much more precise measurements of what's happening to the water and the ice specifically. It's important to understand changes in the shape of the Earth due to the motion of the water and the motion of the ice. They can actually see that we're ripping the water out of the underground reservoirs and evaporating it so that whole areas of the world are going dry, because they are pulling all the water out from underneath. And we can also see the glaciers melting or not in different places and measure from above so you don't have to have a lot of guessing about it. You can take better measurements.

It's also possible to measure the gravitational waves of remote objects coalescing. Neutron stars or black holes merging together are supposed to emit a pulse of gravitational waves in their death spirals. They've never been observed directly but huge efforts have been made and the LIGO Observatory [Laser Interferometer Gravitational-Wave Observatory] may find them in a year or two. There's a coalition of radio observatories using pulsar timing to measure gravitational waves that may find them also. But to directly detect certain categories of them we need a space observatory that has been in planning for decades called LISA [Laser Interferometer Space Antenna]. LISA is difficult and expensive like everything else we do — this is a new technology that might do it as well or better.

It's something I'm really pleased with because it wasn't my idea, but I made some connections between people.

The basic idea has been developed pretty thoroughly but turning it into space engineering is another kettle of fish. It could happen. I think it will. And if I'm lucky I'll see it happen when I'm alive.

The case for teamwork in systems engineering

Samantha Walters
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At the University of Maryland, one class strikes fear in the hearts of space systems-track students more than any other. Dr. Dave Akin's senior design class is legendary in the department, thanks to its massive workload and capacity to provoke stress, frustration and even tears.

This year, my class was blessed with what Dr. Akin calls the second hardest project he's ever assigned (the first being designing a human mission to as many points of interest in the solar system as possible in a single vehicle). Our mission: establish a 24-person Martian settlement, totally independent of Earth, by 2054, using only a fraction of NASA's exploration budget.

Between planning the mission architecture, designing and CAD-ing more than 20 vehicles and structures — and generally just figuring out how to keep people alive — there was a lot to do. To try to tackle all of the work, we split it up into sections, and each of us worked on our assigned tasks until about a week before our PDR, preliminary design review.

As we began compiling our presentation, we immediately realized we'd made a mistake: some of the same work had been duplicated by multiple people, while other work hadn't been done at all. Some people had researched and run calculations for mission aspects that weren't needed.

We did our best to put together a coherent presentation and somehow managed to survive our first PDR trial. We actually garnered a fair amount of positive feedback. Still, almost every reviewer mentioned that we seemed overwhelmed and disjointed, as if we had considered each of our own work for the mission instead of thinking about the mission as a whole. There was a lot of good engineering design work, but a serious lack of systems engineering to tie it all together.

The whole experience reminded me of the previous summer when I interned at NASA Jet Propulsion Lab. JPL has a team of people who are tasked with pre-project design, because that's something the agency believes is essential for the success of long-term missions. JPL's Team X is composed of engineers from every discipline, and typically spends about three days taking missions from concepts to full-on proposals.

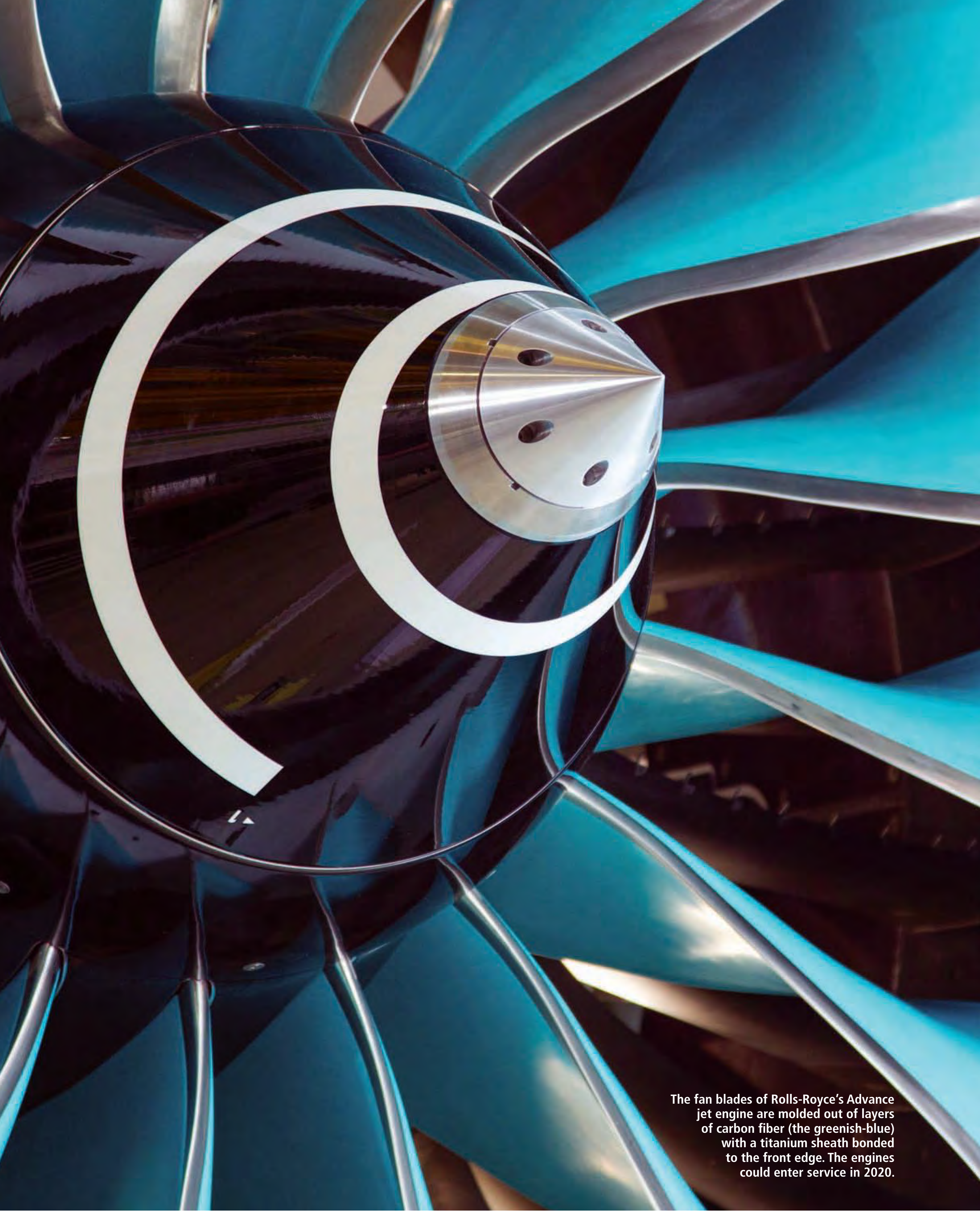
In three days, Team X is able to accomplish more than we did in two months. I believe this owes a lot to the collaborative approach it takes in the mission design process. By putting representatives for every sub-system of the mission in the same room, Team X creates an atmosphere in which engineers can create cohesive, successful mission plans in a minimal amount of time.

As my class prepares for our critical design review, we are trying to emulate Team X's approach as much as possible. We have created focus groups that meet at least twice a week for each main aspect of the mission to keep the design process on track. We also make a point of hanging out in the Aerospace Design Lab as much as our free time allows, to ensure we're all easy to find if a group member has a question. Working with 33 students on an enormous project like this has not been easy, but in the past few months, I have learned more and developed more passion about aerospace engineering than I have in my four years of college. The biggest lesson I will take with me as I enter the workforce is the importance of collaboration and systems engineering in the engineering design process. When engineers truly work together, anything — even something as far-fetched as a self-sustaining human colony on the Red Planet — just may be possible.

Jet Propulsion Laboratory

Helicopters scout the Martian landscape in this artist's rendering. Engineers will need teamwork to figure out how to colonize Mars.

Samantha Walters is a senior at the University of Maryland majoring in aerospace engineering with a focus in space systems. After graduation, she will work in engineering operations at the NASA Jet Propulsion Lab, where she interned for the past two summers.



The fan blades of Rolls-Royce's Advance jet engine are molded out of layers of carbon fiber (the greenish-blue) with a titanium sheath bonded to the front edge. The engines could enter service in 2020.

Rolls-Royce

Composite materials are revolutionizing modern airliners. Designers like them for reduced weight, durability and other advantages. But metal makers aren't giving up. In fact, they're feeling reinvigorated by the advent of additive manufacturing. Henry Canaday looks at the "horse race" between metals and composites in the commercial aircraft industry.

COMPOSITES VS. METALS

When it comes to the world's newest jetliners,

composites would appear to have metals hammered. Boeing 787s and Airbus 350s, for instance, are now built with at least 50 percent composites, with lesser amounts of aluminum, titanium, steel and other metals.

The advantages of polymer-composite aerospace structures are many: They weigh less than equivalent-strength aluminum, do not corrode or fatigue, require less maintenance and reduce the need for drilled holes and parts. Composite parts generally cost more than equivalent metal parts, but that premium is decreasing. And the cost premium is offset by operating savings in fuel and maintenance.

Metal suppliers are determined to stay competitive by innovating. New metal alloys weigh less and manufacturers are beginning to make some aircraft parts through automated, additive manufacturing processes that build complex objects one layer at a time. Composites and metals manufacturers aren't the only ones with stakes in the duel. Aircraft designers will need to make the right picks if they are to meet the demand from airlines for ever-lighter planes, satisfy passengers with cheaper fares and answer calls from governments for reduced carbon emissions. All of this must be done without sacrificing safety.

by Henry Canaday
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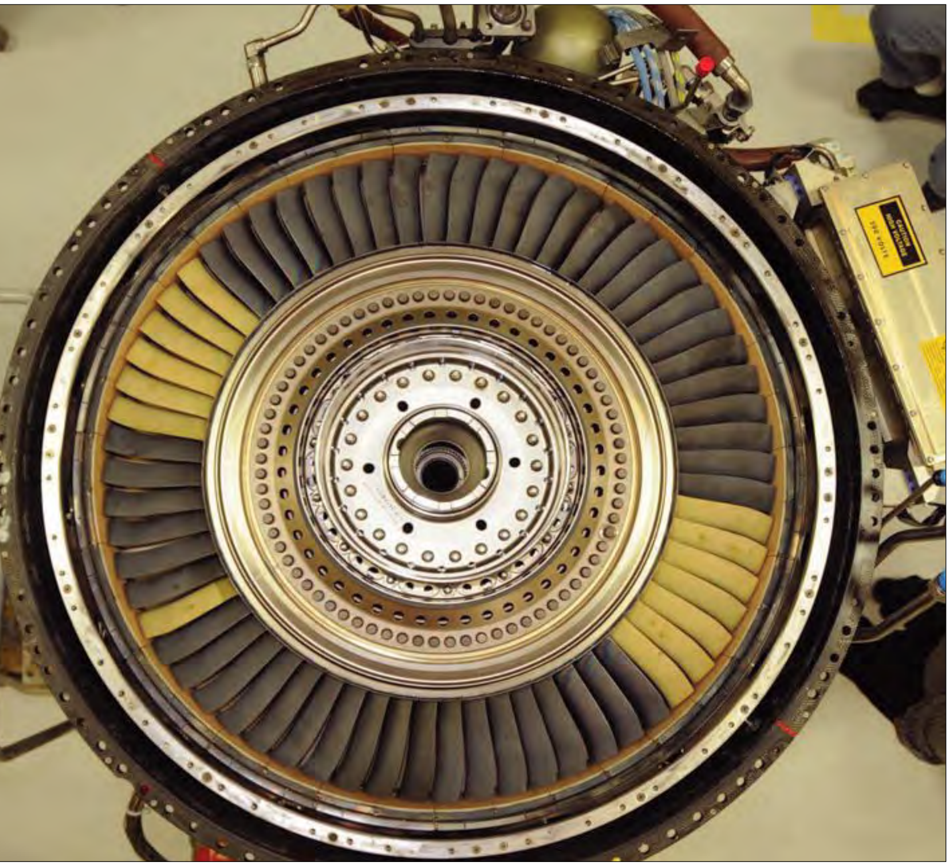

GE Aviation

The blades in this General Electric Aviation turbine rotor are made of ceramic matrix composites for lightness.

Advanced metals, according to Alcoa's Aerospace Technology Manager Markus Heinimann, have an inherent advantage over composites for parts that bear high or complex loads, such as interior bulkheads and attach fittings. Fuselage frames joining composite sections are also aluminum, landing gear is typically steel and landing-gear doors are still made of metal.

That's why Boeing's Chief Technology Officer, John Tracy, for one expects a continued "horse race" between metals and composites. That's echoed by Russ Dunn, senior vice president of GKN Aerospace, the British automotive and aerospace components maker. Dunn expects the current 50-50 balance between composites and metals on airframes to remain roughly stable, for at least a little while. But that balance may not hold.

Ceramic composites

One key battle area is the inroads that ceramic matrix composites, called CMCs, are making in aircraft engines. Composed of silicon carbide ceramic fibers and ceramic resin, CMCs weigh a third as much as the mostly nickel-alloy parts they would replace, and their lesser weight enables knock-on weight reductions in adjacent parts. CMCs also tolerate higher temperatures than metals. They will initially be used in static parts such as combustion liners, vanes, and shrouds and eventually in critical rotating parts like blades.

"In 20 to 30 years, the entire hot section [of a jet engine] will be CMCs, except for the disk that holds the blades," predicts Ajay Misra, chief of materials and structures at NASA's Glenn Research Center in Ohio.

Misra says CMCs today are unlikely to have the strength required in such parts as blade disks. Metal temperatures in hot sections now reach 90 percent of melting points. First-generation CMCs, he estimates, could increase hot-section temperatures up to 200 degrees to 300 degrees Fahrenheit. In another decade, CMCs could add a further 400 degrees. Higher temperatures boost fuel efficiency.

GE's LEAP engine for the next generation of single-aisle aircraft uses CMCs on the stage 1 high-pressure compressor shroud. The GE9X engine for the Boeing 777X will use it on combustion liners and stage 1 and 2 nozzles. These shrouds, liners and nozzles are all static parts in the hot sections of engines, which are divided into two stages of compression to increase efficiency. The Pentagon is testing CMCs on rotating parts, and GE will seek to do that eventually for commercial engines.

Use of CMCs in GE's LEAP is expected to shave fuel consumption by 2 percent. The company predicts a 10 percent reduction in fuel consumption is possible. Jon Blank, GE's design leader for polymer and ceramic composites, acknowledges that CMCs cost much more than the materials they replace, but GE expects to push costs lower through vertical integration, volume and experience.

Polymer composites

If the new CMCs will slowly supplant metals in engines, traditional polymer composites have already become common in airframes. The Airbus A350 is 53 percent composites, and its lower wing is the biggest polymer composite in civil aviation. The rest of the aircraft contains 19 percent aluminum, 14 percent titanium, 6 percent steel and 8 percent miscellaneous materials.

The Boeing 787 is similar; it is made

of 50 percent composites, 20 percent aluminum, 10 percent titanium, and less than 10 percent steel.

Composites now weigh 20 percent to 25 percent less than equivalent metal parts. The weight savings could theoretically reach 60 percent, says David Hills, director of research technology for Airbus Americas. Less weight means less fuel burn, a huge savings for airlines.

What's more, composites reduce maintenance costs by eliminating metal fatigue and corrosion. Airbus estimates that alone will cut the maintenance tasks for the A350 by 60 percent. Composites offer advantages in the manufacturing stages as well. The 787s, for example, have just 1 percent of the drilled holes required by the older 747s and only a third as many fasteners and other parts. Simplification offsets a lot of composite materials' higher prices.

Those costs have been a major issue. Raw aerospace aluminum costs about $4 per pound, compared to $10 a pound for composites. Titanium, used for engine fan blades and other select parts requiring strength, is about $48 per pound. But the price of the raw materials in composites only accounts for 15 percent of their overall costs. Another 15 percent of the costs is taken up by curing, 10 percent by assembly, 30 percent by inspections and 30 percent by jig tools.

Composites also have poor fly-to-buy ratio, which measures the material used rather than discarded or recycled. Two of every 3 pounds of composite materials go to waste during aircraft parts fabrication where blocks or sheets of composites are cut to the exact shapes required.

Boeing expects to incorporate more composites into its newest jetliners. The 777X will have composite wings when it starts flying in 2020. Regardless of oil prices, Boeing's Tracy said, the company aims to cut fuel burn by 15 percent for each new generation of jets. Weight is a crucial part of that equation.

Airbus's Hills says composites assembly may eventually move from bolting to bonding. Furthermore, composites could provide opportunities for structural health monitoring of airframes. Instead of drilling into metals or putting sensors on their surface, monitoring sensors could be embedded into composites during assembly.

GKN Aerospace

A GKN Aerospace engineer inspects a section of a composite wing spar for the A350 Xtra Wide Body.

Bombardier

Bombardier's C Series regional jets use composites for the rear fuselage, tail sections, wings and engine nacelles, shaving 2,000 pounds.

Tracy expects composites costs to continue to drop as their volume of use rises, especially driven by the demand from the auto industry. Advances in technical knowledge also will broaden the use of composites. For example, the 787 did not fully exploit the ability to tailor composite strengths for required loads. With more data, that will be possible.

"Manufacturing and inspections will be quicker, raw material costs will be lower and performance will improve," Tracy says.

Delamination is the chief vulnerability of composites, but Tracy is not worried. "We designed [composite parts] so they can carry loads even if delaminated. We know how to inspect and we know how to repair."

The 787s still use aluminum for wing ribs, lightly loaded parts that can now be cut efficiently in one piece from a block. Tracy says metal manufacturers have developed high-speed machining that can cut single parts where multiple parts were once required.

Other aerospace manufacturers are embracing composites, too. Bombardier's new C Series regional jets use composites for the rear fuselage, tail sections, wings and engine nacelles, shaving 2,000 pounds of weight. Gulfstream's current G650 and future G500 and G600 use the material for a wide range of smaller parts, including horizontal stabilizer, elevator, rudder, fairings, pylons, cowlings, thrust reversers, winglets, spoilers and landing-gear doors.

Composites require less frequent and intensive maintenance than metals, because they do not corrode or crack. But they demand more sophisticated diagnostics, specialized training and expensive capital equipment, such as autoclaves.

Inspection techniques are improving. Switzerland's CSEM is developing a nondestructive technology, or NDT, based on phase-contrast X-ray images to detect cracks, porosity and other microscopic defects. Senior Engineer Vincent Revol says NDT relying on ultrasonics cannot spot defects that small, and thermography and shearography do not perform as well with thick aerospace composite structures. Revol estimates the approach will be applied on a small scale in two to three years and more widely used in five to 10 years. The technology is aimed at airframe composites but has been tested on CMCs with what Revol calls promising results.

Other efforts are focusing on reducing the weight of composite materials even further. NASA engineers are working on the Pultruded Rod Stitched Efficient Unitized Structure [PRSEUS], attempting to take at least 10 percent off composite weight. PRSEUS adds stitches and rods to large composite panels, saving money and building larger parts by avoiding the need for autoclaves.

That technique could be used for fuselages, wings, doors, fairings, tails and trailing edges. Without rivets, bolts or fasteners, PRSEUS parts would be less expensive to make and offer no holes to inspect for cracks. And stitching would reduce delamination risk. A test to take PRSEUS to Technology Readiness Level 5 was scheduled for April 2015, but many further tests are needed. Senior Engineer Dawn Jegley says investors are also needed to turn PRSEUS's vision into reality.

In the meantime, researchers and firms are pursuing innovations with metals. For example, Alcoa since 2000 has developed more than 65 specifications of aluminum and aluminum-lithium alloys for aerospace. The results: structures that are cheaper than titanium and composites and up to 10 percent lighter than composites at the system level, according to Alcoa's Heinimann.

In addition to making aluminum, titanium and other high-temperature alloys for aerospace, Alcoa researches improved manufacturing methods such as new ways of joining, friction-stir welding and additive manufacturing, a very promising field.

Heinimann says additive manufacturing of metals is especially suited for small, complex components. One big advantage of the technique is that several engine parts can be manufactured as one component, improving efficiency by reducing leaking and cooling.

That is one reason, GE's Blank predicts, "there will always be metals in engines."

In fact, additive manufacturing could turn out to be the wild card for metals. When manufacturers do not have to throw away 50 percent to 90 percent of a pricey metal like titanium, it may look a lot more attractive, GKN's Dunn notes.

Right now, the technique is used for small components but not large structures, which will require both new facilities and more understanding of the process. "Additive layer manufacturing [for large structures] could change things substantially," Airbus's Hills says. "But it may be a long way off."

EOS of North America, the Michigan-based additive manufacturing technology company, has a system for producing small, complex parts from nickel alloys for engines and polymer nonload-bearing parts for airframes. The big advantage of additive manufacturing is that "complexity is free," and it can be very economical for small volumes, says Business Development Manager Scott Killian.

EOS equipment made 777s polymer ductwork, which would otherwise require laborious handwork on metal parts. The company is now moving toward what it calls PEEK polymers, which are lighter than aluminum and capable of sustaining temperatures up to 570 degrees Fahrenheit.

GE used EOS's direct-metal laser-sintering system to make a one-piece fuel nozzle that replaces more than 20 parts, which had to be joined by hand. The same system could produce static engine parts in the near term and rotating parts eventually. It can currently manufacture parts up to 16 inches.

Boeing

The use of composites in the 787 Dreamliner reduces the number of components and improves aerodynamic performance.

Some companies are making improvements in both composites and metals. GKN, for example, wants to cut 20 percent from the cost of manufacturing a composite winglet. GKN says it can make winglets that require 50 percent fewer fasteners and take 25 percent less time to build than they would with current composites.

GKN's Dunn predicts use of composites could increase for both the external parts and hot sections of engines. Composites are most appropriate for components with simple load paths, Dunn argues. On the other hand, it is going to be harder to keep composite costs competitive with metals as metal manufacturing becomes more efficient. ▲

The flying public, regulators and academics are pondering safety improvements following the deaths of 150 passengers and crew at the hands of an apparently suicidal pilot.

AVIATION AFTER

Emergency cockpit takeover: The technology exists, but faces hurdles

by Kyung M. Song
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Revelation that the crash of Germanwings Airbus A320 might have been a deliberate act of a suicidal pilot prompted airlines and authorities in Canada, the U.K. and Norway to opt for a seemingly easy solution: Insist on two crew members in the cockpit at all times. For years, however, leading aircraft makers have researched technologies that possibly could have saved the 150 lives lost in the Germanwings crash without anyone in the cockpit at all.

In a 2013 test, a BAE Systems Jetstream turboprop flew 500 miles across the U.K. with a pilot on the ground controlling the passengerless plane and the two on-board pilots handling only the takeoff and landing.

Boeing since 2006 has held a patent for an "uninterruptible autopilot" system that, once triggered, theoretically could thwart hijackings by deactivating cockpit commands and using a separate power supply to fly the aircraft, or land it at a preprogrammed location. And as far back as 1984, a NASA research pilot remotely flew and intentionally crashed an unmanned Boeing 720 jet near Edwards Air Force Base in California during a test of a fire-suppressing fuel additive.

Cable TV and the blogosphere have lit

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Germanwings Flight 9525

Rescue workers sift through debris of the Germanwings jet at the crash site near Seyne-les-Alpes, France. Investigators recovering remains from all 150 people aboard the Airbus A320 have accelerated their time frame for identifying and matching the victims' DNA.

Associated Press

A new complication for Europe's 'just culture' safety plans

The crash of Germanwings Flight 9525 is shining fresh light on the European Union's embrace of just culture, a legal and management principle that encourages aviation workers to admit mistakes and report safety concerns. In exchange, they receive confidentiality and protection from civil or criminal prosecution and firing, except in cases of criminal or grossly negligent acts. Proponents want to prevent accidents by feeding these reports into a database of technical issues for access by aircraft engineers and aviation authorities, but not the general public or lawyers.

Just culture advocates are concerned that French authorities, in a bid to stay ahead of the Germanwings story, may have undermined traditional air crash investigative processes and exacerbated deep tensions among pilots, investigators and judicial leaders about the right balance between confidentiality and transparency. The just culture principle, which is due for a major regulatory expansion in November, was already under fire from some lawyers because of its promise of confidentiality and its shift away from assigning blame.

Pilots in particular are worried that judicial investigators may now bend on the

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by Philip Butterworth-Hayes
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Cockpit

(Continued from page 24)

up with debate over whether the addition of the two-crew-member rule, which already existed in some jurisdictions, is enough or whether it's time for the industry to adopt an alternative technical solution for rogue or disabled pilots. That option, however, carries significant hurdles, mainly cost and culture.

Airbus

Airbus A320 cockpit: Voice and data recordings suggest the co-pilot ignored the aircraft's terrain warning system.

"Technically, it's possible" to have ground-based takeover of a commercial flight, says Clint Balog, an assistant professor in the College of Aeronautics at Embry-Riddle Aeronautical University.

A key obstacle to introducing the technology commercially would be cost, says Balog, a former engineering test pilot and an FAA-designated pilot examiner. Redesigning flight systems to remotely fly and land a jetliner would be expensive, and testing and certifying the aircraft would take years. Balog says that expense would have to be weighed against investments in other safety steps and the extreme rarity of pilot suicides. "What would be the payback?"

Of the 2,758 fatal aviation accidents in the United States between 2003 and 2012 — the vast majority of which were general aviation accidents — just eight were what the National Transportation Safety Board calls "aircraft-assisted suicides." All eight involved Cessnas, Pipers and other general-aviation aircraft.

For a likely case of murder-suicide by airliner, one has to go back to the 1999 crash of EgyptAir Flight 990. The Cairo-bound Boeing 787 went down with 217 people on board off the coast of Massachusetts. The cockpit voice recorder revealed that the first officer uttered repeatedly in Arabic, "I rely on God," as the captain tried futilely to override the nose-down command. Some observers say a suicidal captain also caused the 1997 crash of SilkAir Flight 185 into an Indonesian river at near supersonic speed, although Singaporean investigators never established that conclusively.

Boeing, for its part, does not appear to have immediate plans to deploy the uninterruptible autopilot. "Boeing studies many advanced concepts, innovations and technology," says Boeing spokesman Paul Bergman. "Just because Boeing studies a particular concept or technology does not necessarily mean that we will introduce that concept or technology in the near future."

Another hurdle to remote intervention is the pilots themselves. Patrick Smith, a commercial pilot who writes the askthepilot.com blog, has been exasperated by the number of times the public has asked why air traffic control couldn't simply have taken over the Germanwings jet.

"The public has such an exaggerated sense of cockpit automation. Yes [remote control of an airliner] is technically possible. But it's not in the realm of practicality."

The Air Line Pilots Association has long opposed ceding final command of an aircraft away from the cockpit. That tension is reflected in the differing philosophies by Boeing and Airbus on automation.

Airbus jets are designed to make it more difficult in many cases for humans to supercede the machine. If an Airbus senses an imminent stall, the aircraft will automatically lower the plane's nose in order to retain lift, and pilots would find it extremely difficult to override the automation by switching commands.

Boeing jets, by contrast, give more deference to human judgment. The company calls automated flight decks an assistant, not a replacement, for the cockpit crew. Pi-

BAE Systems

In 2013, a BAE Systems Jetstream was flown over the U.K. by a pilot on the ground, with backup pilots aboard the plane.

lots can execute commands that might exceed the aircraft's structural normal operational limits in some circumstances if the pilot deems it necessary for the overall safety of the flight.

Airbus says its planes are designed so that pilots can always override any automated protection features.

"According to the Airbus philosophy, pilots are a safety element. They can take control of the aircraft at any time," says Airbus spokeswoman Kristi Tucker. "Automation helps pilots in routine situations, so that they can focus on important decisions and procedures in the cockpit."

Yet even Airbus's automation philosophy did not save the Germanwings Airbus A320 as it headed for a certain collision. The co-pilot, Andreas Lubitz, did not respond to the plane's terrain-warning system urging him to "pull up."

Intentional crashes, however, are not the only argument for remote piloting. Some airlines are looking ahead to solo-pilot cockpits — a concept that might go over better with nervous passengers with a back-up pilot on the ground. Europe's low-fare carrier Ryanair, for one, has said it would like to switch to a single pilot for shorter flights. Brazil's Embraer says its regional jets may eventually be flown by a single person.

Current FAA regulations require two pilots aboard all major airliners. Even so, pilots must be able to operate the aircraft alone in case of an emergency. The main attraction of solo-pilot operations is economics, primarily from lower labor costs.

The greatest risk with solo-pilot jets likely will arise when the pilot becomes incapacitated from such causes as loss of cabin pressure or illness.

"Having the option of a ground controller taking control of the aircraft definitely helps to avoid" potential disasters, says Alex Stimpson, research scientist at the Humans and Autonomy Laboratory at Duke University.

But that fall-back command creates potential for safety issues of its own. Taking control away from a suicidal pilot or hijackers might be an easy call, Stimpson says, but "what happens if the ground control station operator is the one who has malicious intent?"

Without additional safeguards against the possibility of a disgruntled remote operator as well, he says, the system may merely shift risk from the air to the ground.

Passengers on the Germanwings flight arguably were unintended victims of post-9/11 security measures, specifically of reinforced and secure doors that prevented the captain from reentering the cockpit to wrest control of the aircraft.

Stimpson says any shift toward transferring final control of a plane "will not sit well with many current pilots. Any implementation of such a ground control station would have to be sensitive to this issue."

Smith, the pilot blogger, is skeptical the Germanwings tragedy will create any real clamor for, say, a Boeing 777 commanded from outside the cockpit, whether by human or computer.

"Check back in 30 years and we'll see if that's changed," he says.

Whistleblower

(Continued from page 25)

principle's core promise of confidentiality in much the same way they appeared to have brushed aside standard investigative practices in the Germanwings case. One senior pilot notes that just two days after the Germanwings accident, French prosecutor Brice Robin spoke at a press conference and, based on the cockpit voice recordings, declared the co-pilot intended "to destroy the plane." Under the European Union's 2010 regulation governing accident investigations, cockpit voice recordings "shall not be made available or used for purposes other than safety investigation".

The fear now is that workers might be reluctant to report safety incidents, as aviation safety investigators may come under increasing pressure from government lawyers to release information given in confidence.

"Very often, the judicial authorities with their vast powers show very little sensitivity to the requirements of the safety investigation," says pilot Paul Reuter, technical director of the European Cockpit Association, which represents pilots at European Union discussions on the just culture topic.

"This does of course undermine the trust in just culture principles, especially if cockpit voice recordings leak to the media, or if prosecutors start investigating incidents that have come to their attention only through confidential safety reporting schemes," Reuter says. He worries that safety reporting could "dry up."

Investigators aren't supposed to face judicial surprises when examining an accident. Under a 2010 regulation, all European Union countries are supposed to work out "advance arrangements" whereby judicial authorities and accident investigators work side by side during accident investigations and agree on how the need to improve safety should be balanced with the need for justice.

"The recent Germanwings accident will show how well this arrangement has worked (or not) and what lessons we can learn to improve cooperation and mutual understanding between the judiciary and the safety investigators," Reuter says by email.

All this comes on top of the longstanding, fundamental skepticism of lawyers like Andrew Charlton of the Geneva-based Aviation Advocacy consulting firm.

"At the risk of sounding cynical, just culture practices produce neither justice nor good culture," says Charlton. "The aim of the system is to stop incidents from becoming accidents which is a good thing, but is confidential reporting the way to achieve that? It is only if there is transparency and accountability of the reports," he says.

European lawmakers have tended to favor just culture, but the legal community has been more divided. Here's how Reuter of the pilots' group describes the situation:

Whistleblower protection, *European style*

Eurocontrol, Europe's air traffic control organization, champions the just culture principle in which aviation workers would be protected from civil or criminal prosecution in most cases to encourage them to speak up about safety violations or concerns. Here is how Eurocontrol defines just culture:

> "Just Culture is a culture in which front-line operators and others are not punished for actions, omissions or decisions taken by them which are commensurate with their experience and training, but where gross negligence, willful violations and destructive acts are not tolerated. Punishing air traffic controllers and pilots with fines or by suspending their licences can discourage the front-line operators from reporting any kind of mistake, with a consequent reduction in safety information. It is therefore fundamentally important to encourage the development of an environment in which occurrences are reported and the necessary processes for investigating and developing preventive action (such as re-training, improved supervision, etc.) are put in place."
>
> **– Eurocontrol, the inter-governmental air traffic control organization**

"The judiciary is very reluctant to accept just culture because for them it is a question of giving the industry a get out of jail card — which it is not, " he says. "The biggest current challenge with regard to just culture is to reconcile the need for the administration of justice with the absolute need of the aviation industry to maintain the trust required to promote and encourage open safety reporting by safety professionals like pilots and controllers."

In November, all European Union countries are required by European law to start enacting a 2014 regulation that will introduce further just culture practices in all aviation industries. The regulation is meant to encourage the confidential reporting of "any safety-related event which endangers or which, if not corrected or addressed, could endanger an aircraft, its occupants or any other person and includes in particular an accident or serious incident."

Some lawyers say there is a fundamental flaw in this process: Confidential reporting might lead to more data but a lot less transparency. Making the reports public but continuing to protect the identity of the worker who reports the concern would be better than keeping the reported incidents confidential, these lawyers say.

"If the intention of the regulation is to encourage whistleblowing, then the solution is to protect the whistleblower, not drive the whistleblower underground," says Charlton, the Aviation Advocacy lawyer.

Plus, lots of assumptions are at play in just culture, and some of them could prove faulty, critics say. It's presumed that employers will welcome reports and act appropriately on the information in them; that there is a clear understanding by all parties about the distinctions among honest mistakes, carelessness, negligence, gross negligence and criminal behavior.

The regulation that goes into effect in November "is a major step forward," a European air traffic controller tells Aerospace America, but this controller offers a major caveat: "To have a just culture reporting environment there is a risk that some of the fundamentals of the balance between administration of justice and safety might be put at risk."

When it comes to investigations, the need by the judicial authorities for fast identification of the culprit clashes with the meticulous, measured nature of a safety investigation that can reveal all the multiple and sometimes complex elements leading to a fatal aircraft accident. This might lead to the judicial investigation taking precedence over the safety investigation, as a result of media or political pressures, experts say.

The International Civil Aviation Organization requires that aviation service providers worldwide develop and maintain a formal process for collecting, recording, acting on and generating feedback about hazards in operations, as part of their safety management systems. Many aviation professionals agree confidential reporting of safety concerns has been a major factor in improving the aviation accident record. But recent events in Europe suggest that if pilots, controllers and other aviation professionals are to continue to have confidence in reporting incidents before they become accidents, more work will need to be done to reconcile the competing aims of national justice systems and aviation safety regulators.

"If the intention of the regulation is to encourage whistleblowing, then the solution is to protect the whistleblower, not drive the whistleblower underground."

– Lawyer Andrew Charlton

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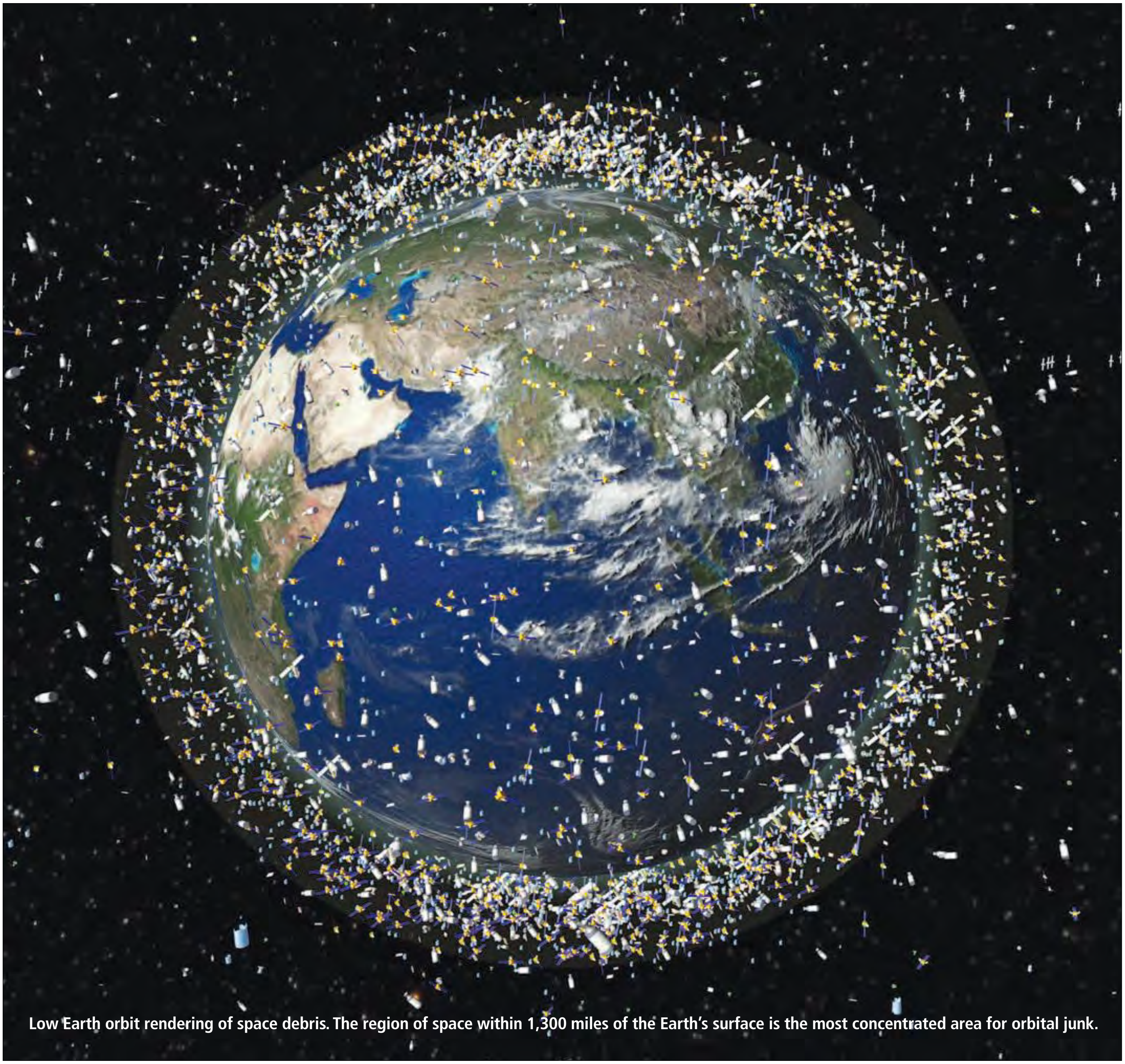

Low Earth orbit rendering of space debris. The region of space within 1,300 miles of the Earth's surface is the most concentrated area for orbital junk.

European Space Agency

ACE

Once upon a time, only space wonks and those in charge of keeping the crews safe aboard the International Space Station and the shuttle orbiters worried much about space debris. The problem is fast becoming a boardroom issue, given all the new proposals to populate low Earth orbit with swarms of small commercial satellites. Even if the new satellites don't add to the junk pile, their mere presence will make space more crowded and increase the likelihood of catastrophic collisions. Debra Werner spoke to technologists about ideas for addressing the problem.

Six thousand metric tons of spent rocket stages and circuit board fragments clutter Earth's orbit amid 1,300 operational satellites, including billions of dollars of spy satellites and commercial communications, weather forecasting and scientific spacecraft. Into that mix, most of which float in low Earth orbit, entrepreneurs now hope to inject thousands of small satellites to satisfy demand for broadband Internet in remote areas.

The sheer size of these constellations has raised alarms about potential high-speed mash ups with functional spacecraft, the International Space Station or existing trash — which would create thousands of new pieces of detritus.

With that nightmare scenario on their minds, technologists are working on ideas for zapping, catching, corraling or nudging dead satellites and space junk out of the paths of functional satellites or into Earth's orbit where they would burn up. Technologists know they must work fast, because while an international rule says old satellites should be disposed of, not everyone does so. And technical solutions are just beginning to emerge for the smallest of satellites whose size just doesn't permit the thrusters

by Debra Werner
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and propellent of larger spacecraft.

In January, OneWeb Ltd., a startup backed by Richard Branson's Virgin Group and microchip-maker Qualcomm Inc., unveiled plans to send 648 satellites into low Earth orbit to deliver broadband Internet. That was followed two days later by a declaration by SpaceX CEO Elon Musk to "rebuild the Internet in space" through a constellation that eventually could number 4,025 small satellites. These projects aim to bring Internet service to the roughly half

Internet via space: SpaceX CEO Elon Musk tells employees and supporters in Seattle about plans to launch a constellation of 4,000 satellites to deliver broadband to remote locations.

Washington Aerospace Partnership

of the world's population that lacks online access. That fleet of new satellites, however, will exacerbate the hazards from space garbage. Already, the U.S. Air Force is tracking some 21,000 objects — each the size of a softball or larger — orbiting Earth with 1,300 operational satellites. Ground-based radars have detected an additional 500,000 smaller floating objects, ranging in size from one to 10 centimeters.

Launching a few small satellites would not add much to the overall debris problem, says J.-C. Liou, chief scientist in NASA's orbital debris program office at the Johnson Space Center in Houston. "But if you are talking about deploying hundreds or thousands of small satellites, then that could be a problem."

OneWeb and SpaceX insist they won't be adding to the debris collection. SpaceX's Musk, speaking at a news briefing, said his company's satellites would travel in a sparsely-populated orbit at an altitude of around 1,100 kilometers to avoid striking debris. What's more, he said, "We are going to make sure we de-orbit satellites effectively so they burn up on reentry and land in the Pacific somewhere."

Terminator tape

For at least 15 years, Rob Hoyt, chief executive and chief scientist at Tethers Unlimited, a small aerospace research and development company based in Bothell, Wash., has been promoting the idea of using tethers to pull satellites down from orbit. Hoyt in the late 1990s urged NASA and the U.S. Air Force to equip satellites with electrodynamic tethers, long pieces of conductive metal tape that would unfurl at the end of the spacecraft's mission. The tether would expand a spacecraft's cross-section to increase neutral particle drag and to generate a current as it plowed through Earth's magnetic field. Some of the satellite's kinetic energy would be converted to electrical energy, and its orbit would sink lower as it slowed and became more susceptible to gravity's tug.

Hoyt's idea made little headway at first because satellite developers weren't required to equip satellites to move out of the way or deorbit at the end of their missions. If satellites are low enough, they eventually return to Earth's atmosphere and, if they aren't too huge, burn up. Most big satellites, however, can remain in orbit indefinitely.

"We were 15 years ahead of the market with a product people didn't want to pay for," he says.

The commercial market wasn't interested at that time, but in 1995 one government agency saw the debris problem coming. NASA adopted guidelines that year requiring its own spacecraft to re-enter Earth's atmosphere or move to undesirable orbits, often called graveyard orbits, within 25 years of the end of their useful lives. In 2002, the Inter-Agency Space Debris Coordination Committee, a group that included 11 international space agencies at that time and now includes 13 members, adopted that policy.

Not everyone complies. Only about 60 percent of the satellites and rocket bodies in low Earth orbit from 2000 to 2013 were expected to re-enter or move into graveyard orbits within 25 years, according to the 2013 report, "Mitigation Rules Compliance in Low Earth Orbit," released by CNES, the French space agency. Liou says the first step in dealing with the problem of orbital debris is to get operators to respect that voluntary deadline. "It is important for the global space community to do a better job of complying with the 25 year rule," says Liou.

For decades, large satellites have carried extra propulsion to move into graveyard orbits or return to Earth's atmosphere and burn up. Small satellite operators are just beginning to experiment with alternative de-orbiting technologies more suitable to the limited mass and volumes of their spacecraft.

In December 2012, Tethers Unlimited sold its first CubeSat Terminator Tape, a simpler, cheaper version of Hoyt's earlier product. The first CubeSat Terminator Tape, an 83-gram de-orbit module the size of a drink coaster, was purchased by the Aerospace Corp., a nonprofit based in El Segundo, California, that provides research, development and advisory services for U.S. national security space programs. The Aerospace Corp. bolted the $7,000 Terminator Tape onto AeroCube-5 and launched the spacecraft in 2013 on a mission to test on-orbit pointing and tracking technology.

Whenever AeroCube-5 completes its mission — no date has been set — it will send a 1-second signal to the spacecraft to release its 250-meter long conductive tape and provide the first space-based demonstration of the Terminator Tape, Hoyt says.

Next year, at least two additional Tethers Unlimited customers plan to launch spacecraft carrying the smaller NanoSat Terminator Tapes, a 50- to 70-meter conductive film designed to de-orbit satellites weighing 50 to 200 kilograms. The length of the NanoSat Terminator Tape varies based on the mass and orbit of its host satellite.

Surrey Satellite Technology US, the Colorado-based subsidiary of Britain's Surrey Satellite Technology Ltd., is slated to launch the NanoSat Terminator Tape in May 2016 on its Orbital Test Bed, a spacecraft with five payloads provided by academic organizations, commercial firms and U.S. government customers. In addition, leaders of the U.S. Air Force's University Nanosat Program purchased two NanoSat Terminator Tapes for use on two satellites. The NanoSat Program is a joint effort of the Air Force Research Laboratory's Space Vehicles Directorate, Air Force Office of Scientific Research and AIAA to develop a skilled workforce through support of small satellite initiatives. One of the tapes is scheduled to fly in 2016 on the Georgia Institute of Technology's Prox-1, a 50-kilogram satellite with an embedded five-kilogram cubesat. Once in orbit, Prox-1 is designed to release the cubesat but remain nearby to inspect it through the use of automated guidance, navigation and control systems. The second satellite has not yet been selected.

Surrey Satellite Technolgy

An engineer indicating the integration location of the Nanosat Terminator Tape Deorbit Module.

Drag sails

Circling overhead at this moment is another idea for deorbiting small satellites and rocket parts, this one a device called dragNET made by engineers at MMA Design in Boulder. Technicians folded DuPont Kapton polyimide film into a 2.8 kilogram box about the size of a telephone book and attached this dragNet to an experimental Air Force satellite called STPSat-3, short for Space Test Program Satellite-3. Another dragNet was installed on the Minotaur upper stage that launched STPSat-3 in 2013.

The Air Force officials confirmed that the 14-square-meter dragNET unfurled on the Minotaur after the launch, says Mitchell Wiens, MMA's president and chief operating officer. That sail is expected to bring the rocket body into Earth's upper atmosphere sometime in mid-2016, less than three years after it was deployed.

When the sail on STPSat-3 springs open, probably next year, it will demonstrate dragNET's ability to work after being stored in its box for three years, Wiens says. The polyimide film is protected by a proprietary coating.

Sweeping up debris

Even if all new satellites were equipped to avoid becoming space debris once they finish their missions, that wouldn't address the junk that's already up there or the problem of satellites malfunctioning so badly that they can't be commanded.

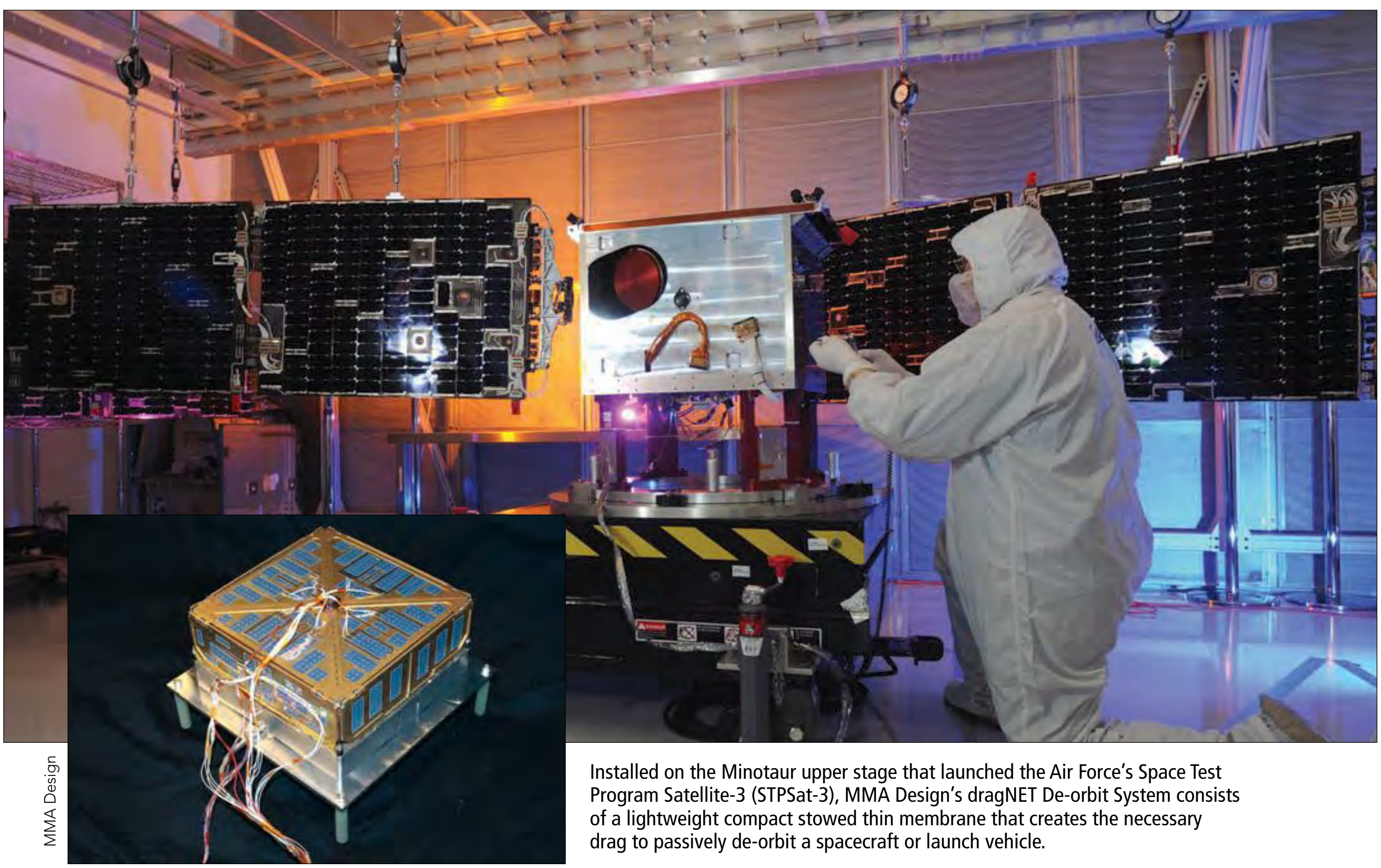
Claude Phipps, founder of Photonic Associates LLC of Santa Fe, New Mexico, suggests that the answer should be space-based lasers. With short, repetitive pulses focused on 50-gram objects, such as shards from an exploded upper stage, a laser beam could slow their momentum, bring the debris closer to earth and speed its descent into Earth's atmosphere, where all but the largest satellites burn up entirely or break apart into small pieces before reaching the ground.

Those small objects, which are difficult to track using ground-based telescopes "are like shrapnel, it's important to get rid of them," Phipps says.

For larger objects, Phipps proposes aiming laser pulses on a single object over a period of months or years. The trick would be to slow its momentum without breaking it into pieces, which Phipps says will not be a problem if the pulses are aimed at metal or other appropriate targets.

Phipps began advocating a similar campaign using a ground-based laser in 1996. That plan drew vigorous opposition from U.S. intelligence agencies, who worried that a laser beam might blind spy satellites. So Phipps began looking at options for positioning the lasers in space, where they could not accidentally shine into a downward pointed sensor.

Other industry and university teams are designing satellites to catch hold of debris. Busek Co. of Natick, Massachusetts, wants to unreel a small satellite from a larger one, and direct the smaller one to grab debris weighing more than 1,000 kilograms. The larger satellite, weighing roughly two metric tons,



Ball Aerospace

MMA Design

Installed on the Minotaur upper stage that launched the Air Force's Space Test Program Satellite-3 (STPSat-3), MMA Design's dragNET De-orbit System consists of a lightweight compact stowed thin membrane that creates the necessary drag to passively de-orbit a spacecraft or launch vehicle.

Photo illustration: The Swiss Space Center at École Polytechnique Fédérale de Lausanne CleanSpace One, a project to develop and build the first installment of a family of satellites specially designed to clean up space debris.

would be called ORDER for the Orbital Debris Remover, and it would provide propulsion, power and communications for its 10-kilogram companion, called SOUL for Satellite on an Umbilical Line. SOUL would rendezvous, inspect and grab its target without human intervention. ORDER would reverse the direction of its electric thrusters and tug the debris to another orbit, where SOUL would release it. ORDER would then reel in SOUL and find its next target.

That fetch-and-relocate system won't come cheap but it could be quite busy. Busek estimates a customer would pay about $80 million to build the twin satellite system, which could make 100 trips in geostationary orbit, moving 2,000-kilogram spacecraft to graveyard orbits, or take 40 2,000-kilogram satellites out of low Earth orbit, says Dan Williams, Busek's business development director.

Astroscale, a Singapore startup that earlier this year attracted an investment of $7.7 million, wants to show how a pair of satellites and newly-developed silicon adhesive might catch debris. In 2017, Astroscale plans to launch what it calls the Active Debris Removal System, consisting of a 60-kilogram satellite shaped like a flying saucer called Mother connected to a 20-kilogram cylindrical satellite known as Boy. Once in orbit, Astroscale intends to send the Mother-Boy spacecraft toward a 50-kilogram satellite the firm also plans to launch in 2017. When Mother finds the target, which will not have navigation features to make this approach easy, it will release Boy to fly nearby and catch it with the silicon adhesive, says Philippe Moreels, the company's business development manager. Boy would fire its hydrogen peroxide-fueled solid propellant thrusters to move itself and the debris toward Earth's atmosphere, where Boy and the debris would burn up during re-entry.

If that demonstration succeeds, Astroscale's Tokyo manufacturing plant would start work on one or two Active Debris Removal Systems to launch annually. Each Mother spacecraft would be designed to launch six Boys, Moreels says.

Meanwhile, a Swiss university group is working on a technology specifically meant for snaring cubesats. The École Polytechnique Fédérale de Lausanne in 2018 plans to launch a 30-kilogram satellite called Clean Space One. The satellite would be loaded into a small spaceplane that Swiss Space Systems is designing to be launched in 2018 from the roof of an Airbus A300. The student-designed Clean Space One would approach SwissCube, a cubesat EPFL launched in 2009, fly around it to analyze its shape and tumbling motion, catch it — no one knows yet whether this would be done with claws, a cage or a net — and maneuver toward the upper atmosphere.

"Maybe by demonstrating we can clean up the little SwissCube which we put up there, we would show others how to act responsibly," says Volker Gass, director of EPFL's Swiss Space Center.

COSMONAUT

Roscosmos (Russian Federal Space Agency)

DIARIES

Soviet cosmonaut Anatoly Berezovoy made only one space flight during his career, but it was one for the books. His 1982 mission, the first expedition to the Salyut 7 space station, lasted a then-record of 211 days. That record was broken 16 months later by Leonid Kizim, Vladimir Soloviev and Oleg Atkov, the third crew aboard the Salyut-7, whose mission lasted 237 days. During much of Berezovoy's time in space — as well as afterwards — he chronicled his observations on paper.

After Berezovoy died last September at age 72, his widow, Lidia Berezovaya, contacted Aerospace America through her husband's longtime interpreter, Olga Tunison. Berezovaya and Tunison wanted to know if we were interested in publishing excerpts of his writings in English. We were very interested, because the writings give a fascinating glimpse of a budding Soviet human space flight program, from the physical travails of learning to live in space to the social breakthroughs required for men and women to work together effectively in space.

As commander, Berezovoy lifted off with flight engineer Valentin Lebedev on May 13, 1982 aboard the Soyuz rocket bound for Salyut 7, the final spacecraft in the Salyut series before the launch of the Mir space station.

The spindle-shaped Salyut spacecraft were the first to have a second docking port, which permitted entry for crew on another Soyuz spacecraft or for delivery of fuel, water, food and other supplies from unmanned Progress cargo ships. The latter innovation enabled virtually unlimited stay in space for humans, leaving only medical issues as a limiting factor for length of spaceflight.

Berezovoy and Lebedev returned to Earth on December 10, 1982.

Six weeks into the mission, Berezovoy began keeping a diary of life in space for his wife and two children. He first started writing on the margins of his flight journal and later wrote several letters to his wife, which he twice was able to send out for delivery with visiting space crews. He eventually published his 92-page diary in Russian.

In the following excerpts, Berezovoy muses on topics ranging from the prosaic to the profound.

— Anatoly Zak
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Tricks to staying warm in the space station

Berezovoy: It was June 1982. It was the 23rd day of flight on the space station Salyut 7. [The nearly 19-ton space laboratory was the ninth space station developed and launched by the Soviets since the introduction of the Salyut series in 1971.]

Valentin Lebedev, my space engineer, and I got accustomed to the space station. We found our favorite spots: by the small round window, on the workout machines and by the equipment. Our station was much bigger compared to the early Salyut stations. It consisted of three cylindrical sections which were connected by short transfer rings.

The length of the station was almost 15 meters (about 50 feet) and the maximum diameter was more than 4 meters (about 13 feet). The amount of space inside our "house" was 82 ½ square meters (about 888 square feet). Our Soyuz T-5 spacecraft stayed docked at the station. Still, there was almost no spare room on the station because most of it was occupied by various equipment.

Roscosmos

Anatoly Berezovoy (left) and Valentin Lebedev were the first residents onboard the Soviet Salyut 7 space station. The pair's 211-day mission in 1982 set a then-record for a space stay.

But the zero gravity gave us some advantages. For example, you could sleep practically by staying near the wall or "lying" on the ceiling or just floating in space by the exercise machine. Very soon each of us picked our favorite places and positions.

A space station is a complex organism and it's not always easy to understand the reason why something was going on. We were the first inhabitants of the new station and were the "test pilots." We had surprises all the time. Most of them were minor problems, but they created a lot of uncomfortable situations and worries. By the third week of our flight, the temperature started to drop to between 18 degrees to 19 degrees Celsius (between 64 degrees to 66 degrees Fahrenheit). We reported this to the flight control center and we let them know that we were very cold. Specialists replied that they hadn't found any problems. They said the space station and the equipment are using more energy so, at this moment, it cannot maintain the higher temperature. Besides, they said, 19 degrees Celsius (66 degrees Fahrenheit) is a quite normal temperature and should allow us to continue the work. We were able to continue to work really because we had to move during our working hours and we would warm up during our mandatory training on workout machines.

But the difficulty remained with our sleep. You cannot cover yourself with a blanket in zero gravity. We had to sleep all dressed up and buckle ourselves to the wall and we were freezing more and more. When a body doesn't move it gets colder faster. So we were waking up very often.

Uncomfortable sleep in turn was wearing us out. We couldn't figure out what to do to warm up. We were trying to eat hot food, wearing extra underwear and socks, but still couldn't warm up. Ground control was continually convincing us that everything was just fine. It is very likely that my crew mate [flight engineer Valentin] Lebedev was suffering much more than me because he liked being warm and was a civilian who grew up in more comfortable conditions.

Once, as usual, I woke up from being very chilly. In order to warm up, I decided to work out on the treadmill. Very soon, I was able to warm up and give a shout to my flight engineer to try it for himself. But I didn't get any answer. He must be asleep, I thought. I looked around the corner by the equipment, a favorite sleeping spot for him. But Lebedev wasn't there.

Slightly worried, I started my "flight"

around the station checking other likely sleeping spots. But my flight engineer was missing. I got really worried and started to examine the whole station. It wasn't too big, but we had a lot of corners because of the amount of equipment. Valentin seemed to have vanished.

I didn't know what to think. Automatically, I looked out the open window thinking he may have gone back to Earth looking for warmth!

My head then filled with all kinds of weird thoughts about "green men," flying saucers and alien invaders. My back started to feel cold from fear. Finally, I had to call mission control and report Lebedev's disappearance. Ground control went totally silent.

Then somebody rhetorically asked liked a child, "Where is Lebedev?"

"I don't know. He disappeared," I answered.

This time, the silence lasted even longer. Then a volley of questions and exclamations began flying: "Maybe he doesn't feel well?" "Did you look for him thoroughly?" "Where could he possibly be?" "What else could you do?" "Look one more time." "It's impossible."

Roscosmos

Based on the sheer number of nervous questions, I realized the people on Earth were panicked. In order not to panic myself, I decided to examine the station one more time, this time especially thoroughly, by opening every single closet and looking behind every panel.

Finally, I found him in the section where we stored spacesuits, sweetly sleeping in his own spacesuit. The fact is spacesuits have an independent heating system, and my enterprising flight engineer figured out that he could sleep with the suit's heat turned on. A spacesuit is airtight and a cosmonaut can use it to live and work outside spacecraft or on the surface of planets. Spacesuits have been compared to a small spacecraft, and this is an apt description. It consists of all the panel blocks and systems which pertain to airtight sections of a spaceship. In a spacesuit the cosmonaut can breathe normally and move, he is neither hot nor cold, no matter how outside temperatures fluctuate. Besides that, the space station Salyut 7 was using a new type of spacesuit called Orlan, which was designed to work up to 6 1/2 hours — just long enough for warm, proper sleep. [*Orlan spacesuits were introduced aboard the Salyut-6 space station in 1977.*]

It turned out flying saucers had nothing to do with Lebedev's disappearance!

Roscosmos

Dining in space with a vacuum cleaner

People on the space station live in the conditions of zero gravity, which changes your perceptions about things. For example, the small packaged foods consumed in zero gravity create a lot of inconvenience. When we sit down at the table to have dinner, we are surrounded with many objects: cups, spoons, forks, bread, napkin, knife and a steak. All these things have the ability to fly around us.

A cosmonaut doesn't have enough hands to hold all the objects down while eating. He has to use two fingers to hold the spoon, two more to hold the juice glass, with perhaps another to hold down the bread. But the most difficult — and unpleasant — was eating something that crumbles.

It is not simply that the crumbs fly around and get in your nose and eyes. The debris can seriously damage the spaceship's equipment, and removing them from the ship is very difficult.

That explains why on the Salyut-7 space station, we started to eat with the vacuum cleaner running. The vacuum cleaner near us would prevent crumbs from floating around the space station.

But that wasn't the only way a vacuum cleaner came in handy.

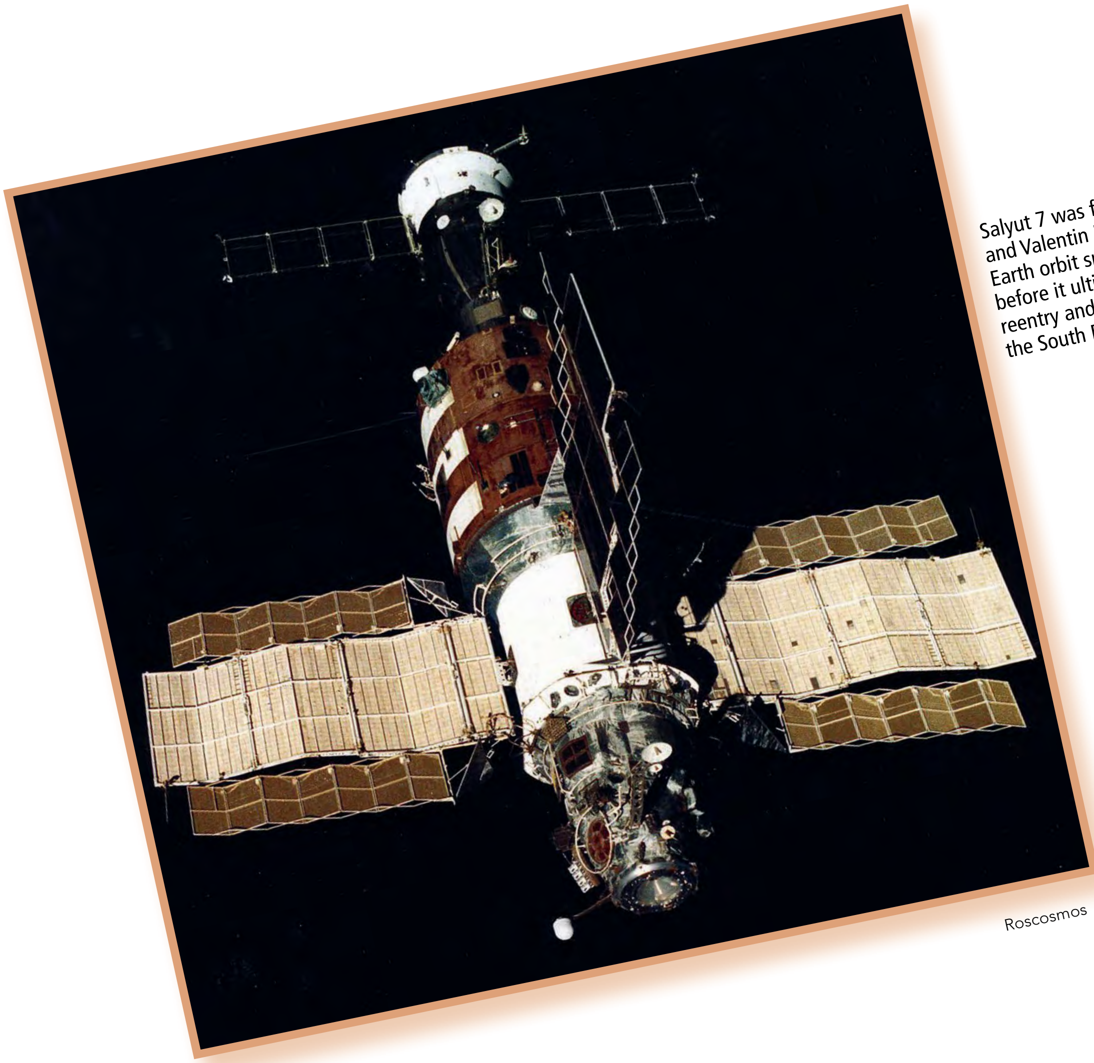
Because my spaceflight with Lebedev was such a long expedition (it lasted 211 days), the flight control center everyday would conduct "psychological" sessions for us. It included meeting virtually with our wives, children, friends and even famous actors and musicians via television conferencing whenever the Salyut was flying over Soviet ground stations. Such connections were meant to strengthen our psychological well-being and help us cope with our isolation from Earth. But in reality, Lebedev and I were too busy with work at the space station to suffer any isolation pangs. Indeed, our families and friends worried and thoughts about us much more than we were thinking about them.

Roscosmos

So we often spent our meeting time demonstrating our psychological health by entertaining our virtual visitors. My children were eight and 12 at that time, too young to understand what space flight was and what their daddy was doing up there.

One of these sessions happened to be my daughter's birthday and she had just started at school. Valentin and I thought a lot about how we could surprise and entertain them in educational ways. Finally we decided to demonstrate rocket propulsion with the aid of a vacuum cleaner.

As you know when a vacuum cleaner is working, one side sucks in the air and the other side expels out the air. In zero gravity, however, the vacuum cleaner will move like a rocket because of the expelled air. The "session" of connection to my family started and we began to explain what happened when working a vacuum cleaner in zero gravity. But the sound transmission was going on and off and my 8-year-old daughter couldn't understand anything we were saying. She was almost crying. Then Valentin suddenly sat on the vacuum cleaner and turned it on. His flight was very short, because the equipment in the space station could be damaged very easily, but we heard a loud laugh from our children on earth! The difficult explanation suddenly became very clear to them and this demonstration produced applause. After that, mission control suggested that we do a whole lesson for school children about how rockets move in space. On the space station, any object can perform many different functions, as well as the Cosmonaut himself.



Salyut 7 was first occupied by Anatoly Berezovoy and Valentin Lebedev in May 1982. The low Earth orbit space station hosted 6 manned crews before it ultimately underwent an uncontrolled reentry and burned up in the atmosphere over the South Pacific Ocean in February 1991.

Roscosmos

Apron for a Cosmonaut

The question regarding whether it is possible for a woman to be a real cosmonaut was first asked at the same time that humans began flying in space. The first answer was given by Valentina Tereshkova in 1963 [*who piloted Vostok-6 alone in 1963*] and it was confirmed many times in the following years.

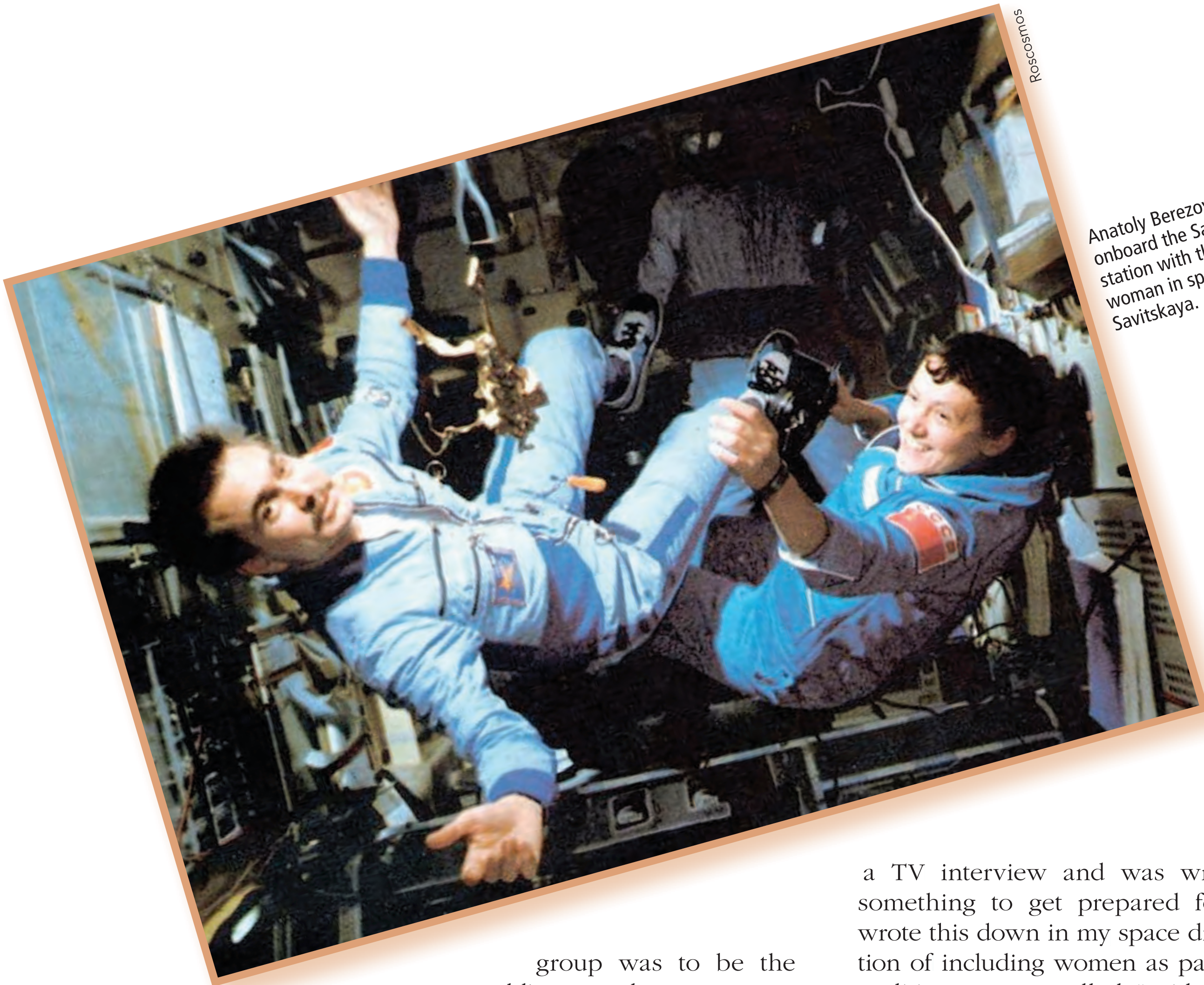
By now [*1980s*], about 50 women have been in space already and they perform all sorts of activities during the space flights. Women such as Kathryn Sullivan and Linda Godwin have taken space walks while Claudie Haigneré and Elena Kondakova took part in long-duration expeditions with international crews. Some, such as Eileen Collins and Pamela Melroy, served as commanders. Still others, including Judith Resnik and Kalpana Chawla, lost their lives during missions.

Now the leaders of the space program would not consider women working in orbit as anything special. In the Soviet Union, after the successful work of Svetlana Savitskaya in 1982 and 1984 and then Kondakova in 1994 and 1997, any special interest in the subject was lost.

[*It would take nearly two more decades, until 2014, for another Russian woman, Elena Serova, to make a space flight.*]

The only inconvenience remaining was linguistic, since the Russian word "kosmonavt" has a masculine gender. [*The Russian language is flexible enough to convert the word into feminine "kosmonavtka," but it is rarely used.*]

But in 1982 when Lebedev and I were working on the Salyut 7 space station, the problem of women in space was serious because at that time only one woman, Valentina Tereshkova, had been in space. Therefore, the participation of women as part of a space crew was an exotic experiment. As a part of our long flight, it was planned that there would be an expedition bringing a group of visitors and part of this



Roscosmos

Anatoly Berezovoy floats onboard the Salyut 7 space station with the second woman in space, Svetlana Savitskaya.

group was to be the world's second woman cosmonaut, Savitskaya.

Her list of accomplishments was something to be envied by any male cosmonaut. She was a pilot trained to fly several types of aircraft. She had won three world records for parachute jumps from the stratosphere and she held 15 world records piloting jet planes. She was also the world champion in aerobatic flying of Porsche planes. And on top of that she was a master of sports in the Soviet Union.

Before she became a cosmonaut, she was an instructor for test pilots. And she was getting ready for her space flight very seriously and she didn't give herself any slack as a "weaker sex." She would reject any sympathy toward her as a woman.

I have to say that in the Russian social tradition, we are convinced that there are "male" and "female" professions. Work on the space station unconsciously was looked upon as "male" profession and presence of women in space was a forced exoticism. I kind of fell into this stereotype too.

In 1982, when the expedition with Svetlana was started, I was getting ready for a TV interview and was writing down something to get prepared for that and wrote this down in my space diary: The action of including women as part of the expedition crew, I called "evidence of high reliability of the space equipment" and psychological effect of a mixed crew I called "a stabilizing factor which increases the work ability of the whole crew." Unconsciously however, I thought of "women's" and "men's" type of work in the space station and I was still giving a priority to the "men's work" on the space station.

Even today in Russian society women appreciate it when somebody reminds them of their beauty or talks of "women's weakness" and even sympathy to women regarding their "women's mind" and "women's logic."

At the time, we were getting ready to meet the expedition of visitors: Leonid Popov, Aleksandr Serebrov and Savitskaya; we were still living up to those stereotypes. And even before our flight started, we prepared special souvenirs for the first expedition of visitors, including the Frenchman Jean-Loup Chrétien.

[*Berezovoy and Lebedev hosted two visiting crews. In June, Soyuz T-6 brought Soviet cosmonauts Vladimir Dzhanibekov and Aleksandr Ivanchenkov, as well as Chrétien, a NASA astronaut who also flew* *on Franco-Soviet missions. All three returned home on July 2, 1982.*]

We were trying to come up with some surprise for our visitor Svetlana and took advice from Alexei Leonov.

Leonov became the first human to walk in space during the mission of the Voskhod-2 spacecraft in March 1965.

We were planning on giving [Savitskaya] a beautiful, ornamented apron which a housewife could wear in the kitchen.

I have to say that by August 1982, when we were preparing to have our visitors (including Svetlana) we had already spent four months on the space station and we were sick and tired of the necessary drudgery of kitchen work. We were hoping very much that Svetlana will be touched by our gift and its implied message and would take charge of the chores in the kitchen, which traditionally was considered "women's work."

August 20, 1982, the visitors' expedition which included Svetlana arrived. Lebedev and I were very well prepared. As a part of our work schedule, before the guests arrived, we had a big cleanup, and installed sleeping bags in the best locations around the spacecraft. Being gentlemen, we prepared for Svetlana the most comfortable sleeping spot, on the right wall of the station. Because our docking with Soyuz T-7 took place very late at night Moscow time, our special dinner was planned for 2:30 a.m. But our present to Savitskaya backfired. She suggested we take turns doing kitchen chores. Our hopes to dump all of this "women's work" on her failed. And our scheduled time for dinners together disappeared from our daily journal completely the next day.

That was the result of our experiment to divide "male" and "female" work in space. And the word "cosmonaut" didn't get a feminine gender form.

The subsequent history of piloting space stations has shown us that our early experiment gave us an exact result; there is no "men's work" and "women's work" in space.

Out of the

25 Years Ago, May 1990

May 24 Boeing announces that sales for its classic 747 have broken the 1,000 mark with the purchase of 20 additional 747-400s for Japan Air Lines. JAL is the world's largest operator of this pioneering wide-bodied airliner. David Brown, Flight and Flying, A Chronology, p. 77.

50 Years Ago, May 1965

May 6 The S-1C first stage of the Saturn 5 Project Apollo launch vehicle is static-fired for the second time at the NASA Marshall Space Flight Center, Huntsville, Alabama, in a 15-second test in which it generates 7.5 million pounds of thrust. The duration is gradually increased until reaching its full time span of 2.5 minutes. MSFC Release 65-117.

March 9 Eight satellites are launched into orbit from Vandenberg Air Force Base, California, by a Thor-Agena D, making it the largest number of payloads the United States has orbited with a single launch vehicle. The satellites are mainly military, including the Surcal (Space Surveillance Calibration) satellite to improve the precision of satellite tracking networks, and an OSCAR (Orbiting Satellite Carrying Amateur Radio) that broadcasts on frequencies tracked by amateur radio operators. New York Times, May 19, 1965.

May 12 The Soviet Union's Luna 5 space probe fails to decelerate and strikes the moon in the area of the Sea of Clouds. The craft, designed to soft-land and send back the first pictures of the moon from the actual surface, was launched on May 9 by a Molniya-M rocket. Despite the crash, some useful data is still gained. New York Times, May 13, 1965, pp. 1, 24.

May 14 China detonates its second test nuclear bomb in the air after being carried up by a missile launched from a military base. Washington Daily News, May 17, 1965, p. 18.

May 16 Explorer 23, the last of three S-55 series satellites, is launched; they are the first spacecraft orbited specifically to measure meteoroid penetrations through spacecraft structures. NASA Release 65-157.

May 17 NASA's Marshall Space Flight Center awards a $1.6 million contract to Aero Spacelines Inc., to transport Saturn rocket upper stages and outsize rocket components in its modified Boeing Stratocruiser aircraft known as the Pregnant Guppy. MSFC release 65-123.

May 18 The General Dynamics F-111B Navy version of the jet fighter aircraft makes its first flight from Grumman's Calverton, New York, facility. During the flight, the low-speed characteristics of the F-111B's swept wings, as well as other aircraft systems, are tested. The Navy's version of the plane are longer than the standard model to improve carrier takeoff capability of the aircraft. Aviation Week, May 24, 1965, p. 19.

May 20 The Nerva NRX-A3 experimental nuclear rocket is restarted and operates at full power (1,100 watts) for about 13 minutes, the longest full power test to date. During an earlier run, the engine ran just 3.5 minutes and a technical problem caused the test to shut down prematurely. Aviation Week, May 31, 1965, p. 66.

May 20 The De Havilland DHC-6 Twin Otter turboprop short-takeoff-and-landing aircraft achieves its first flight from the company's facility at Downsview, Ontario, in Canada. The plane is the first in the initial production batch and is powered by two United Aircraft of Canada Ltd. PT6-A20 engines, each with 570 horsepower. Aviation Week, May 31, 1965, p. 93.

May 21 Sir Geoffrey de Havilland, the founder of de Havilland Aircraft Co., now part of the Hawker Siddeley group, dies at Watford, England. De Havilland flew his first aircraft in 1920 and established his company in 1920. Aviation Week, May 31, 1965, p. 23.

May 24 The Early Bird 1 communication satellite is used to transmit the first trans-Atlantic art auction in which audiences at the Parke-Bernet Galleries in New York City and Sotheby's Galleries in London are linked. New York Times, May 25, 1965, p. 1.

May 25 The ninth Saturn 1 vehicle in the 10-vehicle program is test-launched and orbits a 3,200-pound Pegasus meteoroid detection satellite. It also carries a boilerplate Apollo Command/Service Module unit. The vehicle is also the first in which both stages are built by industry, in this case the Chrysler Corp., since the previous vehicles were built by NASA's Marshall Space Flight Center. Aviation Week, May 31, 1965, p. 21.

Past

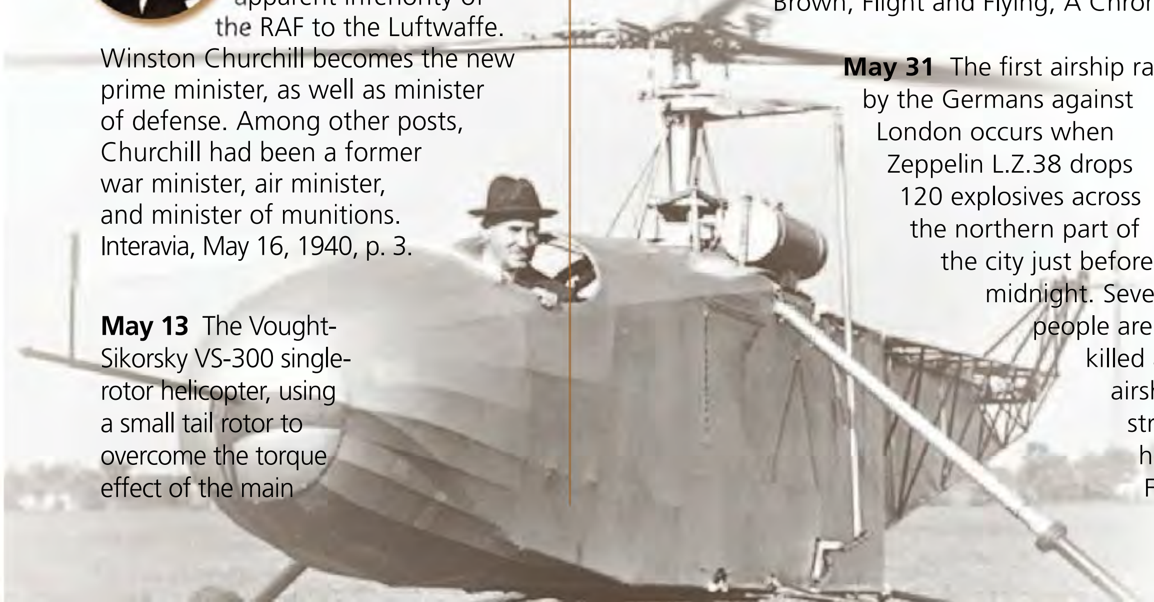
An Aerospace Chronology
by **Frank H. Winter**
and **Robert van der Linden**

May 25 The Bell X-22A, which introduces a radically new V/STOL (vertical/short-takeoff-and-landing) design concept, is rolled out at Bell's facility near Buffalo, New York. Designed and built for the Navy, the X-22A features four shrouded ducted fan propellers, two forward and two on the tips on the wing aft. Aviation Week, May 31, 1965, p. 61.

May 30 Specially modified Boeing C-135A and a NASA General Dynamics/Convair 990 aircraft, fitted with experimental devices including cameras with filters, are used for observations of a total solar eclipse in the South Pacific area, 1,000 miles east of Samoa. The experimental equipment is furnished by the Atomic Energy Commission and the Air Force's Cambridge Research Laboratory in Massachusetts. Aviation Week, June 7, 1965, p. 87.

75 Years Ago, May 1940

May 10 British Prime Minister Neville Chamberlain resigns over the failure of the British campaign in Norway, pointing to the apparent inferiority of the RAF to the Luftwaffe. Winston Churchill becomes the new prime minister, as well as minister of defense. Among other posts, Churchill had been a former war minister, air minister, and minister of munitions. Interavia, May 16, 1940, p. 3.



May 13 The Vought-Sikorsky VS-300 single-rotor helicopter, using a small tail rotor to overcome the torque effect of the main rotor, successfully makes its first free flight. The anti-torque tail rotor is one of the main control improvements made by Igor Sikorsky toward the eventual development of the long-duration practical helicopter. Kenneth Munson, Helicopters and Other Rotorcraft Since 1907, p. 116.

May 28 American rocket pioneer Robert H. Goddard meets Gen. Henry "Hap" Arnold, chief of the Army Air Corps, in Washington, with representatives of the Navy also present. At the suggestion of Harry F. Guggenheim, who has financially supported Goddard's work through the Guggenheim Foundation, Goddard offers his research data and facilities to the government "without cost" for military purposes. However, except for the possible use of rockets for speeding planes in takeoffs and climbs, there appears to be no official interest in rockets or rocket propulsion, and the Army believes that if any development work is to be carried out it should be the improvement of trench mortars. E.C. Goddard and G.E. Pendray, eds., The Papers of Robert H. Goddard, pp. 1310-1311.

May 29 The Chance Vought XF4U-1 Corsair Navy fighter with inverted gull wing makes its first test flight. Subsequently, more than 12,000 of the planes are built in its operational version, the F4U Corsair, and it is regarded as the best carrier-based fighter used during World War II. E.M. Emme, ed., Aeronautics and Astronautics 1915-60, p. 40.

100 Years Ago, May 1915

May 23 Anthony Fokker dramatically demonstrates the performance of his E.I type monoplane before an audience that includes the German crown prince. The airplane is fitted with a new interrupter gear that permits the firing of a machine gun through the propeller arc without striking the propeller blade. Although it is widely claimed that Fokker invented this device after seeing Roland Garros' deflector plate in April 1915, Fokker's engineers had long been working on the device, securing a patent beforehand. This invention greatly improves the accuracy of aerial gunnery and makes aerial combat much more deadly. David Brown, Flight and Flying, A Chronology, p. 77.

May 31 The first airship raid by the Germans against London occurs when Zeppelin L.Z.38 drops 120 explosives across the northern part of the city just before midnight. Seven people are killed and 35 wounded before the airship withdraws. It is the first strategic bombing attack by air in history. David Brown, Flight and Flying, A Chronology, p. 77.

AIAA Bulletin

Senator Jean Fuller provides AIAA with the Senate resolution proclaiming the week of 23–27 March 2015, as California Aerospace Week. Left to right: Assemblyman Richard Bloom, John Rose, Assemblyman Katcho Achadjian, AIAA Executive Director Sandy Magnus, Senator Jean Fuller, Steve Sidorek, Assemblyman Bill Quirk, Senator Patricia Bates.

MAY 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			
5 May	AIAA Fellows Dinner	Crystal City, VA (https://www.aiaa.org/FellowsDinner2015)	
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)	
20–21 Jun	Optimal Design in Multidisciplinary Systems	Dallas, TX	
20–21 Jun	FUN3D Training Workshop	Dallas, TX	
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)	
25–26 Jul	The Application of Green Propulsion for Future Space	Orlando, FL	
25–26 Jul	Advanced High Speed Air Breathing Propulsion	Orlando, FL	
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**
30–31 Jul	Business Management for Engineers	Orlando, FL	
30–31 Jul	Hybrid Rocket Propulsion	Orlando, FL	
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)	
29–30 Aug	Introduction to Space Systems	Pasadena, CA	
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)	**1 Apr 15**
13–17 Sept†	34th Digital Avionics Systems Conference	Prague, Czech Republic (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
22–25 Sept†	3AF/AIAA Aircraft Noise and Emissions Reduction Symposium	La Rochelle, France (www.aners2015.com)	**30 Apr 15**
23–24 Sept†	19th Workshop of the Aeroacoustics Specialists' Committee of CEAS and 5th Scientific Workshop of the European X-Noise EV Network	La Rochelle, France (www.aners2015.com)	
12–16 Oct†	66th International Astronautical Congress	Jerusalem, Israel (Contact: www.iac2015.org)	
27–29 Oct†	Flight Software Workshop	Laurel, MD (Contact: http://www.flightsoftware.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 Information Systems—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 3rd AIAA Spacecraft Structures Conference 34th Wind Energy Symposium	San Diego, CA	**2 Jun 15**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
25-28 Jan†	**Annual Reliability and Maintainability Symposium (RAMS)**	Tucson, AZ (Contact: Sean Carter, seancarter67@gmail.com, www.rams.org)	
14–18†	**26th AAS/AIAA Space Flight Mechanics Meeting**	Napa, CA (Contact: Ryan Russell, 512.471.4190, ryan.russell@utexas.edu, www.space-flight.org/docs/2016_winter/2016_winter.html)	
5–12 Mar†	**2016 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, Erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
16–20 May	**SpaceOps 2016: 14th International Conference on Space Operations**	Daejeon, Korea	**30 Jul 15**
13–17 Jun	**AIAA AVIATION 2016 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **34th AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **8th AIAA Atmospheric and Space Environments Conference** **16th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference** **46th AIAA Fluid Dynamics Conference** **17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **47th AIAA Plasmadynamics and Lasers Conference** **46th AIAA Thermophysics Conference**	Washington, DC	
5–8 Jul†	**ICNPAA 2016 Mathematical Problems in Engineering, Aerospace and Sciences**	University of La Rochelle, France (Contact: Prof. Seenith Sivasundaram, 386.761.9829, seenithi@gmail.com, www.icnpaa.com)	
25–27 Jul	**AIAA Propulsion and Energy 2016 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **52nd AIAA/SAE/ASEE Joint Propulsion Conference** **14th International Energy Conversion Engineering Conference**	Salt Lake City, UT	
12–15 Sep	**AIAA SPACE 2016 (AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA SPACE Conference** **AIAA/AAS Astrodynamics Specialist Conference**	Long Beach, CA	
25–30 Sep†	**30th Congress of the International Council of the Aeronautical Sciences (ICAS 2016)**	Daejeon, South Korea (Contact: www.icas.org)	**15 Jul 15**

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

LOOKING BACK ON A YEAR OF CAREER GROWTH

In the December 2014 AIAA Bulletin*, you were introduced to Samantha Waters and Nathan Wasserman, two seniors at the University of Maryland, College Park (UMD), who have been serving as AIAA's inaugural Norris Space View Interns. With their graduation upon us, I asked them to co-author this month's column to share their experiences and perspectives with you, their fellow members, as they begin their careers as aerospace professionals.*—Sandy

When the school year began, we came to the organization with very different experiences and expectations. Nathan comes from an aeronautics background and spent the previous academic year interning full time at Sikorsky Aircraft before returning for his senior year and accepting the Norris Internship. He admits that initially, he was interested in the job because the salary would help him to pay for his education, but now believes the internship will help shape his career in aerospace. Sam, who has a focus in Space Systems and was previously the president of UMD's student chapter of AIAA, was looking to serve the organization in a broader way. Despite our differences, we have both gained more than we ever could have expected from this experience, and have grown both as engineers and business professionals. Thanks to the networking, public outreach, and countless learning opportunities, we have gained experience and connections that are worth more than any paycheck.

One of our favorite experiences of the internship was attending AIAA SciTech 2015. For both of us, it was our first real conference experience, and it definitely did not disappoint. AIAA SciTech is the premier conference for aerospace technology, and we had an all-access pass. Sam was amazed by the size of the event, which included over 3,000 aerospace professionals and students. Nathan enjoyed just about every aspect, from the impressive speakers to the inspirational student leaders; he relished the opportunity to meet and speak with so many people in the industry attending AIAA SciTech. We both left the conference feeling inspired by the week's events, and even more excited to begin our professional careers.

During the Norris Internship, we both had a chance to learn about the importance of policy and politics in the aerospace industry. Aerospace companies and agencies like the ones we will be joining after graduation rely heavily on funding from Congress, but we had never considered just how important the government is in supporting the aerospace industry. We both had the privilege of meeting freshman Congressman Steve Knight (R-CA), a staunch supporter of aerospace throughout his career. Nathan also had the opportunity to attend AIAA's Congressional Visit Day (CVD).

Once we got to know each other a bit more, we realized that we were both passionate about education and public outreach. We had a chance to put that enthusiasm to work when we were asked to help out with designing, planning, and executing AIAA's programming for National Engineers Week 2015. Our work, along with that of the professional staff and other section participants, generated a twofold increase in traffic to the Engineers Week webpage, and several hundred views and visits to our videos and quiz. Included in this year's programming was a chance to do some outreach of our own. We visited Parkland Magnet Middle School for Aerospace Technology in Rockville, MD, and spoke with 150 eighth-grade students about the engineering profession. Nathan gave a talk on how to become an aerospace engineer, and Sam taught students about the Curiosity rover. On our drive home, we agreed that getting to share our stories with the students and encouraging them to pursue engineering was one of the best parts of our internship so far. Seeing their excited reactions reminded us, in the midst of our midterms, just how cool aerospace engineering really is.

We owe an exceptional amount of gratitude to Laurie Norris for funding our internships. Without her generosity, all of the growth we have achieved and experience we have gained over the year would not have been possible. Ms. Norris reached out to AIAA, saying that she wanted to create the Norris Internship to honor her father, Alexander Norris, an aerospace industry pioneer. His legacy has allowed us, and we hope it will allow future Norris interns, to diversify our experiences in the industry and to grow personally and professionally as aerospace engineers. In addition to the Norris family, we owe thanks to the entire AIAA team for their welcoming attitude, unfaltering patience, and willingness to teach us about what it means to be professionals in the aerospace industry. They have given us a range of exciting jobs to do and have opened doors to many more incredible experiences than we could list in this article.

Over the past few months, we have made incredible personal connections with both AIAA employees and industry engineers. We have learned aspects of our future profession beyond engineering, from networking to politics to public outreach. We have been involved in everything AIAA does and have realized that this organization is much more than what we had experienced at the university level. As we begin our careers, at Boeing for Nathan and JPL for Sam, we know AIAA will be a constant throughout the lifetime of our aerospace careers. It has been an honor to serve as the inaugural Norris Space View Interns.

Networking at AIAA SciTech 2015. From left to right: Al Romig, executive officer, National Academy of Engineering; Sam; Nathan; and John Tracy, chief technology officer, The Boeing Company.

2015 BOARD OF DIRECTORS ELECTION RESULTS

AIAA is pleased to announce the results of its 2015 Board of Directors election. The newly elected board members are:

President-Elect—Jim Maser, Pratt & Whitney

Vice President-Elect, Education—Richard Wlezien, Iowa State University

Vice President-Elect, Public Policy—John Rose, The Boeing Company

Director–At-Large—Ben Marchionna, Lockheed Martin Corporation

Director–At-Large, International—Christian Mari, SAFRAN Group

Director–Technical, Aerospace Design and Structures Group—Achille Messac, Mississippi State University

Director–Technical, Aerospace Sciences Group—James Keenan, U.S. Army, Aviation and Missile Research, Development, and Engineering Center

Director–Region 2—Mark Whorton, Teledyne Brown Engineering

Director–Region 3—Daniel Jensen, Rolls-Royce Corporation

Director–Region 6—L. Jane Hansen, HRP Systems, Inc.

"Congratulations to all of the newly elected Directors," said AIAA President Jim Albaugh. "Your election reflects the confidence that the AIAA membership has in your abilities and also your commitment to the aerospace industry. I look forward to working with all of you."

The newly elected board members will begin their terms of office on **7 May 2015**.

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

AIAA MEMBERS EXPERIENCE CVD

On 4 March 2015, AIAA held its 18th annual Congressional Visits Day (CVD). Nearly 80 AIAA members from 18 different states, including dozens of student members, visited representatives from their state's congressional delegation to help raise awareness of the long-term value that science, engineering, and technology bring to the nation.

Representative Ed Perlmutter (D-CO) with AIAA Fellow Jason Kuchera (right).

Tucson Section members Jeff Jepson, Michelle Rouch, and Matthew Angiulo visited the Tucson office of Representative Martha McSally (second from left).

LSU students prepping for CVD visits.

Representative Mo Brooks (R-AL) with AIAA representatives.

Representative Robert Scott (D-VA; third from right) with AIAA representatives.

JEREMY PINIER WINS LAWRENCE SPERRY AWARD

Duane Hyland

Each year, AIAA presents the Lawrence Sperry Award for a notable contribution made by a young person, age 35 or under, to the advancement of aeronautics or astronautics. This award honors Lawrence B. Sperry, pioneer aviator and inventor, who died in 1923, in a forced landing while attempting a flight across the English Channel. The winner of the 2015 award, **Jeremy Pinier**, Space Launch System Aerodynamics Technical Quality Lead at NASA Langley Research Center, Hampton Roads, VA, is a modern renaissance man. By day he works on NASA's next great exploration system, specifically on its launch vehicle, but in his spare time he is a pianist, short track speed skater, SCUBA diver, and a licensed pilot.

Pinier is a 2007 graduate of Syracuse University, where he earned his doctorate in Mechanical and Aerospace Engineering, writing a dissertation entitled "Low-Dimensional Techniques for Active Control of High-Speed Jet Aeroacoustics." While at Syracuse, he performed research on jet noise using Particle Image Velocimetry, as well as "multiple pressure and sound measurements in conjunction with low-dimensional mathematical models to introduce novel techniques for active jet noise reduction." After graduation, Pinier joined the staff at NASA Langley as a research engineer working on the aerodynamics of the Space Launch System (SLS). In February 2014, he became the SLS Aerodynamics Team Lead at Langley, and in September 2014, he became the program's Technical Quality Lead. In his role as Technical Quality Lead, Pinier is responsible "for the Technical Quality and Certification of all Space Launch System (SLS) Aerosciences products, databases, and documentation, including Aerodynamics, Aeroelasticity, Aeroacoustics and Venting analysis covering all phases of the launch vehicle's flight through the atmosphere (Liftoff, Ascent, Stage Separation) from the low-subsonic to the high-supersonic regimes."

Pinier found some time in his busy schedule to talk to me about the Sperry Award and his life in general. When I asked him what led him to become an engineer, Pinier replied, "I have a rather multicultural background since I was born and raised in France, by an American mother and French father. We traveled a lot as a family to visit my family in the U.S. every year. I was 3 months old when I flew across the Atlantic for the first time to come visit, and even though I can't say I remember that day, I can say that flying has always been with me." His love of flying spilled over into his schooling, "I was very excited about science and physics in school, and did well enough in math that engineering was a natural path for me." Pinier was influenced and encouraged from an early age by his grandfathers, as he explained, "However, the person that inspired me most growing up was my grandfather who was an engineer in telecommunications in France his entire career. He built his own television at a time when very few people had them and that always fascinated me. My other grandfather was also an influential figure in my life since he joined the U.S. Navy during World War II, trained to be a pilot and flew B-24 airplanes, helping to free France from the Nazi regime."

When I asked him what inspired his interest in fluid mechanics and applied aerodynamics, Pinier relayed that his first love was actually particle physics, not aircraft, explaining that "Well before falling for the art and science of airflows and flight, I was drawn in grade school toward particle physics, since I grew up less than an hour away from the CERN particle accelerator and loved everything about smashing atoms together at great speeds to understand where our stars and planets come from. Visiting the place and seeing Nobel Prize laureates in Physics riding their bikes around the lab was also an inspiring moment for a young naïve kid full of energy and ambition." However, it was the discovery of the works of Professor Richard Feynman, an American theoretical physicist, that changed his life: "I read many of his books, borrowed his many recorded Cal Tech lectures from the library, and one day was transformed by his elegant demonstration of "The Motion of Planets Around the Sun." From that day, space travel became a new fascination for me. In addition, when I read that Feynman referred to turbulence as 'the most important unsolved problem of classical physics,' I had to figure out what this business of fluid mechanics was all about. The beauty of flying, fluid flows, airplanes, rockets, and space became my main interest and a serious career goal." This new discovery propelled Pinier toward an aerospace education, and he "attended an aeronautics and space engineering school in Toulouse, France, where I also was fortunate to learn to fly airplanes, receiving my Private Pilot's License at the age of 21 and somehow following in my grandfather's footsteps. I designed and built my first high-power model rocket as a team project there and never left the business of rockets since." And his work paid off with his NASA position, "After some incredibly enriching years of research as a grad student, I was able to land my dream job at NASA, helping with the aerodynamic design of our nation's future crew and heavy lift launch vehicles. Space, astronauts, rockets, and wind tunnels…what more could I want to be involved in at the start of my career?"

When I asked Pinier to describe his ongoing research and work, he became quite animated, explaining, "I am now leading a great team of aerodynamicists at NASA Langley Research Center. We are working closely with our colleagues at NASA Marshall Space Flight Center and are well into the design process of the Space Launch System family of vehicles that will send humans farther than ever before starting in the early 2020s, with a long-term goal for humans to explore Mars in the 2030s. Building such a large and complex rocket is hard, but it's also extremely engaging and exciting. Our team is responsible for predicting all of the vehicle's aerodynamic environments as it flies through the atmosphere: from the low-speed liftoff to the booster separation event, as the rocket is going almost five times the speed of sound. In order to do this we use some unique wind tunnel facilities around the country, we run very large computational fluid dynamics simulations, and develop multi-dimensional, multi-degree-of-freedom databases using advanced data analysis. Every day is a learning experience and I'd like it to stay that way. We are all looking forward to our first uncrewed full-scale flight test of the SLS, Exploration Mission-1 (or EM-1), which will occur in 2018 and take the Orion crew capsule in a trans-lunar injection orbit around the moon and back. This hasn't happened since the Apollo program, and it is time to explore again."

As for the future of heavy lift vehicles and crew capsule design, Pinier first discussed Orion and the SLS system, saying "In terms of payload capabilities combined with a human rating, the SLS along with its Orion crew capsule will be like none other. This vehicle will take humans to extraordinary places, and we will be back into the human exploration of our solar system very soon." In a more general sense, Pinier explained that we are "also at an exciting time where we are seeing all of these private companies developing their own systems for space travel and exploration and I really hope many of them succeed in this endeavor, making it more accessible and affordable." Moving beyond NASA's role in space exploration, Pinier attributed the excitement of these days to private companies like “SpaceX, Boeing, Virgin Galactic, Blue Origin, etc.” As for capsule design, Pinier explained that sometimes an older design is the most reliable, noting “The current crew capsule design that was invented by NASA engineer Max Faget back in the 1950s remains the shape of choice for crewed spacecraft that have to reenter our atmosphere at very high speeds. Reentering with a circular heat shield is a very robust and efficient way to slow down and lose energy quickly (via drag forces and aero-heating). Some of the biggest innovations in the near future might happen more inside the crew capsule rather than outside.”

Because the Lawrence Sperry award recognizes the efforts of young engineers, I asked Pinier if he had any advice for young professionals. He stressed listening and reading as key skills, explaining: “As aerospace engineers in the early part of our careers, I believe it is our responsibility to learn from our more experienced colleagues in order to understand and push the envelope of knowledge as soon as possible. This requires skill at listening, and at asking questions. Unfortunately, even nowadays, a lot of knowledge is not reported in publications, but instead remains in people’s brains. We are lucky to work in a field where people genuinely love what they do, and though I’m sure I’ve asked many stupid questions before, no one has ever refused to answer.”

Pinier added that “this worrisome feeling of losing some of the current knowledge is especially true at a time when the average age in our community is around 50 years old, and so much knowledge will go away soon if we don’t do everything we can to learn it, preserve it, and pass it on again to the next generation. I would recommend that young professionals not only make extra efforts toward this, but also provide mentoring opportunities to students as early as possible to give back to the next generation and openly share the knowledge and experience. We are a relatively small community and we will move a lot faster and innovate more often by not having to reinvent the wheel every step of the way.”

Pinier also stressed the need for professionals to relax, re-energize and get out of the office. When I asked him how he accomplished that goal, he replied, “I play the piano, it’s an amazing way to relax, disconnect for a while, and reenergize. I love flying small single-prop airplanes. I practice many sports on a regular basis, including basketball, running, skiing, biking and golfing. I love the outdoors, camping, fishing, gathering around a fire pit and sharing great moments with friends, and family.”

Pinier also took time to acknowledge the role that AIAA has played in his career: “It has really been a springboard for jump-starting my career. Through grad school, and while working toward my Ph.D., I attended many conferences and presented my own research, which was a tremendous way to network and make contacts in the community long before even graduating. I have been involved in our local section leading the Young Professionals committee for three years and participated and volunteered at many events, which is always an enriching experience, and a great way to help the K–12 students get involved in STEM activities. I have both gained responsibility and increased my awareness about all the good work in our industry and academia by being active on a Technical Committee. I think it is important to be curious about everything that is out there and not stay too isolated in our own projects. The biggest innovations happen at the crossroads of disciplines, and it is up to us to explore those crossroads. Involvement in AIAA is a fantastic way to help enable this.”

Pinier closed our interview with these thoughts: “Receiving the 2015 Lawrence Sperry Award has been the biggest honor. When I see the list of previous recipients and consider the extraordinary things they have accomplished in their careers, it gives me additional motivation to try to live up to those giants in our field, and always strive to accomplish more.”

HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY STUDENT BRANCH JUMPS INTO ACTION

Priding itself on high-class research by faculty, postgraduate students, and undergraduate students in various fields within the bracket of engineering, the Hong Kong University of Science and Technology (HKUST) recently introduced a new engineering discipline into its curriculum—Aeronautical and Aerospace Engineering. To coincide with this new venture, passionate undergraduate students undertook the challenge of broadening the community's understanding of the aviation and aerospace industries, with particular focus on aeronautical engineering. As a result, the AIAA Student Branch was set up at HKUST in 2013.

In a short period of time, the student branch successfully held multiple activities, inviting distinguished guests working in Hong Kong's industry to share their experiences and passion. The AIAA Student Branch also led field trips to both local and international organizations overseas, including firms such as the Hong Kong Aero Engine Services Limited in Hong Kong, and the Boeing Edge Training Facility in Singapore.

On 24 February 2015, the student branch in conjunction with faculty from the Department of Mechanical and Aerospace Engineering successfully held the university's first Aero Day. The aim of this activity was threefold: to introduce the aviation industry and its inner workings to HKUST's year one engineer students and enable them to make an informed choice when choosing their majors; to allow the greater HKUST society to understand the developments within aviation in Hong Kong; and to enable penultimate and final year students to understand the possible career prospects in the industry.

Titled "Aero Day 2015," a total of 11 organizations, as well as AIAA Fellow Dr. Susan X. Ying, participated in this event. The participating parties came from across the entire spectrum within Hong Kong's aviation industry, from government establishments to charitable organizations, from airlines to maintenance and repair organizations.

The participating partners included:

- Aero Institute Hong Kong
- Airport Authority Hong Kong
- Boeing
- Cathay Pacific Airways Limited
- China Aircraft Services Limited
- China Aviation Industry General Aircraft Co., Ltd.

- Hong Kong Aero Engine Services Limited
- Hong Kong Aircraft Engineering Company Limited
- Hong Kong Dragon Airlines Limited
- The Hong Kong Institution of Engineers
- The Hong Kong Youth Aviation Academy

A total of 10 participating organizations took the opportunity to deliver a short, 30-minute presentation to the Aero Day attendees, outlining the basic functions and any career opportunities that may be available for graduates and current students.

As an encore to the day, the student branch was very fortunate to have Dr. Susan X. Ying, AIAA's Vice President, International, deliver a presentation outlining the technological advances that are being made within the aviation industry, as well as the challenges companies may face. Titled "ABC of Commercial Aviation: Technology Insertion Rewards and Challenges," more than 100 students gathered great insights into Dr. Ying's experience, expertise, and her outlook on the industry.

Riding on the success of the university's first Aero Day, the student branch is seeking the opportunity to organize the Aero Day as an annual event. In the months preceding the major event, the branch has plans to invite many more distinguished guests as well as organizing field trips to various aviation related firms and organizations.

Shown with David Riley, Vice President, Technical Activities (left) and Sandra Magnus, AIAA Executive Director (right), **Dr. Satya Atluri** (middle) of the University of California–Irvine is the 2015 recipient of the Walter J. and Angeline H. Crichlow Trust Prize. The Crichlow Trust Prize is presented to a single nominee for a special achievement or body of work that became significant during the immediate past 15 years. The prize is presented every four years.

On 8 January, at an AIAA SciTech 2015 recognition luncheon, Dr. Atluri was honored "For lasting contributions to airframe structural integrity and durability analysis using novel computational methods (MLPG meshless methods) and micromechanics of materials genome."

AIAA LAS VEGAS CHAPTER'S FIRST OFFICIAL EVENT

The first official function of the newly established AIAA Las Vegas Chapter, a "Meet and Greet" dinner social, occurred during National Engineers Week on 25 February, in Las Vegas, NV. The evening consisted of a relaxing dinner atmosphere where people could casually network and socialize with others who share similar interests in aeronautics and astronautics. Attendees included AIAA Professional Members, Student Members, and guests of aerospace companies in the Las Vegas area including, among others, the U.S. Air Force, Bigelow Aerospace, Delta Airlines, and UNLV.

The Las Vegas Chapter was established in the fall of 2014 by the Los Angeles-Las Vegas (LA-LV) AIAA Council with the following council members: Sofia Russi and Marty Waldman as Co-Chairs, Zachary Tolley as Secretary, Bob Morin as Treasurer, and Dr. Darrell Pepper as the University of Nevada in Las Vegas (UNLV) Student Advisor. The Chapter is made up of the LA-LV AIAA members who have a Southern Nevada address registered with AIAA.

For the past several years most of the Section activities occurred in Southern California. The goal of the new Chapter is to make AIAA more active within Southern Nevada. Whether you are living in Las Vegas or are looking for one more reason to visit the Live Entertainment Capital of the World, please periodically check out the LA-LV AIAA SharePoint page to see upcoming events: **https://info.aiaa.org/Regions/Western/LA/default.aspx**.

CALL FOR PAPERS FOR JOURNAL OF GUIDANCE, CONTROL, AND DYNAMICS

Special Issue on "Computational Guidance and Control

The *Journal of Guidance, Control, and Dynamics* (*JGCD*) is devoted to the advancement of the science and technology of guidance, control, and dynamics through the dissemination of original archival papers disclosing significant technical knowledge, exploratory developments, design criteria, and applications in aeronautics, astronautics, celestial mechanics, and related fields. The journal publishes qualified papers on dynamics, stability, guidance, control, navigation, optimization, electronics, avionics, and information processing related to aeronautical, astronautical, and marine systems.

A clear trend in the field of aerospace guidance and control has emerged in recent years in what we call "Computational Guidance and Control" (CG&C). In contrast to traditional guidance and control, CG&C has the following identifying trademarks: 1) Guidance and control laws and controllers of fixed structures are replaced by algorithms. 2) The generation of guidance and control commands relies extensively on onboard computation. The extensive onboard computation requirement is in fact the defining difference between CG&C and other branches of computational engineering and sciences. 3) The process of determining guidance and control commands may be model-based or data-based, and does not require significant pre-mission planning, gain tuning, or extensive offline design of nominal references.

This special issue on CG&C intends to bring recognition to this significant trend in aerospace guidance and control and afford it a proper descriptive term. Even with the great strides made in recent years in CG&C, much remains a work in progress. This special issue of *JGCD* will provide a focused forum to disseminate the latest research work in CG&C, and further stimulate interest in this area of great potential. Original research papers that meet the afore-listed CG&C descriptions (with special consideration given to onboard applications) are sought in, but not exclusive to, the following topics:

- Control (model predictive control, computational optimal control, control allocation, etc.)
- Guidance (all flight phases, powered or unpowered, space or atmospheric flight)
- Autonomous mission and trajectory planning and optimization
- Modeling of system dynamics and problem formulations promoting computational benefits
- Air traffic management applications (with focus on onboard applications)
- Embedded computation implementations for real-time guidance and control
- CG&C verification and validation

More information about this special issue as well as guidelines for preparing your manuscript can be found in the full Call for Papers on the journal website in Aerospace Research Central, **http://arc.aiaa.org/loi/jgcd**.

Deadline: Submissions are due by **31 October 2015**.
Contact Email: Ping Lu, Editor-in-Chief of *JGCD* (plu@iastate.edu)
Guest Editors: Panagiotis Tsiotras (tsiotras@gatech.edu) and Mehran Mesbahi (mesbahi@uw.edu)

LONG ISLAND SECTION'S 8TH ANNUAL FLYING MODEL AIRPLANE COMPETITION

The eighth annual Flying Model Airplane Competition for third through fifth grade students was held on 17 January at the Cradle of Aviation Museum. Once again, this cooperative effort of the Long Island Section and the Cradle was a great success in terms of the good times had by all participants. All student teams successfully built, and then flew their balsa wood models in three competitive events. The students not only learned about aerodynamics and aircraft flight control, but in teams of two or three, they learned about teamwork and following instructions to accomplish a goal. AIAA members helped plan the event, gave a presentation about aerodynamics and airplane control, and led one of two model construction sessions. AIAA members and

Cradle docents also served as mentors during model construction and served as judges during the competition. Cradle of Aviation Museum Education Manager Kerri Mackay organized the event for the Cradle.

The events not only tested the models, but also tested the ability of the students to learn from their flight successes and failures, and to change the trim and balance of the models to improve their performance. AIAA members and Cradle docents assisted the students in deciding what modifications were best. During an awards ceremony, trophies and prizes were awarded to the teams with the best performing models.

Local TV station Fios 1 covered the event. To see the interview with Section Chairman Dave Paris and student Thomas DiZinno, go to **http://www.fios1news.com/longisland/engineers-for-tomorrow#.VPibeJU5Beg**.

OBITUARIES

AIAA Associate Fellow Mayer Died in March

Norman J. Mayer, an aeronautical engineer and NASA program manager from 1961 to 1984, died 3 March. He was 98 years old.

In 1950, Mr. Mayer moved to the Washington, DC, area to work as a program manager with the Bureau of Aeronautics in Washington. A former Navy blimp pilot, he worked in NASA's advanced materials and structures applications division and specialized in airship design and construction. He continued to do aeronautical consulting until 2010.

Besides being an AIAA Associate Fellow, Mr. Mayer was a past president of the Naval Airship Association and a member of the Lighter Than Air Society, a nonprofit group.

AIAA Associate Fellow Greenwood Died in March

William R. Greenwood, 84, died 9 March 2015.

Mr. Greenwood was an engineering graduate of Purdue University. He earned graduate degrees in engineering from MIT and in business from Ohio State University.

Mr. Greenwood served in the U.S. Air Force on active duty, and in the Air Force Reserve, including three years as an engineering officer at Wright-Patterson Air Force Base. He then worked seven years at RCA in Burlington, MA, as a group leader and engineering scientist on military electronics projects. Mr. Greenwood was then employed at Raytheon for 29 years before his retirement in 1993. At Raytheon, he was a Principal Engineer, working on missile systems. He was a Life Senior Member of the Institute of Electrical and Electronics Engineers, and an Associate Fellow of AIAA.

CALL FOR NOMINATIONS

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

Any AIAA member in good standing may serve as a nominator and are highly urged to carefully read award guidelines (https://www.aiaa.org/Secondary.aspx?id=2915) to view nominee eligibility, page limits, letters of endorsement, etc. AIAA members may submit nominations online or download the nomination form after logging into www.aiaa.org with their user name and password.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Upcoming AIAA Continuing Education Courses

Courses at AIAA Aviation and Aeronautics Forum 2015 (AIAA AVIATION 2015)
www.aiaa-aviation.org/ContinuingEd

20–21 June 2015

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

When you are designing or evaluating a complicated engineering system such as an aircraft or a launch vehicle, can you effectively reconcile the multitude of conflicting requirements, interactions, and objectives? This course 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. You will learn how to evaluate sensitivity of the design to variables, initial requirements, and constraints, and how to select the best approach among the many that are currently available.

The last part of the course will take you to system-level applications where the primary problem is in harmonizing the local disciplinary requirements and design goals to attain the objectives required of the entire system, and where performance depends on the interactions and synergy of all its parts. In addition to imparting skills immediately applicable, the course will give you a perspective on emerging methods and development trends.

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

FUN3D Training Workshop

Please note that FUN3D is export-controlled software and may only be provided to U.S. persons.

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.

Courses at AIAA Propulsion and Energy Forum 2015
www.aiaa-propulsionenergy.org/ContinuingEd

25–26 July 2015

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

Liquid propulsion systems are critical to launch vehicle and spacecraft performance and mission success. This two-day course, taught by a team of government, industry, and international experts, will cover propulsion fundamentals and topics of interest in launch vehicle and spacecraft propulsion, non-toxic propulsion drivers, propellants and figures of merit, applications of non-toxic propulsion, flight experience, and advances in smallsat propulsion. Lessons learned from development and flight of components and systems will be discussed.

Key Topics
- Rocket propulsion fundamentals
- Structural considerations in rocket engine design
- Rocket engine testing
- Development and flight experience with green monopropellants
- Microsat, nanosat, and cubesat propulsion
- Dual mode engines and propulsion system trades

Advanced High Speed Air-Breathing Propulsion (Instructors: Dora E. Musielak, Marty Bradley, Stephen Beckel, J. Phil Drummond)

Revolutionary methods of high speed air-breathing propulsion are needed to extend the flight regime of aircraft, missiles, and improve Earth-to-orbit spacecraft. Advanced High Speed Air-Breathing Propulsion will introduce students to the design and development processes of high speed propulsion, including ramjet/scramjets and TBCC concepts. The course will present a comprehensive overview of the state of the art, including highlights of current high speed propulsion programs in the world. An introduction to multidisciplinary design optimization (MDO) will help students appreciate the challenges of developing this breakthrough propulsion technology.

The instructors are actively engaged in high-speed propulsion R&D. They will discuss the challenges, and development trends and future of the propulsion technologies needed to make truly high speed flight a reality. This course is sponsored by the AIAA High Speed Air Breathing Propulsion Technical Committee (HSABP TC).

Key Topics
- Mission requirements
- Combined cycle propulsion concepts
- Ramjet/scramjet inlet design

- Ram/scramjet combustion structural design
- Fuels and thermal management engine/airframe integration, TBCC integration
- Advanced materials
- CFD modeling and simulation of high speed reacting flow
- Propulsion multidisciplinary design optimization (MDO)
- High speed propulsion ground and flight testing

30–31 July 2015

Business Management for Engineers **(Instructors: Alan C. Tribble and Alan Breitbart)**
This course will help individuals with a technical background master the business principles that guide the leadership of an engineering-oriented company. The course will prepare students for the transition from the role of a technical contributor to that of a business leader.

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

Hybrid Rocket Propulsion **(Instructor: Dr. Joe Majdalani)**
This course reviews the fundamentals of hybrid rocket propulsion with special emphasis on application-based design and system integration, propellant selection, flow field and regression rate modeling, solid fuel pyrolysis, scaling effects, transient behavior, and combustion instability. Advantages and disadvantages of both conventional and unconventional vortex hybrid configurations are examined and discussed.

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

Courses at AIAA Space and Astronautics Forum 2015 (AIAA SPACE 2015)
www.aiaa-space.org/ContinuingEd

29–30 August 2015

Introduction to Space Systems **(Instructor: Dr. Mike Gruntman)**
This course provides an introduction to the concepts and technologies of modern space systems. Space systems combine engineering, science, and external phenomena. We concentrate on scientific and engineering foundations of spacecraft systems and interactions among various subsystems. These fundamentals of subsystem technologies provide an indispensable basis for system engineering. The basic nomenclature, vocabulary, and concepts will make it possible to converse with understanding with subsystem specialists.

Key Topics
- Space enterprise
- Solar system
- Coordinate systems
- Space environment and spacecraft interaction
- Basics of orbital mechanics
- Common orbits and space mission geometry
- Mission support systems
- Space mission overview
- Spacecraft propulsion
- Launch systems
- Attitude determination and control
- Space communications
- Spacecraft power systems and thermal control
- Space missions and applications

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Aerospace and defense contractors are under pressure to win new orders and deliver on-time and at-cost. A key to success is proving that they've achieved requirements through successful test definition, planning and execution.

To stand out in this heavily regulated industry, you need to break through. Siemens PLM Software can help. Our "Verification Management" solution provides a single, integrated environment to ensure that all verification events, whether simulation or physical tests, are driven by requirements, executed in proper sequence and fully traceable.

By improving verification processes, clients reduce costs, improve quality and achieve program execution excellence.

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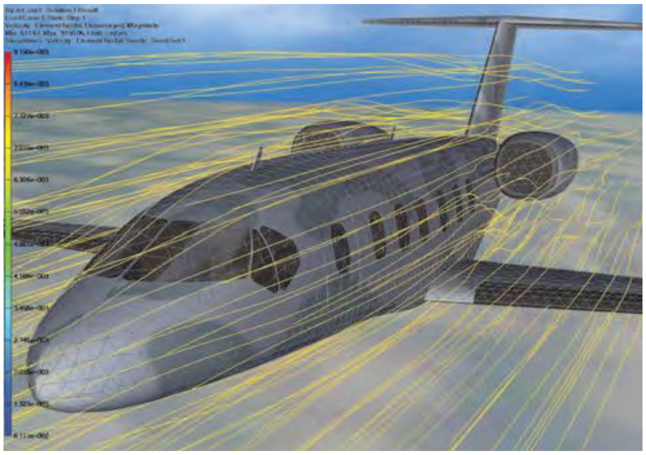

The aerospace Verification Management solution from Siemens PLM Software helps you reduce costs, improve quality and achieve program execution excellence.

Realize innovation.