September 2015

AEROSPACE AMERICA

Two views on Russian space

Bright future or...program in decay?

Page 20

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

AEROSPACE AMERICA

September 2015

DEPARTMENTS

FEATURES

BULLETIN

ON THE COVER
International Launch Services Proton rocket. Photo illustration by Jane Fitzgerald and John Bretschneider

Aerospace America (ISSN 0740-722X) is published monthly by the American Institute of Aeronautics and Astronautics, Inc. at 1801 Alexander Bell Drive, Reston, Va. 20191-4344 [703/264-7500]. Subscription rate is 50% of dues for AIAA members (and is not deductible therefrom). Nonmember subscription price: U.S., $200; foreign, $220. Single copies $20 each. **Postmaster: Send address changes and subscription orders to address above, attention AIAA Customer Service, 703/264-7500.** Periodical postage paid at Reston, Va., and at additional mailing offices. 40,000 copies of this issue printed. This is Volume 53, No. 8

AEROSPACE AMERICA®

is a publication of the American Institute of Aeronautics and Astronautics

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

Contributing Writers
Philip Butterworth-Hayes, Keith Button, Kristin Davis, Jim Hodges, Duane Hyland, Tom Jones, Katie Kriz, James Oberg, Michael Peck, Hannah Thoreson, Robert van der Linden, Debra Werner, Frank H. Winter, Anatoly Zak

Jane Fitzgerald
Art Direction and Design

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

STEERING COMMITTEE
John Evans, *Lockheed Martin;* **Steven E. Gorrell,** *Brigham Young University;* **Frank Lu,** *University of Texas at Arlington;* **David R. Riley,** *Boeing;* **Mary L. Snitch,** *Lockheed Martin;* **Annalisa Weigel,** *Panoptes Systems*

EDITORIAL BOARD
Ned Allen, Jean-Michel Contant, L.S. "Skip" Fletcher, Michael Francis, Cam Martin, Don Richardson, Douglas Yazell

ADVERTISING
Joan Daly, *703-938-5907*
joan@dalyllc.com

Pat Walker, *415-387-7593*
walkercom1@aol.com

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

QUESTIONS AND ADDRESS CHANGES
custserv@aiaa.org

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

September 2015, Vol. 53, No. 8

AIAA
Shaping the Future of Aerospace

Editor's Notebook

Relying on Russia

The biggest value of our cover package about the health of Russia's space program might be that it challenges assumptions on both sides of the debate about the state of Russia's space infrastructure and, by extension, the safety of its Soyuz rockets and crew capsules.

In the U.S., the safety debate about these vehicles has played out too quietly for my tastes, given the human stakes of launching American astronauts in them. The criticism has often boiled down to nationalism, as in the U.S. should be ashamed that it is relying on Russian equipment and expertise to transport its astronauts.

It's time to move the conversation beyond that criticism. The articles by analyst James Oberg and space journalist Anatoly Zak help to do so by offering very divergent perspectives on Russia's space program.

The bigger policy questions for Americans should be: 1) Where does the safety threshold lie beyond which it would be foolhardy to launch American astronauts onboard these Russian vehicles? 2) Has that threshold been reached?

The cover package shows how complicated it must be for NASA and the White House to address those questions amid so much domestic tumult in Russia and political pressure here in the U.S. to get astronauts flying on American-made spacecraft again.

The cover package immediately made me think back to something that Orbital ATK's Antonio Elias said last year in a speech at AIAA's SciTech Forum about space launch: "To a certain degree, reliability depends on your ability to do things the way you did them before."

Many things are different in Russia these days. At the same time, a lot will need to be proven about the reliability of the new Boeing CST-100 capsule and the SpaceX Crew Dragon and the rockets that will boost them.

Too often, the distaste of the U.S. relying on Russia to carry astronauts has been accompanied by two underlying assumptions: One is that American vehicles will automatically be safer than Russian vehicles. The other is that there is simply no choice but to ferry astronauts on Russian vehicles. The reality is that there is an alternative to today's situation, but it's not one that anyone likes: The U.S. could abandon the multibillion-dollar space station and end continuous American presence in space.

Each time an American rides on a Soyuz, the U.S. has, in fact, made a national choice not to abandon the station. That choice can either be a tacit one based on emotion or an explicit one based on evidence, transparency and judgments about acceptable risk. The articles by Oberg and Zak are valuable because they get us thinking in those terms. Safety is the issue members of Congress should be exploring in their oversight roles, more so than trying to untangle the history that brought the U.S. to this point.

Ben Iannotta
Editor-in-Chief

Aerospace outsourcing shows hints of waning

Mexico's aerospace and defense manufacturing industry has been growing at a 20 percent annual rate for the past five years. A similar trend has been seen in China, Brazil, India, and other lower-wage countries.

But there are signs that some Western companies may be rethinking outsourcing. Boeing, for instance, announced in October it will produce parts for the new 777X widebody at its assembly site in St. Louis, Missouri, instead of relying on overseas suppliers that already make similar parts for the current 777 program. That decision, according to aerospace consultants and analysts, is part of a trend by U.S. and European airframe manufacturers and large companies to bring work closer to home amid concerns about quality, turnover among valuable, trained workers and the lengthy wait to recoup investments in overseas operations.

A 2014 study on outsourcing by U.S. aerospace suppliers by the consulting firm ICF International estimated it takes at least five years and typically eight years to earn full payback. Overseas outsourcing, according to the report, "has never been an easy, short-term winning strategy" and the lure of hiring engineers at $20 an hour "was always a heavily qualified principle."

Bombardier

Workers at the Bombardier plant in Querétaro, Mexico, work on a Global Express business jet.

Paul Everitt, chief executive of ADS, the U.K. trade group for aerospace, defense and security industries, agrees.

"Anecdotal evidence is showing that the benefits of outsourcing to low-cost economies are no quite panning out as has been anticipated." The pressure to cut costs and to move work closer to customers on the other side of the world, he tells Aerospace America, meant some outsourcing "decisions were made on the basis not of what's most appropriate to be made there but what's easy to shift there."

Mexico's defense and aerospace industry has been growing at a torrid pace in recent years, thanks to outsourcing by U.S. and European firms. Mexican workers, above, are among 5,000 employed by Safran of France, which is Mexico's largest aerospace employer.

Snecma/Safran

Still, outsourcing remains a powerful economic draw. A majority of the companies surveyed for the ICF report said moving jobs abroad cut their net manufacturing costs by at least 10 percent, One in 10 companies reported that outsourcing led to higher net expenses.

Domestic suppliers in the West have fought back against cheaper competitors by investing in new tools and negotiating more flexible working hours agreements to become leaner and more productive. As a result, per-worker operating profits for U.S.-based aerospace manufacturers have risen by a compounded annual rate of 8.2 percent between 2008 and 2013, according to a 2015 report by Deloitte Touche Tohmatsu.

It's unclear if all those changes will be enough to make a significant dent in the flow of work to suppliers abroad. Most industry experts expect continued consolidation among domestic suppliers will produce more niche players and high-quality suppliers specializing in critical aerospace parts that can't be easily exported.

Philip Butterworth-Hayes
phayes@mistral.co.uk

Russian-Chinese airliner may challenge Boeing-Airbus duopoly

In September, a partnership of Russian and Chinese aircraft companies is expected to formally ask their governments to help fund an audacious venture — building a new passenger plane to challenge Airbus's and Boeing's lock on widebody jets.

If the project gets the greenlight, the world's first competitor to the Boeing 787 and the Airbus A350 could enter service by 2025.

But that's a big if.

The proposed 250- to 280-seat aircraft could take 10 years to develop and cost $13 billion. It's an expensive gambit, experts say, especially given the tough technical and economic hurdles of building a viable third alternative to widebody Airbus and Boeing jets. Nonetheless, many observers believe Russian President Vladimir Putin and Chinese President Xi Jinping, who met in Shanghai in May 2014 to agree to a range of industrial cooperative ventures, will indeed sign off on the new plane.

If they do, Russia's United Aircraft Corp., the Commercial Aircraft Corporation of China and the Aviation Industry of China would begin full-scale work on the jet in 2016. Preliminary design shows a configuration very close to that of the Boeing 787 Dreamliner.

United Aircraft President Yuri Slyusar said in June at the Paris Air Show that the aircraft, as yet unnamed, initially will have either Rolls-Royce or General Electric engines. A new Russian engine, Slyusar said, could power the planes at a later, unspecified time.

To be truly competitive, Russia and China would need to find ways to make their aircraft even more fuel efficient than those built by Airbus and Boeing. But if such technologies exist, they are well-kept secrets.

Glynn Bellamy, head of aerospace and defense at U.K. management consultants KPMG, notes that Chinese companies in particular are keen to work with Western partners as a way to gain access to advanced technologies they lack.

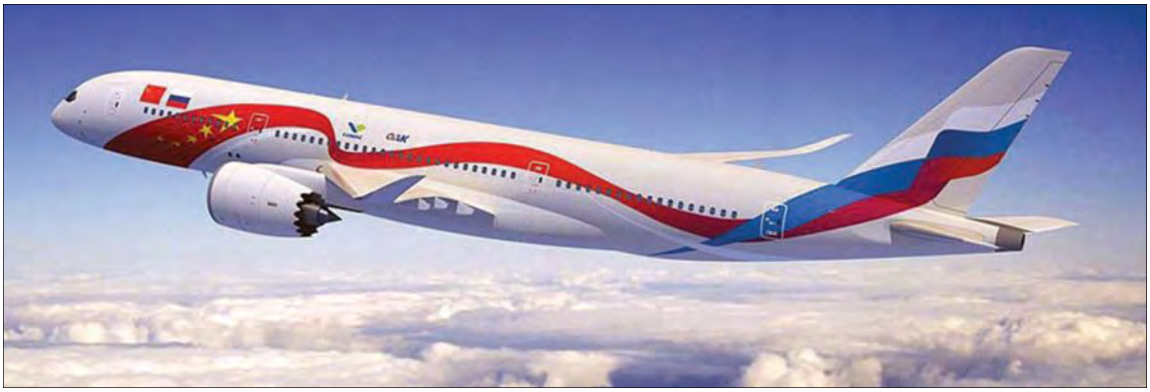
"This doesn't suggest there is some alternative technology which is going to give [the Chinese] a step change," Bellamy says.

What's more, the two countries' track records with their much smaller regional jet programs aren't impressive. Those planes — the Russian Sukhoi SuperJet 100 and the Chinese Comac C919 and the ARJ-21 — are behind schedule and have relatively few orders. The Superjet 100 was delivered three years after the original planned delivery date and has a backlog of just 192 aircraft. The first C919 customer delivery was due in 2016 but now looks more likely to be 2020 but has won orders for more than 500 aircraft. The ARJ-21 was delivered nine years after the original handover date to its first customer and has won orders for 378 aircraft.

Economic sanctions by the United States and the European Union against Russia for its actions in Ukraine also have severely curtailed access to aircraft parts and supplies.

Bellamy says perhaps the biggest obstacles facing the Chinese and the Russians is obtaining U.S. and European certification to fly their aircraft globally — an arduous and expensive process. And if the Russians and the Chinese were to tap state subsidies to make their aircraft cheaper to buy or maintain, Bellamy says, "they would then run into the problem of breaching World Trade Organization agreements."

Still, industry experts don't discount the long-term allure of China and Russia developing their domestic technology in such areas as aircraft engines, avionics and electrical systems to loosen Western monopolies.



United Aircraft Corp.

The governments of Russia and China could decide in September to help fund a new jetliner to compete against Boeing and Airbus widebodies.

Philip Butterworth-Hayes
phayes@mistral.co.uk

Naval interceptor takes on both ballistic and cruise missiles

A problem for the U.S. Navy has been that its Aegis ships must carry some interceptors for targeting ballistic missiles and others for cruise missiles.

A July missile defense test off Hawaii shows that it is now possible to fire one kind of sea-based missile at either low-flying cruise missiles or space-hugging ballistic missiles as they near their terminal points of impact, industry and Navy officials say.

During the test, a Raytheon-built Standard Missile-6 Dual 1 fired from the USS John Paul Jones intercepted a short-range ballistic missile launched from the Pacific Missile Range Facility in Kauai, Hawaii. It was the first live demonstration of the new SM-6 variant's ability to destroy a ballistic in the last moments of flight.

A Raytheon Standard Missile-6 Dual 1 blasts off from the USS John Paul Jones in July. The missile intercepted a short-range test ballistic missile fired from Kauai, Hawaii, adding ballistic-missile defense to the SM-6's cruise-missile capability.

The SM-6 Dual 1 was derived from the existing SM-6s built to target cruise missiles. The Dual 1 joins the U.S. Army's Patriot missiles as the only U.S. interceptors capable of defending against both cruise and ballistic missiles.

When the new missiles are deployed starting in 2016, the Navy could launch one type of interceptor for ballistic missiles as well as air targets including fixed- and rotary-wing aircraft, cruise missiles and unmanned aerial vehicles.

"This gives combatant commanders at sea the flexibility to address a wider range of threats with the missiles they have on board," says Tirso Rosario, Raytheon's sea-based terminal program director.

The new version retains the attributes of the current anti-cruise-missile version carried by Navy ships equipped with the Aegis Weapon System. It has more powerful processors to track and target threats than its predecessor, the SM-2. The SM-6 can switch to fully active seekers to lock on a target independently without sensor data relayed from ships or from other locations.

When the SM-6 is in semi-active mode, the Aegis-equipped ship uses its radio frequency illuminator to lock on the ballistic target. The radio energy bounces off the target and is collected by the missile's on-board receivers, allowing it to pursue the target at long range. In active mode, the SM-6 employs its on-board radars to home in on the target on its own, track it and intercept.

Ian Williams, director of advocacy for the Missile Defense Advocacy Alliance, said the SM-6's unique dual mode combines the advantage of semi-active guidance — a longer range stemming from the reach of the ship's radars — with the greater homing accuracy of on-board sensors in active mode.

That versatility could be especially beneficial for Navy destroyers and cruisers with older Aegis Baseline 5.3 Combat System. Those ships, Williams says, lack adequate computer processing power, which limits the number of missiles they can track simultaneously. The SM-6 gives them the option to "fire and forget."

The Navy is currently modernizing its Aegis fleet. Ships with the Baseline 9 upgrade will be able to track air threats such as aircraft, drones and cruise missiles and to target ballistic missiles, which can fly in an arc above the atmosphere at speeds up to 15,000 miles an hour.

Both versions of the SM-6 are part of a layered missile defense strategy against potential attacks from Iran, North Korea, Russia and China, the last of which is stockpiling an arsenal of anti-ship cruise missiles.

Kyung M. Song
kyungs@aiaa.org

Mapping agency boosts recruitment of aviators, engineers

The U.S. National Geospatial-Intelligence Agency is on a recruitment offensive sparked by pending retirements in its Aeronautical Navigation Office in St. Louis and a desire to expand digital capability there.

About 200 analysts in this office produce and maintain the Digital Aeronautical Flight Information File, a global database of runway maps and navigation information used in flight simulators and by commercial pilots who can now access much of the data in the cockpit via tablet computers.

The analysts compile and publish reports of commercial and military runway data, navigation procedures and airspace characteristics for 191 countries every 28 days. They also make custom products that are part of the foundation for airstrikes and other military missions.

NGA officials say they want to raise the visibility of the analyst positions as a potential career path for aerospace engineers and former pilots.

Even the most veteran pilots don't always realize what goes into producing the data.

"I never knew where [the dataset] came from, never understood what went into them," says the NGA's Rob Goodson, a former Navy and commercial pilot who is now the liaison between NGA's Springfield, Virginia, facility and the St. Louis office.

Getting recruits from colleges and universities has often been a matter of luck. An NGA career "wasn't on my radar," says Tegan Rieser, an NGA analyst in St. Louis. She was studying to be a commercial pilot at St. Louis University's Parks College of Engineering, Aviation and Technology when the airline layoffs prompted her to reassess. She learned about NGA from a classmate.

Many aeronautical analyst jobs continue to be filled through word of mouth, but now the NGA is trying to raise the profession's profile. The NGA says it's interested in engineers fresh from college or with real-world experience, especially to meet the military's demand for more digitally presented information.

"As things are transforming, there's an increasing need for folks who understand more than just the operational end of things," Goodson says. Compiling and delivery of data is "based more and more on applications and Web-based interfaces, so the skills of an aeronautical engineer are easily transferable and are welcome here."

Rieser says the tasks are varied.

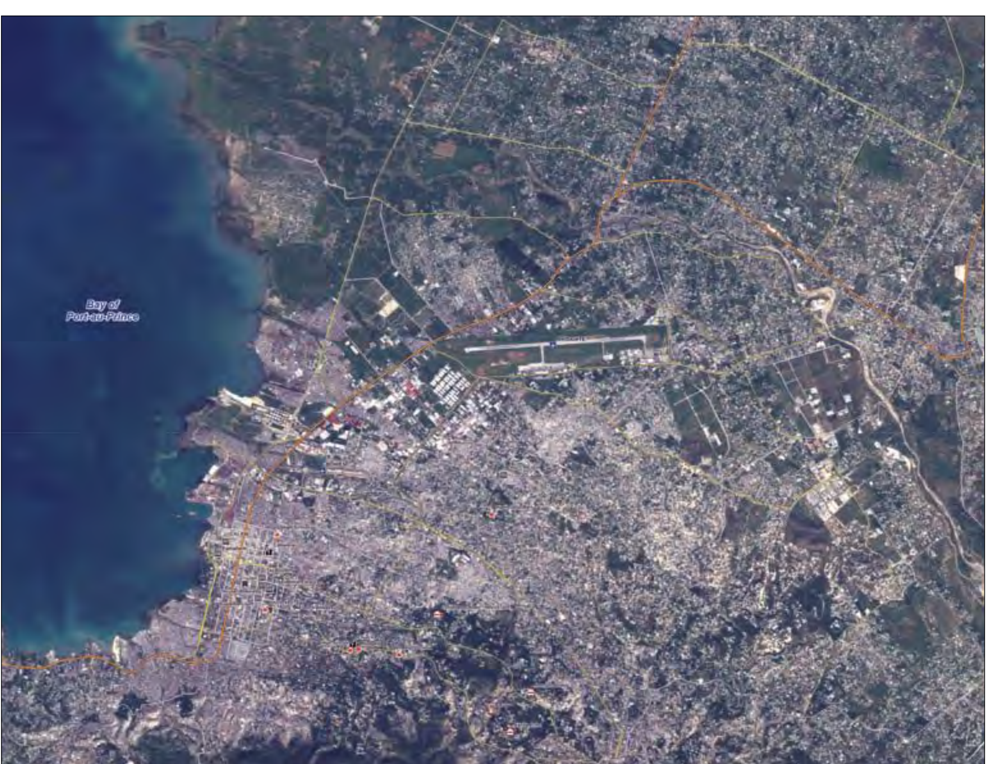
"We have people who do procedure design — instrument approach and arrival and departure procedures that pilots fly," she says. "We have terminal programmers who create the actual charts. We have geospatial analysts who maintain data for different areas around the world."

Custom reports are military or intelligence-community mission centric, designed for planning and operations in a quickly changing environment.

Goodson offered the 2010 Haitian earthquake relief effort as an example. "We learned that the earthquake had disrupted the [Port-au-Prince] runway, so we were asked to evaluate it and produce some products that could allow our aircraft, both commercial and military, to land," he says.

The NGA does not talk about products for military operations. Goodson will say only, "Any time any of our customers are engaged in a mission, we know our products and services have been used as part of its foundation."

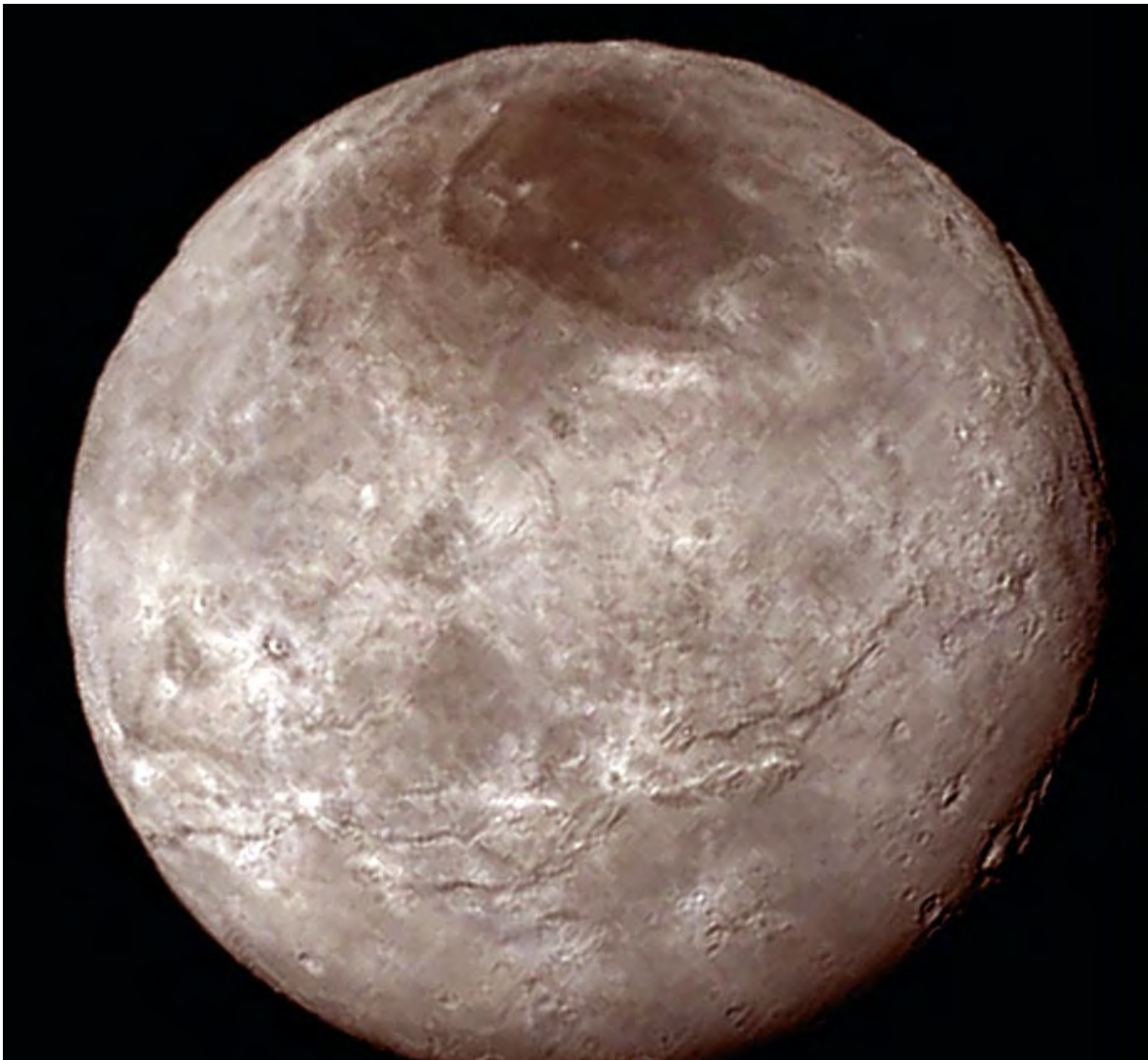
Jim Hodges
jimhodgeswrite@gmail.com



European Space Agency

After the January 2010 earthquake in Haiti, analysts with the U.S. National Geospatial-Intelligence Agency helped commercial and military planes resume service out of the damaged airport at Port-au-Prince.

What if New Horizons had laser communications?


Pluto's largest moon, Charon, was imaged by the New Horizons Long Range Reconnaissance Imager in July from a distance of 289,000 miles.
NASA

As exciting as it was to see the first images of Pluto and its moon Charon arrive from the New Horizons probe, the images were also a good example of a communications limit that NASA technologists are hard at work addressing. The pictures rolled into the Applied Physics Lab in Maryland at an average downlink rate of just 2 kilobits per second, and it will be another 16 months before all the data and images are in hand.

That lag stems from the sheer volume of the data and the spacecraft's reliance on radio frequency signals, which are currently the only means of receiving data from space probes.

That could change in perhaps five years because of experiments NASA has conducted and plans to conduct with optical communications technology. Although radio and optical waves have the same transit time, around 4.5 hours from Pluto to Earth, laser wavelengths are packed more tightly with bits and bytes than radio wavelengths, transmitting more data per second. So lasers would be able to carry about 10 times more data than radio waves. On a future mission to Pluto, the same amount of data could be returned in about 1.3 months.

NASA has not selected an operational mission to use the optical technology and, according to Matthew Abrahamson, mission manager for NASA's Optical Payload for Lasercomm Science (OPALS) experiment, it likely will be at least five more years before it's fully integrated into a spacecraft. But advocates of optical communications, also known as laser communications, expect the technology to fly within the next decade as a part of NASA's Discovery Program, an umbrella initiative for lower cost space probes with a mission cost cap of $425 million. NASA is looking to integrate optical communications into one or more of these missions to build confidence with the technology.

The new technology is needed to keep up with the volume of data that can be fetched from space, Abrahamson says.

"Until a few years ago, it was more convenient to use radio transmitters because the volume of data wasn't large enough to warrant spending a lot of money on new development for those communications," Abrahamson says. "But now that we have all these electronics that are more capable of getting high quantities of data, it's even more important to get it back down to Earth."

Optical communication technology transmits data by focusing a laser beam on a ground station that receives the downlink signal with a 1-meter aperture primary telescope, in the case of OPALS. A photodetector then converts the optical signal to electrical current, which allows the data to be digitized, synchronized, corrected and processed. Three main factors determine the downlink speed: the power behind the laser, the width of the beam and the laser's focus. Narrower and more focused beams channel more energy on the target, and higher laser power allows for faster downlink time.

The challenge is getting all those calibrations just right.

"It's kind of a trade-off because you can make the beam wider, but you're going to lose more energy in the transmission," Abrahamson says. "But if you narrow the beam and make it more focused, it's going to be hard to keep it pointed on the Earth."

So far, NASA has conducted two experiments to demonstrate optical communications: In 2013, an experimental laser transmitter on NASA's Lunar Atmosphere and Dust Environment Explorer passed data from lunar orbit to a receiving terminal at NASA's White Sands Complex in New Mexico. This Lunar Laser Communication Demonstration achieved a download speed of 622,000 kilobits per second, which is more than 300,000 times faster than that of New Horizons. Communications from deep space would not be that much faster, because of weakened signals, but they would still be many times faster than New Horizons. Less than a year after the lunar demonstration, OPALS transmitted data from the International Space Station using a 2.5-Watt 1,550-nanometer laser, at a rate of 400,000 kilobits per second. That video image took 3.5 seconds to arrive, compared to more than 10 minutes for radio downlinks.

NASA plans to conduct its next laser communications demonstration in 2019 aboard a geostationary commercial communications satellite, says Phil Liebrecht, NASA assistant deputy associate administrator for space communications and navigation. The experiment will focus on identifying the specific laser technology that works best for spacecraft close to Earth.

Liebrecht says engineers and technologists are trying to figure out how to narrow the beam and still maintain accuracy.

If a beam is orders of magnitude narrower, "it's orders of magnitude more difficult to point," Liebrecht says.

Optical communications pose other challenges as well. Clouds and dust, for instance, can obstruct signals. For that reason, Liebrecht says the first mission equipped with laser communications will still carry traditional radio communication as a back up.

Katie Kriz
katie.kriz@gmail.com

How to recruit — and keep — aerospace engineers

Carole Hedden, editorial director at Aviation Week & Space Technology

The aerospace industry is having trouble keeping young technical talent, the vast majority of whom are newbies with less than five years in the industry.

According to the latest Aviation Week & Space Technology workforce study, the annual attrition rate among aerospace workers is 5.7 percent, which may be higher than is healthy, said Carole Hedden, the publication's editorial director.

Desire for better balance between work and life and crushing student-loan burdens are two of the drivers behind the departures. Unlike Google, Amazon and Apple, for example, aerospace companies typically do not pay large signing bonuses to ease student debts, Hedden said.

Yvette Weber, developmental system chief for the U.S. Air Force C-5 fleet, said employers need to stop "subliminally" signaling that "time in the office is better and leads to advancement." Weber said the aerospace section needs to "actively work to change that culture to be more results-oriented."

One of aerospace industry's greatest retention tools is fascinating, high-stakes work. Lockheed Martin's Mike Hawes, vice president and Orion program manager with Space Systems, said the company has had no trouble keeping talent to design and build NASA's multibillion-dollar crew capsules.

Hedden said the No. 1 reason given in the survey for joining the aerospace industry was not an aircraft, satellite or rocket project, but Elon Musk's Tesla Motors.

Ben Iannotta
beni@aiaa.org

WIND TUNNELS: diminishing, yet not vanishing, role

Wind tunnels have long been a key part of the testing and validation process in aerospace. But budget cuts and the growth of computational fluid dynamics have made wind tunnel facilities seem increasingly like a luxury.

In times of fiscal austerity, expensive wind tunnel testing sites "naturally become a prime target for mothballing, closure or divestment," said David Schuster, a NASA technical fellow with the NASA Engineering and Safety Center at NASA's Langley Research Center in Virginia. Many aging U.S. wind tunnel facilities were built after World War II or during the Cold War to compete with Germany and Russia. The absence of similar threats today has prompted many wind tunnels to close or relocate overseas, said Michael McWithey, manager of Wind Tunnel Testing Labs with Lockheed Martin Corp.

NASA Ames Research Center

The Transonic Wind Tunnel, part of the complex at NASA Ames Research Center where the space shuttle was designed and tested.

The rise of Computational fluid dynamics simulate air flows with software also has diminished the need for live tests. Nonetheless, according to Michael Mastaler, associate director of the Advanced Air Vehicle Program with NASA's Aeronautics Research Mission Directorate, wind tunnels have unique capabilities that software programs lack, and therefore the two methods should have complementary roles.

Panelists agreed wind tunnel testing may continue to become rarer, but it will never go away entirely. No software program can fully eliminate the need for lab experiments, they said, and wind tunnels will remain essential to develop new aerospace vehicles.

Hannah Thoreson
hannaht@aiaa.org

Kennedy Space Center's post-shuttle revival

When the space-shuttle era ended in 2011, many people worried that NASA's John F. Kennedy Space Center in Cape Canaveral, Florida — the nerve center of the U.S. space program — had passed its best days.

Not so, said Robert Cabana, the Kennedy Center's director. Despite the loss of the iconic Space Shuttle program and the subsequent 43 percent reduction in workers, Cabana said Kennedy is set to become a thriving hub for space programs, both public and private.

Cabana said Kennedy is preparing to host the next generation of launchers and vehicles, chief among them the Space Launch System and the Orion spacecraft. The center also is expanding to meet the needs of commercial space customers. In order to host these new generations of rockets, NASA and its private space company partners are erecting new buildings, constructing new launch pad complexes and modifying older complexes.

Cabana said the projects include a revamp of the Vehicle Assembly Building; transformation of the Orbiter Processing Facility into a Commercial Crew and Cargo Processing Facility; a rebuild of Firing Room 17, the room that launched the Apollo missions; and several other changes.

In addition, Elon Musk's SpaceX is redeveloping the launch pad 39A — which launched nearly every Apollo mission — into a facility to launch its Falcon 9 and Falcon Heavy rockets. Boeing has taken over part of the Orbiter Processing Facility for its X-37B unmanned spacecraft project. Kennedy also has teamed with the state of Florida and NASA's Space Life Sciences Laboratory to create Exploration Park, a research and development facility on the center's property that will serve as a hub for private enterprise and private-public partnerships.

Robert Cabana, director of NASA's Kennedy Space Center AIAA

Duane Hyland
duaneh@aiaa.org

Explaining the high cost of satellites and rockets

Why are government satellites, rockets and aircraft so darn expensive? The answer: Fear. Fear of test failures. Fear of bid protests. Fear of losing political support.

"The paranoia of making a mistake and losing your job drives people to overdo things," said former space station astronaut Frank Culbertson, now president of Orbital ATK's Space Systems Group.

Culbertson said rocket failures, though painful, could be a good thing in one respect. Even if lives are lost and cargo destroyed, "you're going to be stronger the next time around, just as we were in the shuttle program," he said.

Fear also affects costs in subtler ways. Government contracting officers live in fear of successful bid protests, so they "lay out a paper trail of fairness and transparency," said former NASA Administrator Michael D. Griffin, now chairman and CEO of Schafer Corp. "It's nice that America chooses to be fair, but it's extremely expensive to do so."

Fear of losing political support for large projects has historically led government managers to distribute work across as many U.S. states as possible. Mike Hawes, vice president and Orion program manager at Lockheed Martin Corp., said the political motivation can be overblown.

"There are a lot of states that I buy stuff from that I don't have a political reason to go buy from that state. So, I rankle at that a little bit," he said.

Fear isn't necessarily all bad. In the commercial world, Griffin said, market forces are intense.

"Almost everyone in the company is co-aligned in their motivations. Executive bonuses, executive salaries, even continued employment is contingent on doing things in a very balanced way," he said.

In government procurement, "we need something to substitute for market forces," Griffin said.

Ben Iannotta
beni@aiaa.org

Don't worry too much about giant asteroids menacing Earth. Astronomers have their eyes on most of those. It's the smaller objects that pose the greatest risk. Tom Jones explains the race to detect these asteroids, so the dangerous ones can be deflected.

The flash above Chelyabinsk, Russia, from a 20-meter asteroid streaking through the sky on Feb. 15, 2013.

In Hollywood's depictions of asteroid disasters, Earth is invariably menaced by a chunk of cosmic debris the size of Texas. In reality, asteroids smaller than 100 meters in diameter represent a newly realized and significant threat.

Earthlings received a reminder of this hazard on July 7, when an asteroid named 2015 HM10 approached within 440,000 kilometers, little more than the distance between our planet and the moon. HM10, which measured 40 meters by 80 meters, posed no danger of a collision on this pass. But Earth's orbit takes it continually through a swarm of millions of other inner solar system asteroids, some of which could annihilate a city. Today, astronomers estimate they know the whereabouts of less than one percent of near-Earth asteroids, or NEAs, with diameters from 40 meters to about a kilometer.

The HM10 incursion came a week after the June 30 commemoration of Asteroid Day, which coincides with the anniversary of the 1908 Tunguska explosion over Siberia, thought to have been caused by 40-meter-diameter NEA. That blast — estimated at between three and five megatons, the biggest documented asteroid impact of the last century — stands as a fearful example of the power of even a relatively small object moving at cosmic velocity.

Detecting asteroids capable of causing global harm (those 1 kilometer in diameter and larger) has been the focus of NASA's Near-Earth Object Program since 1998, and scientists estimate that more than 95 percent of those large NEAs have been found. None are on a near-term course to strike Earth. But research presented at April's Planetary Defense Conference in Frascati, Italy, showed that the much more numerous asteroids smaller than 140 meters are a worrisome lot. They strike very frequently and can cause greater damage than previously thought. I attended the conference, representing the Association of Space Explorers.

The heightened concern over smaller NEAs is based on new near-Earth-asteroid population estimates and a better understanding of the physics of the 2013 asteroid airburst over Chelyabinsk, Russia. Finding and cataloging the millions of small NEAs, however, will take a significant step up in technology and funding.

I believe NASA now has the technology in hand that could detect a large fraction of these smaller NEAs. A small-asteroid survey would be affordable — just a fraction of one percent of NASA's budget — and would give us the warning time we need to mount an effective response to a predicted impact.

Small, but still dangerous

Geologists realized that asteroids and comets posed a real threat to Earth only 55 years ago. And it wasn't until about 15 years ago that NASA began a focused search for NEAs larger than 1 kilometer. The agency spends $40 million annually on NEA detection and research programs, more than any other space agency. But the dramatic explosion of a small, 20-meter asteroid over the Urals in February 2013 has prompted other nations to increase their search and technology contributions.

The Chelyabinsk airburst came from an asteroid that no one saw coming. It released 450 kilotons of TNT-equivalent energy, and produced a shock wave that sent more

NASA

than a thousand to the hospital with injuries from flying glass and collapsed structures. The event spurred better modeling of the physical effects of small asteroid impacts. Objects smaller than about 40 meters usually break up under entry forces and explode. An asteroid's downward momentum, however, can carry the resulting blast wave to the ground, with increased damage potential relative to a nuclear airburst of the same size. Chelyabinsk taught us that smaller objects, while broken up by the atmosphere, can still inflict significant damage to an urban area.

Astronomers now estimate that there are about 20 million 10- to 40-meter NEAs, twice the previous estimates. That means an object at least as large as Chelyabinsk will strike Earth every 30 years to 50 years, and a 40-meter, Tunguska-sized impactor will pass inside the moon's orbit several times a year. A collision with a small asteroid, striking without warning, is the likeliest impact scenario we face today.

NASA's Near-Earth Object Program discovered 1,477 NEAs in 2014, but the agency lacks adequate tools to go after the smaller NEAs, which are usually distant, dim and hard to spot. NASA-funded ground-based telescopes like the University of Hawaii's Panoramic Survey Telescope and Rapid Response System and the University of Arizona's Catalina Sky Survey can only observe on clear, dark nights, missing asteroids in the daytime sky. NASA's Wide-field Infrared Survey Explorer satellite is not optimized for NEA searches. Even when a second Pan-STARRS telescope is erected in the Hawaiian islands and observations begin with the Large Synoptic Survey Telescope in Chile in 2021, NASA will find it impossible to meet the congressionally directed goal of finding 90 percent of all NEAs bigger than 140 meters by 2020.

Planetary Defense Conference organizers issued a strong recommendation that given the new awareness of the damage potential, NEA search efforts should aim at increasing the discovery rate for these smaller bodies. Raising the discovery rate will require a dedicated, space-based infrared telescope with an aperture about 50 centimeters in diameter. The instrument would fly in an orbit like that of Venus, from where it could look outward and scan all the NEAs in a swath centered on Earth's path around the Sun. A private group called the B612 Foundation is trying to raise funds to build and launch a telescope called Sentinel into this orbit. A second option is to have NASA's proposed Near Earth Object Camera spacecraft station-keep a million miles sunward from Earth at the L1 Lagrange point, one of the locations where competing gravitational forces make it relatively easy to orbit. That would ease the telescope's data communications challenges. Such a telescope should cost half a billion dollars over 10 years, including hardware and operations, just a third of one percent of NASA's budget over that span. Ideally, the cost could be shared among other space agencies interested in addressing the global NEA hazard.

Once discovered, these small NEAs are then prime targets for follow-up observations by ground-based instruments, which can further refine their orbits and characterize their surface composition via spectroscopy. For close approachers, ground-based radar can obtain precise orbital elements and deduce asteroid shapes. For example, NASA's radar telescope in Arecibo, Puerto Rico, observes about 70 NEAs annually, some at 7.5-meter spatial resolution. Depending on distance, NASA's Goldstone radar can image such NEAs at a resolution of 3.5 meters per pixel, even revealing boulders on their surfaces.

Deflecting the threat

The technical options for diverting an NEA are expanding. One is kinetic impact — slamming an asteroid with a hypervelocity spacecraft — that works by transferring momentum to the target NEA, changing its orbit. Momentum transfer comes not only from the spacecraft colliding with the NEA, but also from the resulting debris plume, which adds an additional shove. The European Space Agency, the German Aerospace Center, NASA and the Applied Physics Lab hope to demonstrate ki-

Continued on page 17

Conversation

Charles Elachi in front of a model of the Curiosity rover.

NASA Jet Propulsion Lab/Caltech

When Charles Elachi was a boy in Lebanon in the 1950s, the U.S. Embassy distributed a gift: Copies of a magazine that referenced a far-off place called the Jet Propulsion Laboratory in California, which had built the first American satellite, Explorer 1. Elachi likes to tell this story, because he did not set out to someday run this lab, which is now a NASA-funded research institute and part of the California Institute of Technology. In fact, what brought him to California in the 1960s as a Caltech graduate student was something surprising: The school's proximity to Hollywood. "I was very much into the movies in those days," he says.

Regardless, Elachi had found his professional home. While working toward a Ph.D. at Caltech, he began working at the nearby JPL in 1979. He has been there ever since. Elachi spoke to ***Ben Iannotta*** *by phone about JPL's hopes of unlocking the mystery of how life arose in the solar system and about its efforts to target more immediate problems, such as California's drought.*

Interview by Ben Iannotta

Space explorer

Charles Elachi
Director, the Jet Propulson Laboratory

It's been exciting times with the Applied Physics Lab's New Horizons mission. Would there be value in landing on Pluto?

People have been thinking about that for many years. One idea which is more in the nearer term or more feasible will be to study places like [Jupiter's moon] Europa, [and Saturn's moons] Enceladus and Titan. These are very exciting objects where we actually have orbiters. We have studied them in detail and the next leap is in putting landers or balloons in their atmospheres. Ultimately, I'm sure Pluto will be on the list, but Europa, Enceladus and Titan have a lot of excitement because people believe that they have liquid water, oceans, below the surface, which immediately makes you think: Is there life on them?

Those moons are more exciting targets than Pluto?

As of now, I think they are more exciting but we know very little about Pluto yet. The science community will have to weigh in.

What's the status of the Webb telescope's Mid-Infrared Instrument and cryocooler?

MIRI is a very challenging technology development. It's all going on track now, all the technical challenges have been worked out. We will be putting it in an environmental chamber and actually testing it in the vibration, thermal environment. The normal environmental testing you do with instruments before you deliver them for integration.

I'm going to make a confession. The Mars science is starting to bore me. Tell me why I'm crazy to be bored.

Mars in the early days was very similar to our planet and then the question is: Why did our planet evolve to have humans like you and I and all the beautiful environment that we have, while on Mars, it led to a very dried planet that we see today? The questions that we're exploring on Mars are really fundamental on really understanding how life evolved in our solar system. The rovers are the first step in our exploration of Mars.

So it's not boring?

Lewis and Clark, once they started, I'm sure for the first few days, they said, "Gee, the river looks the same." But then as they proceeded, they started exploring and finding new things. I look at the rovers that we have on Mars as like Lewis and Clark in the first few days of their expedition.

Why are there so many different techniques for landing on Mars?

It's basically driven by the mass of what you are landing. When we did the airbags on Spirit and Opportunity, the total mass of the rover was about 260 kilograms. Curiosity was almost 1,000 kilograms. Building airbags to cushion Curiosity would have been extremely hard. We had to use a combination [of technologies.] After we used the heat shield and the parachute, we used retrorockets and then the Skycrane. We would also use that technique on the Mars 2020 [rover mission]. When you go beyond 2020, for a sample return, now, you'll be talking about three to five tons because you have to land a rocket to bring the sample back to Earth. That's where we are developing a larger parachute to slow us down, building inflatable kind of shields to slow us down in the atmosphere and then, most likely, we'll still use a combination of parachute and propulsion and Skycrane.

Do we know yet what the big lesson is from the June descent test when the parachute tore?

People are working on it. We don't have the final results but the fortunate thing is that we have cameras and sensors, which gave us very detailed measurements and observations about how the parachute inflated, which inflated pretty well and then shortly after that, the parachute sort of broke down. In addition to our team at JPL, we're bringing an independent team of experts to look at it. I'm sure we'll learn from it and we will come up with a solution and we'll move on.

Turning to Earth, how does the Gravity Recovery and Climate Experiment techology figure into climate change science?

One of the key challenges we are all facing, particularly in California but also across many regions around the world is: What's happening to the water? How much water is in the atmosphere? How much does it rain and snow in the Sierras? How does it fill the water table? How much water is being pumped out? Being able to manage and understand that water cycle is very critical for human benefits. GRACE allows us to measure very, very accurately changes in the gravity field. If you have a water table and you observe it over a period of months and years, and the water table is being depleted, then you have less water and you have less gravity.

How would testing lasers on the next GRACE satellites change things?

You fly the two satellites in front of each other and as the first satellite

Charles Elachi

Titles: *Director of NASA's Jet Propulsion Laboratory; science team lead for Cassini Titan Radar*

Age: *68*

Birthplace: *Rayak, Lebanon*

Education: *Bachelor's in physics, University of Grenoble and the Diplom-Ingenieur, the Polytechnic Institute of Grenoble, 1968; Ph.D. in electrical sciences, 1971, Caltech; master of business administration, 1979, University of Southern California; master's in geology, 1983, the University of California, Los Angeles*

Previous positions: *Director for JPL space and Earth science programs, 1982 to 2000; principal investigator, Shuttle imaging Radar.*

Residence: *Altadena, California*

Favorite quote: *"Far better it is to dare mighty things... than to take rank with those poor spirits who neither enjoy much nor suffer much, because they live in the gray twilight that knows not victory nor defeat."* — Theodore Roosevelt

comes in over an area, which has a slightly different gravity, it speeds up a little bit if it's a little higher gravity and then the second one catches up to it. By measuring the distance, that's how you determine the gravity. The more accurate you measure the distance, the more accurate you measure the change of the gravity. Imagine radio signals to be a certain accuracy of measurement. As you go to shorter and shorter [optical] wavelengths, you get even more accurate. On the next GRACE mission, we will still have the radio and then we would be adding to it a laser that we will demonstrate.

Could the laser on the GRACE Follow-on mission be used for science?

Absolutely, yes. Hopefully, it will work well. It would allow us to see how much improvement we are doing between the radio and the optical.

Why do people want improvement? It looks like the radio waves are doing a pretty good job.

As you get more and more accurate, you will get more and more phenomena that you'll see. I could envision more accurately measuring how much snow is coming from the Sierras. That will have dramatic impact on water management. You might be able to measure changes in the gravity related to sub-surface motion of lava, which could have implication to volcanic eruption.

Do you think the California drought is related to climate change?

I really don't know. That's not my field of expertise but clearly, things are changing. We're seeing that the ocean is rising. We have been measuring that now for the last 30 years. There is a change in the ocean height, which is resulting from what we believe is a combination of melting of the land ice in the polar region and change in the temperature of the ocean. The question is: What is driving that change? Is it natural, human or a combination of the two? By having all these facts, that's how policy makers make intelligent decisions.

Is it a mistake for scientists to become activists on climate change?

I separate the two. Conducting the science and really understanding the facts, I think, that's what a scientist should focus on. But then you have scientists as individuals, as humans. They can be whatever they want. They can get involved in policy or articulate science. But when I look at my institution, JPL, our focus is really making sure we get the correct information and scientific data and provide it to the people who are policy makers. Having said that, I wish there are more scientists in Congress.

On the topic of exoplanets, where do you come down on star shades or coronagraphs as the best technique to block the light from a host star, so you can see its planets?

These techniques complement each other. One of them is somewhat simpler because you need only one telescope and a coronagraph inside. With the star shade, you need now a telescope and another spacecraft to be many thousands of miles in front of it but [it would] allow you to get planets much closer to the star. I think, as we evolve our technology, probably, the coronagraph will be done first because that's something we understand how to do. Then the next step will be a star shade mission.

Do you think humans will ever be able to get a recognizable photograph of an Earth-like planet?

I'm going to stick my neck out here. I have no doubt that in the next 20 years, we'll have the family portrait of [a] neighboring planetary system. It might be a dot but once that dot is separated from the star, you can [gather] a lot of information about it. You can do spectroscopy to tell the temperature. Does the atmosphere have oxygen? Carbon dioxide? Methane? Is this an Earth-like planet or is it different? Maybe 30 years from now, we can start getting maybe some multiple pixels on that planet and be able to see changes. If it has clouds, which are moving then you can see some of those changes. We used to be lucky to fly a 50-centimeter telescope. Now, the [Webb telescope] team will be flying a six-meter telescope. I have no doubt 15 years from now, we'll figure out how to fly a 20-meter telescope and maybe my two daughters or grandkids will be seeing a hundreds-of-meter telescope fly.

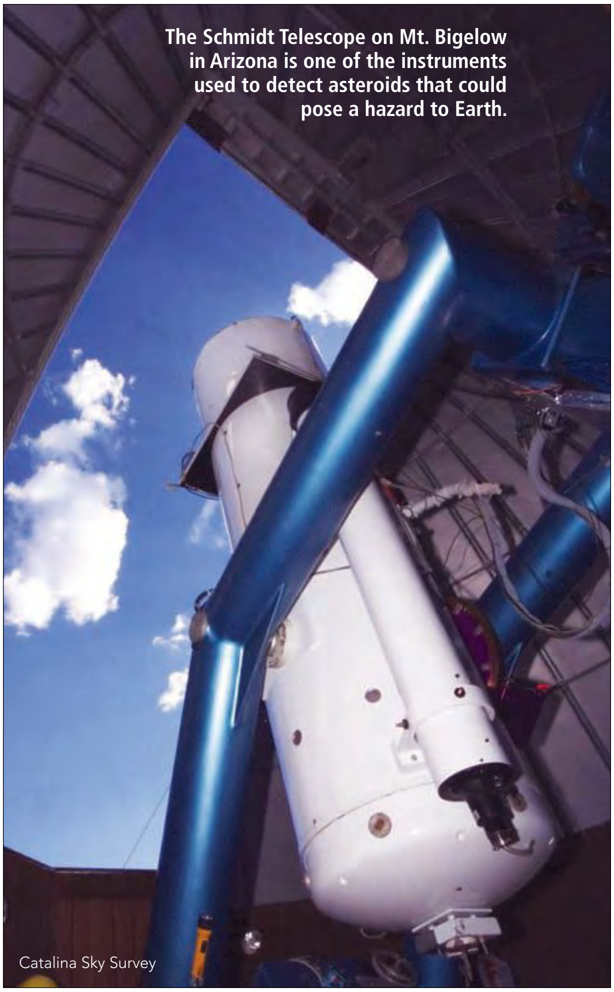
How do you feel about the funding situation at NASA and JPL in particular in the coming years?

Everybody knows budgets are tight across the government. When I interact with some of our representatives in Congress, many of them really believe NASA is the kind of agency that the government should invest in. When I talk with many people in the public who are not involved in space, I present to them what I just told you and show them data from it. Almost every time I get people [who] come and tell me, "That's what our government should spend money on."

Continued from page 13

netic impact in 2022 in a two-pronged mission called AIDA, for Asteroid Impact and Deflection Assessment. ESA would launch a spacecraft called AIM, for Asteroid Impact Mission, toward a binary asteroid system called 65803 Didymos, which consists of an 800-meter-diameter object orbited by a 150-meter object nicknamed Didymoon, which is thought to be a collisional fragment of the larger object. AIM would monitor the binary system while NASA's Double Asteroid Redirection Test (DART) spacecraft slams into Didymoon at 6.25 kilometers per second, blasting out a crater and jetting a high-speed debris plume into space. By detecting the change in Didymoon's orbital period, AIM will measure the impact-driven velocity change, and help refine models of how asteroid materials react to hypervelocity impacts. If the joint mission is funded, AIM would be launched in 2020, and DART would follow a year later toward its Didymos intercept.

Another option could be directed energy deflection in which an ion beam or a laser would precisely target the asteroid. With the ion beam method, a solar-powered spacecraft would aim charged ions toward the surface, striking the asteroid with these very tiny kinetic impactors to impart a velocity change. If a laser were used, it would be pulsed rapidly to vaporize or ablate a small spot on the surface, creating a near-continuous jet of rock vapor that would slowly alter the object's velocity. The time and distance required to guarantee that the object would miss Earth would depend on the target size, delivered power and the beam's accuracy.



The Schmidt Telescope on Mt. Bigelow in Arizona is one of the instruments used to detect asteroids that could pose a hazard to Earth.

Catalina Sky Survey

The Big Bang

Then there is the big-screen favorite: obliterating asteroids with nuclear explosives. Scientists would deploy a nuclear explosion differently than this Hollywood vision. A nuclear device would be detonated near the target to emit x-rays and neutrons that would vaporize a thin layer of dust and rock across a wide swath of the asteroid's surface. The resulting gas jet would propel the asteroid away from the explosion. Because nuclear explosives pack a more energetic punch than kinetic impactors or slow-push methods, they can be used to deflect a broad size range of hazardous asteroids. Experts from the U.S. Department of Energy laboratories noted that the U.S. has nuclear explosives on the shelf today that could fly aboard a spacecraft to deflect an asteroid found too late or too large for kinetic impactor or slow-push methods to work. In June, NASA and the National Nuclear Security Administration agreed to study spacecraft delivery techniques and NEA deflection concepts employing nuclear explosives. However, if NASA is able to mount a thorough, space-based search for smaller NEAs, the resulting increase in warning interval would give non-nuclear techniques more time to work, reducing the necessity to resort to a nuclear explosive.

Learn more

Asteroid exercise:

See how participants at the 2015 International Planetary Defense Conference in Frascati, Italy, prepared for a hypothetical asteroid impact.
http://neo.jpl.nasa.gov/pdc15/

Conference materials are available here:
pdc.iaaweb.org/

Coping with catastrophe

Illustrating how much work lies ahead, attendees at the conference in Italy participated in an exercise in which they were asked to assess the threat from a hypothetical asteroid impact in 2022 and propose technical and policy responses. As events unfolded with impressive detail, role-playing "policy makers" encountered mistrust, planning delays and the partial failure of a kinetic impact deflection attempt. An 80-meter fragment of the asteroid remained on a collision course, and the exercise ended with the object's predicted explosion over Dhaka, Bangladesh, the world's 10th-largest city. Astronomers in the exercise could give only a week's warning of this probable 18-megaton airburst, which would have devastated an area inhabited by 15 million people. The sobering results of the mock response demonstrated the urgency of accelerating asteroid searches and the development of NEA deflection technologies. Equally important will be a cooperative, international policy approach to prevent the low probability, high consequence effects of an avoidable asteroid catastrophe.

Tom Jones
skywalking1@gmail.com
www.AstronautTomJones.com

An airline pilot enchanted by flight

Skyfaring — *A Journey with a Pilot*

Reviewed by Kristin Davis

Nick Morrish/British Airways

Mark Vanhoenacker became a pilot relatively late, at age 29, and never lost his fascination with flight.

As a child, Mark Vanhoenacker strung model aircraft from his bedroom ceiling, conducted aerial-themed science projects and looked forward to family trips not for the destination, but for the plane rides. He was 13 when the sight of a jet from Saudi Arabia parked at New York's John F. Kennedy International Airport struck him like nothing before. He could barely comprehend that the aircraft had been in a land as distant and exotic as "Arabia" only hours earlier.

So began his fascination — and love affair — with flight, a story the author chronicles in his first book. It's an exploration of the joys of air travel in an age when it has become mundane. It is not about the state of commercial flight today or a technical treatise for wannabe pilots, but rather one man's melodic meditation on the wonders of rising above a geography to which all but birds were bound until barely a century ago.

Vanhoenacker takes readers to the beacons and invisible waypoints by which airplanes navigate — geographic coordinates that identify the Netherlands as TULIP, Detroit as MOTWN and the area near California's Charles M. Schulz airport as SNUPY. His observations are those of an insider who kept his outsider's perspective. That is perhaps because he came to the profession relatively late, at 29, first flying the Airbus A320 then the Boeing 747.

"I believed that something I wanted so much could never be practical, almost by definition," he writes.

It is Vanhoenacker's infectious, childlike enchantment with flight — and his captivating prose — that makes "Skyfaring" such an enjoyable read.

Japan is like "the surface of a blue star." Moscow at night is "like some great fire wheel turning on the snow." Rivers and lakes in the vastness of the desert look "as holy as blood."

Knopf

His observations are vivid enough to inspire any passenger to ask for a window seat, to put down a magazine or laptop and watch for shooting stars that "run across the sky like wind-swept drops of water."

Vanhoenacker, like most pilots and frequent travelers, still grapples with the improbability of being in two places as distant as Luanda and Los Angeles in a matter of hours, of the jarring sense of standing in a Sao Paulo food market staring at a dozen fruits he does not recognize. "We are not built for speed, certainly not for this speed."

He names the peculiar sensation "place lag."

"Skyfaring" offers an overwhelmingly optimistic perspective on air travel. He does not speak of the inconveniences or dangers of modern-day flight: the long waits through airport security, the cramped quarters of coach, the threat of terrorism. He finds the silver lining in the odd hours and schedules that keep him away from home for long stretches, of a job that constantly introduces him to new coworkers. He knows that he will come face-to-face with the silver-tinged clouds he transcends, and there is no place he would rather be.

He concedes that while a pilot knows the world intimately from the cockpit, he is less acquainted with it up close.

"The great eye of the world blinks, and then we are somewhere else." But that is the point, and the marvel, of air travel.

"Skyfaring" is for anyone who has ever worked in aviation, and especially those who aspire to. It is also for the weary passenger who takes such an improbable journey in air for granted — and for those who were never awed by it in the first place.

Kristin Davis
kristin.grace.davis@gmail.com

A spate of Russian launch failures and fiscal mismanagement has stirred angst from the Kremlin to Congress. Is the worry warranted? Two space experts provide divergent opinions.

VIEWPOINT

TWO VIEWS

International Launch Services

Space journalist Anatoly Zak reads the same doomsday headlines we all do about the future of Russia's space program. Zak, who was born in Moscow and is now living in the United States, doesn't think a close examination of the facts warrants such a dim view.

The case for optimism

by Anatoly Zak
agzak@russianspaceweb.com

Russia's space program in recent years has given journalists a lot of fodder for apocalyptic headlines and dire prognoses. Rockets and satellites were failing with stubborn regularity, or simply sat on the ground years behind schedule. An emblematic accident came in 2013, when the nation's workhorse Proton rocket veered off course and exploded seconds after liftoff, right in front of high-definition cameras. Turns out a poorly-trained assembly worker had installed the rocket's critical angular-velocity sensors upside down.

Not surprisingly, there is much lament inside and outside of Russia about the state of the legacy of cosmonaut Yuri Gagarin, the first human in outer space. Some pessimists see Russia's space program facing not only a deep crisis, but potential collapse. Yet it's debatable whether those concerns are justified — or just overblown. I do not believe the situation is as bleak as it seems, and even see reasons for optimism.

No question, the Russian space industry has serious quality-control problems. Those deficiencies stem from such root causes as aging or ill-trained personnel, low salaries, mismanagement and corruption. A bloated bureaucracy and obsolescent management structure inherited from the Soviet Union in many ways is still intact, while huge budgets of the former superpower are not.

First, the big picture. Money is critical for space ambitions, and Russia's space budget has been growing quite dramatically for more than a decade now, reaching 128.3 billion rubles, or $4.2 billion, in 2013. As has been true of Russia since the time of the Mongols, some of that money likely was wasted or even stolen. But the remainder has trickled down with visible results. Renovated buildings, gleaming machinery and new uniforms offer a sharp contrast from the lean post-U.S.S.R. 1990s. The big new investments in infrastructure renovations likely will bear fruit in the coming decade.

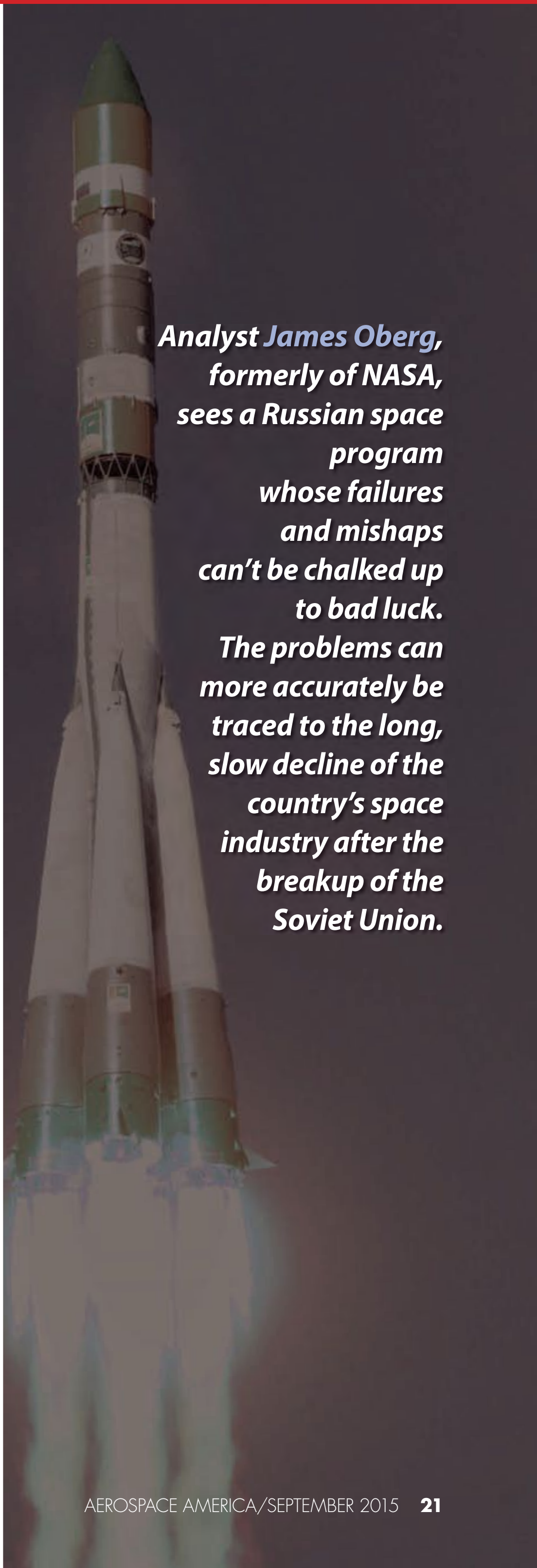
Moreover, the Kremlin this year replaced the military leadership at Roscosmos and initiated a true and radical restructuring of the agency. Within weeks after the takeover, Roscosmos's new leadership issued a clear vision of the agency's space strategy. Officials for instance shelved the super-heavy rocket for the lunar program until better days. They instead accelerated the development of a smaller, cheaper heavy rocket that could have both commercial and human spaceflight applications.

Continued on page 22

on Russian space

Stuck in decline

by James Oberg
jameseoberg@comcast.net



Analyst James Oberg, formerly of NASA, sees a Russian space program whose failures and mishaps can't be chalked up to bad luck. The problems can more accurately be traced to the long, slow decline of the country's space industry after the breakup of the Soviet Union.

Modern spaceflight, former NASA Administrator Mike Griffin was fond of saying, is so complex that it can be pulled off only when people are performing at their absolute best. But judging by their string of spaceflight failures in recent years, the people inside Russia's space industry no longer seem to be at their peak.

The latest mishaps — booster failures, payload failures, control center-command errors and a nagging issue with solar panel deployment on two of the last four Soyuz missions — have reignited concern among Russians over unsolved, perhaps unsolvable, quality control deficiencies within the country's space program. Attempts to reverse the long post-USSR spaceflight retreat have borne little visible success. If anything, a host of new challenges, foremost among them lack of money, have exacerbated the problems.

Because many aspects of Russia's domestic space program are tightly integrated into international projects such as the space station, those concerns affect other national space programs as well.

Recently, Russian Deputy Prime Minister Dmitry Rogozin, Moscow's point man for the space industry, lamented what he called corrupt management and other systemic ills within Russia.

"With such degradation in the leadership, one should not be surprised at the high accident rate," Rogozin told Russian lawmakers in a speech in May, according to news reports. Days later, a Russian watchdog agency alleged that the nation's space programs had misspent $1.8 billion in 2014 alone.

Reforms initiated by Rogozin likely won't bear fruit for several years — assuming he gets enough money to implement them. Igor Komarov, a former auto industry executive and the fourth person in six years appointed to fix the Russian space agency Roscosmos, said a turnaround "will need profound reforms."

The Russian space industry retains a core competency that continues to operate mature space systems, perform regular upgrades, and occasionally pull off respectful leaps in capability such as the new Angara booster family, or not long ago, a 500-day ground isolation test run for a manned Mars mission. But the problem that Komarov and others have been addressing is much deeper than the highly-visible rocket explosions, spaceflight operator errors and corruption trials.

Continued on page 23

Optimism
Continued from page 20


Roscosmos

One of Russia's workhorse Proton rockets exploded seconds after liftoff in 2013, an accident traced to the faulty installation of sensors.

Russia's most serious recent woes have come from the strongest segment of its space program — its rocket fleet. Those troubles for the first time are threatening Russia's leading position in the hyper-competitive field of commercial launch services.

But let's put those launch failures in proper context. Russians launch a lot of rockets, more than anybody else in the world. So far this year, Russians have made a total of 14 orbital launch attempts, two of which ended with failures. In April, a Soyuz rocket failed during the operation of its third stage, whose rapid breakup fatally damaged the Progress cargo ship moments after its separation from its booster, investigators believe. That was followed by a Proton rocket failure in May, resulting in the loss of the MexSat-1 communications satellite, also due to the third-stage failure. By comparison, Americans flew 13 missions, including the SpaceX Falcon 9 v1.1 that disintegrated in June. During the same period, Europeans launched just five rockets, and the Chinese two. Last year, Russia fired 37 missions into orbit with two failures; the United States launched 23, with one failure. China and Europe were far behind with 16 and seven successful orbital attempts, respectively.

It's worth noting that the latest failure of the Proton rocket was traced to a historical engineering flaw that had previously doomed two other vehicles. Roscomos, the Russian space agency, says new diagnostics tools installed on the latest Proton have now pinpointed and fixed the problem once and for all.


The Soyuz TMA-9 spacecraft launches from the Baikonur Cosmodrome in Kazakhstan. Soyuz rockets and capsules are currently the only vehicles that can ferry crews to the International Space Station.

NASA

Continued on page 24

Decline

Continued from page 21

The scope of the problem goes far beyond the evident troubles; it also shows in the things we don't see.

Russia has not ventured beyond Earth orbit in a quarter century. And the list of promised deep-space missions invariably seems to retreat further and further into the future.

Russia also has been unable to replace the Soviet-era full-orbit coverage communications relay satellite network — code named Luch, the equivalent of NASA's Tracking and Data Relay Satellites. This is curtailing human spaceflight operations and forcing Russia to rely on NASA's communications network.

More embarrassing is Russia's inability to produce and deliver the long-promised and years-delayed Nauka Science Module, which was supposed to host a major upgrade of Russian station-research capabilities. It's uncertain whether Nauka will ever be built, making Moscow's boasts about building its own orbital outpost ring hollow.

The litany goes on. GLONASS, Russia's answer to the American GPS network, is mired in production shortages for handsets. Fabrication of next-generation spacecraft has been seriously hampered by lack of access to Western electronic components put under embargo after President Vladimir Putin's annexation of Crimea. Thanks to breakdowns of old satellites and delays of promised replacements, Russians still must buy much of their weather and Earth imagery from abroad. The new weather-forecasting satellite is officially still undergoing acceptance testing two years after launch. Even a key rocket fuel, heptyl, is now imported from Germany.

Perhaps most dangerously in an era of growing world tensions, Russia's military officials are publicly complaining that the missile early-warning satellite network has totally collapsed. The delay of replacement satellites means Moscow must rely on ground radars to detect any missile attack, slowing detection and giving dangerously brief window to make life-or-death decisions.

All this may seem like piling on, and no major program is immune to sporadic failures. But the sheer number of technical, operational and financial woes bedeviling Russia's once-vaunted space program is worrisome. The recent failure of a crewed Soyuz to deploy a solar array, the second in the last four flights — after 30 years of faultless performance — is a disturbing reminder of the "canary in the coal mine" metaphor, a sign of more widespread danger.

NASA

Soyuz TMA-14M lifts off toward the space station in 2013 carrying a crew of three. Two of the last four Soyuz missions have been bedeviled by trouble with solar panel deployment.

Many of the root causes, including an aging workforce, low salaries, obsolescent infrastructure and the deterioration of a culture of disciplined quality control, remain largely unresolved. Meanwhile, a spate of new problems adds to the strain on Russia's space program.

The economic embargo and boycotts following Russia's claim over the Crimean penisula has exacerbated Russia's vulnerability stemming from its reliance on foreign avionics components. This has added to the

Continued on page 25

Optimism

Continued from page 22

By contrast, April's Soyuz rocket failure resulted from a transition to a more powerful Soyuz-2 variant, rather than any obvious shortcomings in quality control. What's more, in a display of remarkable flexibility, Roscosmos immediately switched to an older and reliable Soyuz-U, ensuring that the next ISS supply mission two months later went without a hitch. Try that, SpaceX!

Oh, I need not mention that the Soyuz spacecraft and its rocket are still the only vehicles capable of delivering crews to the space station, and probably will remain so for a few more years.

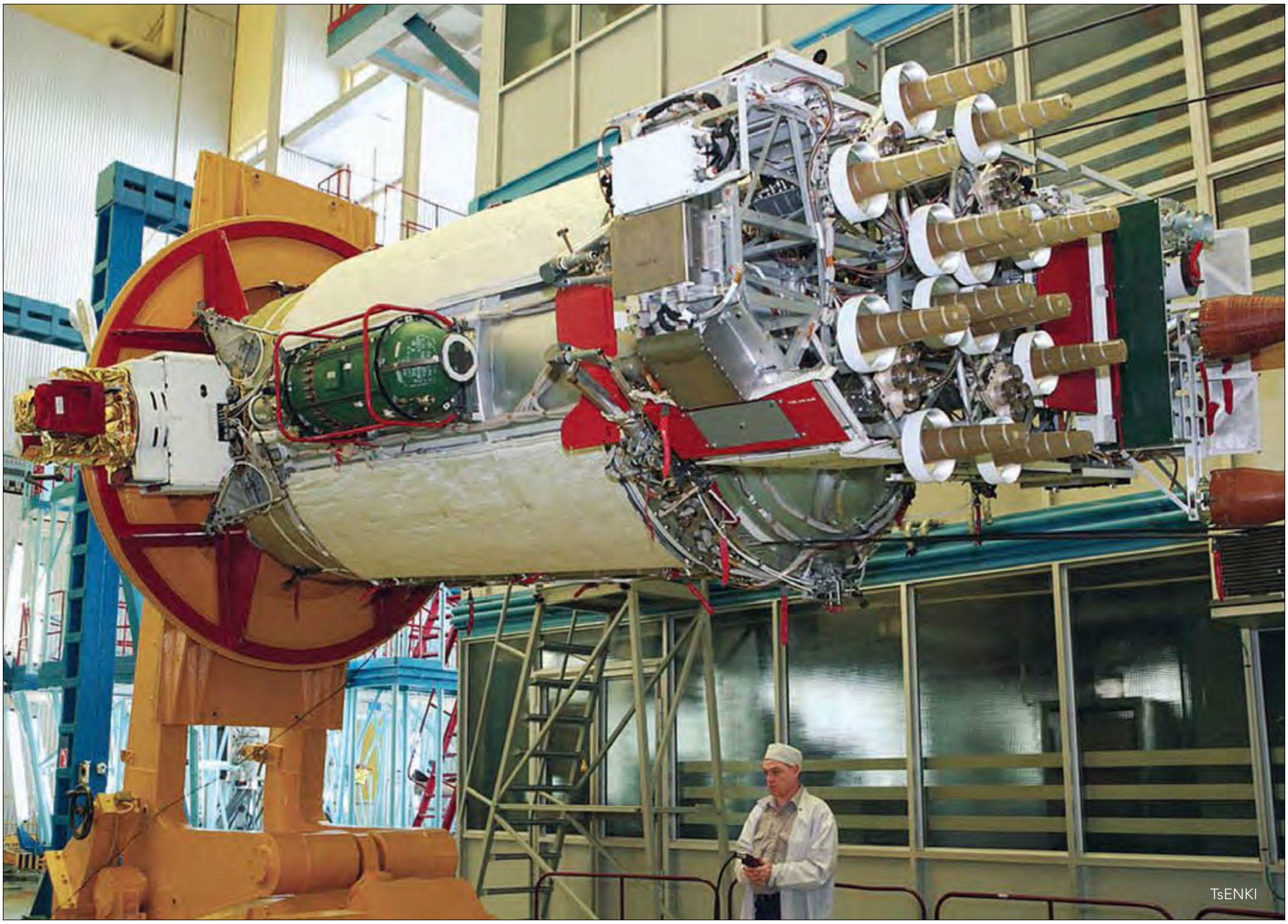
Meanwhile, the Proton's replacement — a brand-new Angara rocket that had been in development for two decades — has just made two promising inaugural flights, proof that Russia is finally replacing its Soviet heritage with 21st-century technology.

Last, but not least, Russian workers are putting finishing touches on a monumental spaceport in the far-eastern taiga, with first launch tentatively scheduled for late December. Granted, Roscosmos's previous leadership designed the new Vostochny Cosmodrome with a launch pad for the Soyuz, the world's oldest rocket and the kind that launched Sputnik in 1957. Still, the scale and the technical potential of the Vostochny spaceport marks a truly new beginning for the entire Russian space program. Add the construction of a second launch complex for the Angara family that will start next year, and by the mid-2020s Russia should have a new spaceport, a new operational workhorse rocket and a new-generation spacecraft for human space flight.

That picture doesn't take into account perhaps the most remarkable — if least celebrated — Russian space achievement of the past decade. A decade ago, Moscow's military and civilian satellites were ap-

Continued on page 26

The 24-satellite GLONASS navigation constellation, Russia's answer to American GPS, has been revived after facing near death in the 1990s.



TsENKI

Decline

Continued from page 23

previously recognized need to develop domestic suppliers for several hundred critical aerospace products previously purchased from Ukrainian factories.

The plunge in world oil prices has slashed Russia's space budget by as much as one third less than promised. What's more, Russian policymakers have been siphoning rubles from the space program to military investments. Still more money is being diverted to dubious infrastructure projects, such as the Vostochny Cosmodrome in Siberia and refitting confiscated Ukrainian-owned space facilities in the Crimea. Even if properly managed — and it clearly has not been — this enormous construction boondoggle is sucking up a large share of the financial resources.

The entire space industry is undergoing a massive reorganization with the stated goal of eliminating redundant industrial capability and standardizing quality control processes. While touting the need to hire 10,000 college graduates per year, Rogozin has declared that 100,000 of the 250,000 current workers will lose their jobs as underused and duplicate production capacity is eliminated. The trick then is to retain enough skilled veterans who can work alongside new hires and pass on the hard-earned wisdom of their experience.

A perennial problem in Russia, graft and corruption, has resulted in more than a hundred prosecutions of middle- and upper-level officials, including Vitaly Lopota, former head of the Energiya Rocket and Space Corp., and Vladimir Nesterov, former chief of the Khrunichev State Research and Production Space Center, the two biggest enterprises in the Russian space industry. Leaders in the west should feel a chill from Putin's recent call for a return to "1930's discipline" and media nostalgia for finding "a

Continued on page 27

Russian Presidential Press and Information Office

Russia's Deputy Prime Minister Dmitry Rogozin, Moscow's point man for the space industry, reportedly warned that corruption and mismanagement is reflected in the high rates of accidents.

Roscosmos

The mammoth Vostochny Cosmodrome under construction in Siberia could recharge Russia's space aspirations — or prove to be a costly boondoggle.

Optimism
Continued from page 24

proaching near extinction. However, in the past several years, the industry has slowly rebuilt the nation's satellite network amid several failed attempts.

The 24-satellite GLONASS navigation constellation, Russia's answer to American GPS, was fully assembled and brought to operational status. After its near collapse in the 1990s, GLONASS is now regularly replenished.

Russia also sent a new weather-forecasting satellite to a geostationary orbit after an almost two-decade hiatus. A new-generation communications satellite designed to rival most advanced western equivalents has entered orbit, as has a formidable fleet of high-resolution Earth-watching satellites.

The reinvigorated space industry also delivered to the nation's military a new generation of eyes and ears in the sky. A miniature satellite inspector made three progressively more sophisticated appearances in orbit. The point is, this again testifies to the growing engineering potential of the Russian space industry.

One major hole for Roscosmos remains space science. No Russian planetary probe has been sent beyond Earth's orbit since 1988 and only one major space observatory is currently operating. That could change with the ExoMars project that aims to deliver a European-built rover onto the Red Planet around 2018 with the help of a Russian-built lander.

If successful, Roscosmos will have, for the first time, a proven method for planetary landing. This experience could later pave the way to more ambitious projects, including a pioneering mission to return soil samples from Mars.

Albert Einstein famously said, "You never fail until you stop trying." Clearly, if the Russian space program withers, it will be not from lack of trying.

Anatoly Zak, a native of Moscow and a U.S.-based journalist, is publisher of RussianSpaceWeb.com and the author of "Russia in Space: Past Explained, Future Explored."

Decline
Continued from page 25

new Beriya," brutal leader of Stalin's post-World War II Soviet nuclear program.

Top-level plans seem to focus on a relentless crash effort to make a satellite launch out of Vostochny Cosmodrome by the end of this year. However, it's worth noting that the same construction group that rushed the Sochi Olympics to last-minute completion is in charge. But getting the launch off will not signify the achievement of operational capacity. That's because the fixes largely come at the expense of existing resources. These schedule-driven directives have called for use of emergency utilities, the shortcutting of other infrastructure by leaving out all facilities not directly supporting the initial launch, and the temporary duty of key personnel from experienced launch teams from other launch sites. None of these ad hoc measures will ameliorate the growing weaknesses that have already been inducing an intolerably high error rate in the mainstream Russian space industry, nor will a successful but purely symbolic "on time" first launch.

That NASA officials have been downplaying Russia's problems reflects respect for Russia's space heritage. It also indicates a blind faith in the constancy of the odds governing catastrophic failures, which for Russia have historically been low. That faith results from a logical fallacy, and not merely because dice have no memory. In the space business, engineers like to rely on as many of the same fabrication tools, human skills and techniques as possible from mission to mission, but some change is inevitable no matter how hard they try. This means that every mission is carried with a new set of dice — and a growing number of external factors are loading each new set of dice more and more against Russian success.

James Oberg is a former NASA Space Shuttle mission control specialist who led the orbit design team for the first International Space Station assembly mission in 1998. He is author of a dozen books on space exploration and is a former space consultant for NBC News.

Safer ejection seats

Ejecting from a warplane has always been hazardous, but many pilots face more danger than ever. That's because their ejection seats weren't designed to accommodate modern helmets and displays. Keith Button looks at ideas for solving the problem.

Martin-Baker

A mannequin ejects from an F-35 during a test of the Martin-Baker US16E Ejection Seat at Hollman Air Force Base in New Mexico in 2010. The U.K. company is competing with UTC Aerospace Systems to upgrade ejection seats in the current U.S. Air Force fleet.

The pilot inverted and rolled his F-16 hard to the right into a 460-mile-per-hour dive toward the Adriatic Sea. He was on a training run, practicing a last-ditch maneuver to evade a simulated surface-to-air missile. Suddenly he called out, "knock it off, I'm spatial D," meaning stop the simulation because he was spatially disoriented. Seconds later, according to U.S. Air Force accident investigators, Air Force Maj. Lucas Gruenther pulled the ejection handle at the front of his seat and rocketed out of the plane.

Gruenther's helmet was torn off, and when the seat's drogue chute deployed, it jerked him with a force 40 times that of normal gravity. The Air Force medical examiner concluded he suffered head and neck injuries that were "rapidly fatal."

Gruenther's death illustrates a growing technical challenge facing ejection-seat designers. Fighter pilots now wear helmet-mounted cueing systems, or HMCSs, which are electronic visors that sense where a pilot is looking and target weapons or sensors there. Gruenther was flying at night, so he also wore night-vision goggles. The size, weight and aerodynamic drag of this modern equipment has complicated the job of ensuring that pilots can eject safely. So much so that in 2010, three years before Gruenther's accident, the Air Force recommended neck exercises for pilots who wear HMCSs. In March, the Pentagon recommended that pilots remove night vision goggles before ejecting.

None of this should be a problem for the newest warplanes in the American and British inventory, the F-35s. All three fighter variants are being equipped with seats specifically to handle ejections with modern helmets. But even if those seats work as well as hoped, that still leaves lots of F-22s, B-2 bombers, and T-38 trainers with the same kind of older ejection seat that Gruenther used, called the Advanced Concept Eject Seat 2. This product was introduced in 1978 and upgraded over the years, but not specifically for the modern helmets, although leg and arm restraints were added to the seats in some aircraft.

The Gruenther case has given fresh momentum to a proposed retrofit program for some of the ACES 2-equipped aircraft starting in late 2016, although probably not the U.S. F-16s because they could be nearing retirement. Once the request for proposals comes out, the world's top two ejection-seat makers will compete to convince the Air Force that they can do the best job of preventing more cases like Gruenther's fatal flight.

The bidding will amount to a rematch of the 2001 competition in which Lockheed Martin chose the U.K.'s Martin-Baker company as the ejection seat provider for all three versions of the F-35s, turning aside a bid from ACES-maker Goodrich, which was purchased in 2012 by United Technologies Corp. and renamed UTC Aerospace Systems.

Martin-Baker will offer to upgrade older versions of its seats and provide new US16E ejection seats, the kind going on F-35s, as replacements for ACES 2 seats.

UTC Aerospace, based in Charlotte, North Carolina, will offer kits to upgrade the ACES 2 seats with the same head, neck and leg restraints as on its newest seats, called ACES 5.

"We believe that if [Gruenther] had the benefit of an ACES 5 ejection seat design, he would have in all likelihood survived ejection," says Jim Patch, UTC's senior program manager for ACES 5 and a retired Air Force pilot who flew fighter jets for 21 years.

ACES 5 protects the head with pads that pop up during ejection to keep the pilot's head angled forward and to prevent the head and neck from snapping backward. Recessed bars on each side of the seat also pop out to keep the head from moving from side to side as the pilot encounters the wind blast. The protection pads and bars cradle the head like a softball glove, Patch says. The equipment retracts to avoid any chance of the pilot being injured by it as the pilot separates from the seat and parachutes to the ground.

Martin-Baker employs a much different approach for its US16E. Nitrogen gas is ported from the back of the seat to inflate three "air-beams," which look like oversized, hot dog-shaped pillows. An airbeam on each side of the head is inflated immediately at ejection to provide lateral support and protection.

The technology meets all "physiological requirements for head and neck load minimization across the aircrew population range," says Martin-Baker's Steve Roberts, the company's Joint Strike Fighter integrated product team lead, by email.

In the Gruenther case, Air Force acci-

by Keith Button
buttonkeith@gmail.com

U.S. Air Force Capt. Christopher Stricklin uses an ACES 2 ejection seat to escape from his F-16 Thunderbird moments before it crashes at an Idaho air show in 1982. Stricklin, who steered the plane away from the crowd, was uninjured.

dent investigators concluded that "it is reasonable to expect the HMCS helmet would fail and that this would result in potentially fatal loads on the mishap pilot's neck."

Violent event

McDonnel Douglas developed the first version of the Advanced Concept Ejection Seat in the 1970s in response to the Air Force's concern about each airplane maker making its own ejection seats, and doing so poorly in the Air Force's view.

The Air Force adopted the ACES 2 seat for every A-10 Thunderbolt; F-15, F-16 and F-22 fighter jets; and B-1 and B-2 bombers in its fleet. In all, 29 countries have equipped their aircraft with about 6,000 ACES 2 seats.

After the Gruenther acccident, Congress told the Defense Department to examine the safety implications of pairing the modern helmets with ACES 2. In March, the Inspector General's office released its findings, "Evaluation of Aircraft Ejection Seat Safety When Using Advanced Helmet Sensors." The report makes clear that ejecting from an airplane is such a violent event that injuries are not uncommon. A typical ejection from an F-16 lasts two to three seconds from the point that the pilot pulls the ejection handle until the parachute is fully deployed. Pulling the ejection handle blows the canopy off the cockpit, then the pilot is rocketed up with about 4,000 pounds of thrust.

Outside the aircraft, the pilot can face extreme windblast forces — up to 1,200 pounds per square inch, at 684 miles per hour. At 0.4 seconds into the ejection sequence, a rocket fires and a drogue parachute deploys to stabilize the seat, exerting about 7,600 pounds of backward force on the pilot. Then, at 1.8 seconds in, the main parachute deploys from a container in the seat, exerting about 3,000 pounds of force on the pilot via a harness, and the ejection seat falls away. Once the chute is fully open, the pilot falls at up to 7.6 meters per second, which means hitting the ground with up to 2,938 foot-pounds of energy.

According to Air Force figures, from 1995 to 2014, there were 203 ejections using ACES 2, 93 percent of which occurred at speeds of 518 miles per hour or less, which is considered the safe envelope for ACES 2 ejections. Of the 189 ejections within the envelope, 12 percent resulted in fatalities or other injuries from windblast, ejection shock, parachute landing, hitting the ground or objects during ejection and from burns or hypothermia.

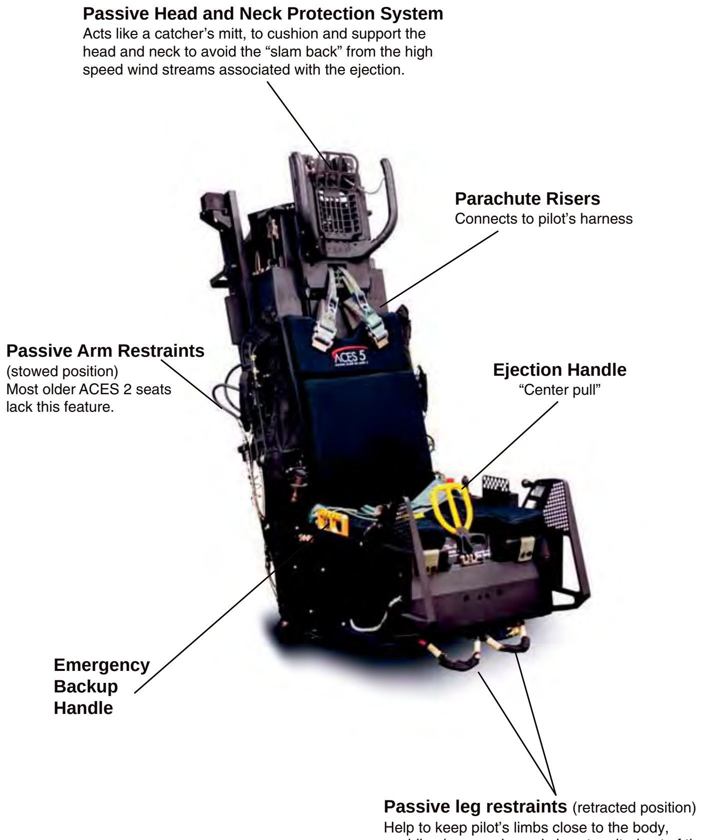
Nevetheless, the March Pentagon report concluded that the helmet-mounted cueing system and night-vision goggles don't significantly increase the risk of injury during ejection, so long as the aircrew members follow proper ejection procedures detailed in their flight manuals. They should remove night vision goggles before ejection and properly wear their helmet at all times. The Navy, according to the report, restricts air crew members who weigh 136 pound or less from wearing certain helmet-mounted devices because of the increased risk of injury.

Parachutes

As significant as the head and neck issue is, Martin-Baker and UTC are concerned about much more than that. Impact injuries from parachuting to the ground are one of the most common injuries for ejected pilots. To help solve that problem, UTC engineers designed a new chute to bring an air crew member down at a slower rate and greatly

Modern times, modern seat

Martin-Baker and UTC Aerospace are on a mission to make bailing out of a plane safer, even with the added weight and aerodynamic drag of modern aviator helmets. Pictured here is UTC's ACES 5, short for Advanced Concept Ejection Seat 5.



UTC Aerospace

reduced oscillation, meaning the occupant won't swing at the 30-degree angles allowed by the older parachute, called the C-9. The new GR-7000 chute should reduce the chances of a crew member being in mid-swing when he or she hits the ground.

Martin-Baker says it too has created a larger chute, one that can inflate quickly, even with a suspended mass of 152 kilograms, and keep the descent rate at 7.3 meters per second. The company worked on the chute with Airborne Systems Ltd. of Bridgend, U.K.

Engineers must also work to keep the wind of a high-speed ejection from pulling a crew member's legs or arms away from the seat, an effect called flail.

"There have been high speed ejections that have resulted in — this is maybe a difficult analogy — but if you think of a wishbone from a turkey, and you pull it apart, you can imagine at high speed, left undeterred, if the legs were free to flail to the extreme, that can be what happens to the pilot or aircrew member," says UTC's Patch.

To attack the arm-flail problem, ACES 5 deploys a net from the sides of the seat to cradle the arms and hands. As the seat rides up and clears the cockpit rail, a cable attached to the cockpit floor activates the arm restraints.

For the leg injury risk, engineers designed the ACES 5 seat with two cable loops recessed into the walls and ceiling of the standard cockpit leg wells. As the seat goes up, loops pop out of tracks, wrapping around the pilot's legs just below the top of the flight boot, and pull the legs back against the front of the seat, so they don't flail. Only some ACES 2 seats on F-22s have arm and leg restraints.

There are other improvements too. Under the ACES 2 design, two Pitot tubes were fixed at a 90-degree angle to the surface of the seat, leaving them exposed to damage if the seat were to hit the canopy during ejection. That could be disastrous, because the Pitot tubes sense the air speed pressure for a microprocessor called the sequencer, which calculates the steps necessary for a safe descent. In the ACES 5 seat, the Pitot tubes stay recessed in the seat to the sides of the headrest until the seat clears the canopy.

UTC engineers designed the ACES 2 and 5 seats to deploy the main parachute as soon as possible to maximize terrain clearance, when an ejection occurs at low altitude and low airspeed, says John Hampton, engineering manager at UTC. At high altitude, where temperatures can reach minus 60 degrees Fahrenheit and oxygen is scarce, the seat deploys the drogue but waits until it falls to 15,000 feet to deploy the parachute and release the occupant member from the seat.

To minimize injuries during the force of the ejection, the ACES 2 and 5 seats are designed to adjust their ejection force based on the mass of the occupant to give a relatively constant acceleration, regardless of the size of the aircrew member. The seat senses the load, or weight of the crew member, and compensates the rate of rocket burn depending on the weight — more burn for a heavier crew member and less for a lighter person.

950 1960 1970 1980

Tube-and-wing

Since the dawn of jet travel in the 1950s, the basic configuration of airliners has barely budged. The tube-and-wing design won't become a relic anytime soon, but that doesn't mean engineers can't make progress toward quieter, more fuel-efficient aircraft. Michael Peck looks at the future of airliners.

by Michael Peck
michael.peck1@gmail.com
@Mipeck1

It was perhaps fitting that on July 20, 2007 — the 38th anniversary of a spidery spacecraft depositing the first humans on the Moon — another flying machine made history.

That was the day that Boeing's X-48B Blended Wing Body soared on its inaugural flight. Weighing just 237 kilograms, the remotely-piloted demonstrator was a fraction of the size of an actual airliner, but the ensuing flights brought a touch of the exotic to the industry, like a 1950s World of Tomorrow display from the World's Fair. The subsonic design had the potential to deliver quieter and more fuel-efficient flight.

Yet, it was not to be. After 122 flights of the X-48B and C, a version tailored for noise reduction and stability tests, NASA

what's

1990 2000 2010 202

ended the program in April 2013. Today, air travelers in Chicago are no closer to catching the flying-wing shuttle to Beijing.

The X-48 saga symbolizes the dilemma facing designers of the next generations of airliners. Reach too far, and customers accustomed to today's tube-and-wing designs might not accept the changes. Indeed, passengers who sat in a mock-up of a Blended Wing Body airliner didn't like the unfamiliar seating. NASA, which funded the X-48 work, is now regrouping.

"While we've knocked down many risks of such configurations, there remain challenges to overcome before industry, the airlines and the public are ready for such a change," says NASA's Jay Dryer, director of the Advanced Air Vehicles Program.

Designers are now searching for innovations that would be palatable to consumers but bold enough to satisfy growing government demands for dramatically reduced CO2 emissions from airliners, but in an affordable way. These innovations could include bigger, more efficient geared turbofan engines; the use of tiny jet engines to blow air over rudders for better flight control; trusses to support larger wingspans; and a new Double Bubble fuselage for improved lift and engine efficiency.

When might these innovations enter the market? That's the difficult question.

"The problem is that just when you think you've made some kind of breakthrough, you realize there are major problems," says Richard Aboulafia, an aviation

next?

Shape of the future? MIT engineering students prepare the D8 airliner model for testing in NASA's 14-foot by 22-foot Subsonic Tunnel at the Langley Research Center in Virginia.

analyst at Teal Group in Virginia. "Big engines? That makes sense. More bypass is good," he says, referring to a measure of jet-engine efficiency. "But at a certain point, you begin to get into diminishing returns, and you get a lot more drag. There are no definite ways forward. Improvements take a lot longer than you think."

Market economics must also be considered. The airlines are raking in record profits with today's aircraft, so there is no pressing demand for dramatic technical leaps. "This is an incremental industry that is doing very well," Aboulafia says. The FAA and Environmental Protection Agency are working on the first CO2 efficiency standards for airliners, but it is unclear exactly how much impetus those standards would provide.

A better fuselage

NASA and MIT are working on a concept that would depart from the venerable tube-and-wing aircraft, but not as radically as the Blended Wing Body. They've devised a 4-meter-long wind-tunnel model called the D8 Double Bubble. It resembles two conventional fuselages fused together. This shape has been tested repeatedly in a wind tunnel at NASA Langley. The team wants to point the way toward an airliner that would have an unusually wide fuselage, low-slung wings and three engines embedded between a double tail. The NASA-MIT team estimates that this aircraft would fly a bit slower than the Boeing 737-800, but carry about the same number of passengers and burn 37 percent less fuel when equipped with conventional turbofan engines .

The D8's wider fuselage — 5.3 meters compared to 3.9 for a 737 — should allow it to support about 18 percent of the aircraft's total weight, which puts less load on the wings and enables even greater wing span, thus reducing drag. Its upturned nose reduces the downward lift that the tail must generate to balance the aircraft in pitch, and allows a smaller and lighter tail.

Perhaps most daring, the design takes advantage of an effect known as boundary-layer ingestion, or BLI. The engines on the D8 would not take in air from an undisturbed airstream as the engines on the 737 do from their perches under the aircraft's wings. The D8 engines would get an efficiency boost by gulping air from the wake of the fuselage. The air here has been slowed, resulting in a drafting effect for each engine's front fan or propulsor. The strategy is not unlike a Tour de France cyclist drafting behind a competitor. The lower the velocity of the air entering the engine, the less power must be exerted to turn the fan.

"Less power then translates to less fuel burn," says Mark Drela, the MIT aeronautics professor who helped develop the D8 concept. Today's aircraft don't take advantage of this effect. Picture an airport's people-mover conveyor, Drela says. "A conventional airplane is like walking alongside an operating people mover.".

If NASA and MIT can make boundary-layer ingestion work, the D8 would have smaller, lighter engines with nacelles covering only their top halves, because the bottom halves would be shielded by the rear fuselage.

That's the theory, but there is still a lot to prove. While boundary-layer ingestion should reduce fuel burn, "it also introduces many difficulties for the engine design and operation," including "greater engine stresses, and potentially more noise," says Alejandra Uranga, an MIT researcher and the technology lead for the Double Bubble. As Drela explains, while the incoming air is moving more slowly, "the ingested airflow is distorted, which causes additional cyclic loads on the front fan blades, and thus complicates their mechanical design."

Drela predicts that airflow distortion won't ground the D8 concept. "Any existing jet engines today operate with varying levels of inlet distortion from a variety of causes, so this really isn't something new. In any case, we do not see these mechanical complications from distortion as a roadblock for BLI."

The D8 might also represent a philosophical shift in an industry whose technologists have tended to split into two camps: engine designers and airframe designers. "The airframe and propulsion system must be designed to work together as a single unit: the performance of the fuselage and of the engine is now linked," Uranga says. "One can neither apply the classical metrics of thrust and drag, nor use the mature design tools developed for tube-and-wing aircraft."

Drag reducer: In April, Boeing fitted the 757 ecoDemonstrator's tail with 31 air-blowing devices, part of an active flow control test to see if the tail can be made smaller to reduce drag without sacrificing control during takeoff and landing.

A potential complication to commercial acceptance of the D8 is that it trades speed for efficiency. Its cruise speed would be Mach 0.72, or 8.3 percent less than the Mach 0.785 of the 737. On the other hand, the lower speed allows the D8's wings to be nearly unswept, which permits a longer wing span and more efficiency.

Drela and the team are confident about the concept's merits, but a big question remains: "Can we develop propulsion systems that can tolerate the distorted flows that would be seen in this concept?" NASA's Dryer says, whose portfolio includes the D8.

More design innovations

Another less radical idea would be to support wings with trusses, which would allow engineers to make thinner wings that would generate less lift-induced drag. Boeing has been pursuing that idea with its Subsonic Ultra Green Aircraft Research, or SUGAR, design, which is part of a NASA-sponsored project to develop quieter and environmentally cleaner aircraft. Boeing and NASA have tested a 13-foot semi-span (a sub scale aircraft cut in half) in a wind tunnel at NASA Langley. On top of the potential fuel-efficiency benefits, the result would be an airplane that looks more familiar to the public than the Blended Wing Body. "There is still significant uncertainty if the structure can be designed and built to achieve the desired level of performance in terms of drag and weight and ultimately fuel burn," Dryer says.

When or if the D8 and truss concepts will reach the market is unclear, so innovators aren't waiting. They are seeking to improve today's tube-and-wing designs to fly more efficiently and quietly. Big airliners have big, heavy rudders. So, NASA and Boeing are developing active flow control technology in which jet actuators — tiny jet engines — would be flush mounted into these rudders or potentially other control surfaces, too. These actuators would blow air over the surface to keep the airflow from separating.

Aircraft need a big, heavy tail for stability and directional control during takeoff and landing, but not when cruising at altitude. Active flow control should enable a smaller, lighter tail without sacrificing control during takeoff and landing. Wind tunnel tests suggest that the tail area can be reduced 17 percent and that the smaller tail would reduce drag by about 0.5 percent, says Naveed Hussain, vice president of aeromechanics technology at Boeing Research & Technology.

Boeing also flight-tested the concept six times on its leased 757 ecoDemonstrator jet in April. Engineers fitted 31 actuators in the plane's tail.

Work is also underway on a new class of material called ceramic matrix composites, or CMC, in which ceramic fibers are embedded in a ceramic "much like the familiar carbon fiber reinforced epoxy plastics," Hussain says. "The result is a material which structurally behaves more like wood than a tea cup."

Boeing has tested CMC engine nozzles in flight on the 757 ecoDemonstrator. The nozzles are up to 20 percent lighter than current metallic components, and can last longer at temperatures as high as 1,500 degrees Fahrenheit, according to Hussain. "This offers a material solution that exceeds the temperature capability of superalloys at a weight less than titanium."

While aircraft manufacturers are developing better airframes and materials, engine makers aren't idle. Pratt & Whitney's Alan Epstein, vice president of technology and environment, notes that jet engine manufacturers have improved engine efficiency from 10 percent in the first engines to 40 percent today, with efficiency measured as the propulsive work of the aircraft divided by the energy in the fuel. "Theoretically, we can get to about 80 percent, so we're only halfway there."

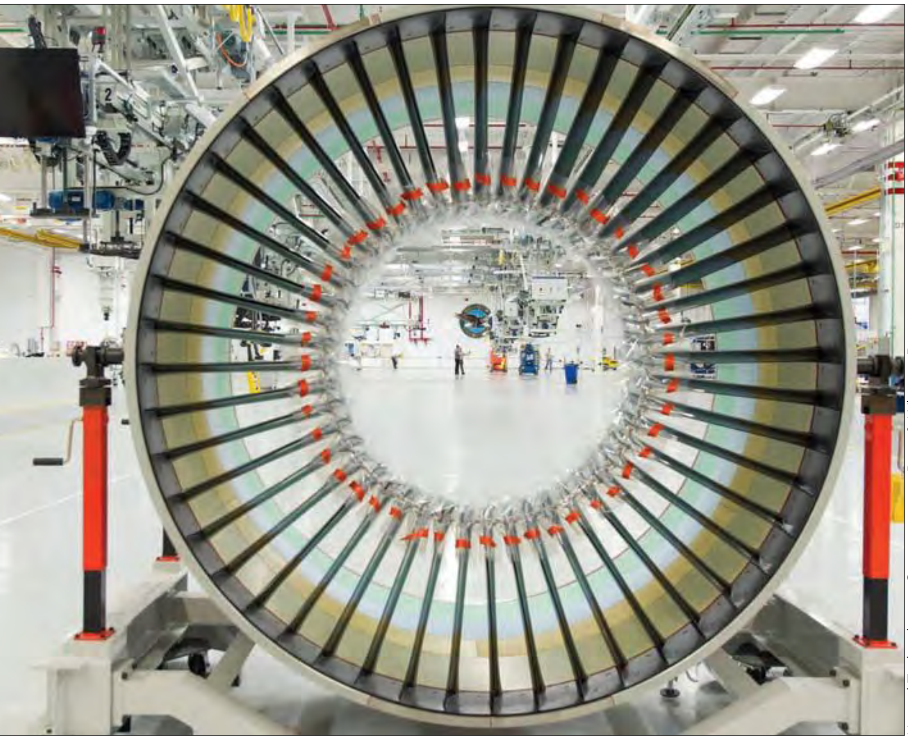
But as a practical goal, Epstein suggests the industry "should aspire to efficiencies in the range of 60 to 70 percent. Getting there will take new ideas and quite a bit of research."

Getting there could also become a regulatory necessity, as the FAA and EPA push for pollution standards. Last June, the EPA proposed classifying greenhouse gas emissions from aircraft engines as contributors to global climate change.

Whatever the impetus, Epstein says work is underway. "We know that our next engine has to be 8 to 10 percent better fuel burn than our current engines," he says. "We know that [airlines] are looking for lower noise and lower emissions."

Pratt & Whitney and its partner, Munich-based MTU Aero Engines, have already made a mark in the industry with their new geared turbofan engines. Geared turbofans such as the Pratt & Whitney PurePower PW1000G use a gearbox between the engine fan and the low-pressure compressor and turbine. The gear keeps the fan turning at a safe speed but lets the compressor blades turn as fast as necessary to compress air most efficiently for combustion. The resulting engines have unusually large front fans compared to their combustion cores, which means lots of air from the

Bigger, more efficient geared turbofan engines could be one answer to reducing C02 emissions from airliners.



United Technologies Corporation — Pratt & Whitney Division fan can pass entirely through the engine as thrust, relative to the amount that must be diverted for combustion. Engineers describe that relationship as the bypass ratio, and the higher the ratio the better.

While early 1960s engines had bypass ratios of less than 1 to 1, geared turbofans now have ratios as high as 12.5 to 1. Epstein expects that engine ratios will soar to between 14 to 1 and 18 to 1 by the 2020s, and up to 25 to 1 by the 2030s.

Epstein also estimates that engine-fan diameters will increase for single-aisle narrowbody aircraft. "We may see narrowbodies with inlet diameters approaching that of Boeing 747 engines — 94 inches — by the end of the next decade," he says.

Mounting those engines on a conventional tube-and-wing design "will be an interesting challenge for aircraft designers," Epstein notes. At some point, mounting ever-bigger engines with ever-bigger fans under an airliner's wings creates issues. An obvious one is ground clearance, but there are other issues. Increasing the size of the front fan increases the size of other components. "There are the nacelles for the propulsor, which adds weight and drag," says Epstein. "So I also need a shorter nacelle and a shorter inlet to keep weight and drag manageable."

This is why Epstein argues that aircraft and engine manufacturers need to work together more closely. "I would say that one of the most unexploited technologies is the idea of propulsion integration," Epstein says. "To a large degree, the propulsion companies and the airplane companies play independently side by side. And then the airframe companies use great ingenuity and analysis to get the engines closer to the wing without disturbing the wing too much, as opposed to embracing propulsion as a method of changing airplane design."

Epstein says that while the industry has shifted from four-engine to two-engine planes, that's probably not the final word.

"I think we may go back to more engines. And this is not the dream of a guy who wants to pedal engines," Epstein says. "What I know is that I can make eight engines for the same price as two engines, with [the] same amount of thrust. So thrust is almost a commodity. So you may see many more smaller engines on the same-sized airplane. You can also embed them differently and mount them differently because they are smaller."

Nonetheless, Epstein expects that the familiar turbofan engine will be with us for the foreseeable future. "Until we come out with warp drive or ornithopters, these engines are going to have fans or propellers," he jokes.

Yet if nothing else, engines are no longer the prime culprit for noise, even if most of the public does not yet realize this. Geared turbofans and other new engine designs are so much quieter that it is now the airframe that is becoming the primary noise generator, according to NASA's Dryer. Thus, NASA is exploring quieter airframes through modified landing gear, or aircraft lift components such as flaps and slats. Mounting engines above rather than below the wing may also reduce noise, which is a plus for the new Hondajet business jet and its above-the-wing engines.

Some of these technologies, or perhaps their precursors, are already making their way into the newest airliner designs. Boeing says its upcoming 777X will have a high-span wing made of composite materials (the same composites are used in the 787 Dreamliner). The aircraft will be powered by two General Electric GE9X engines. The GE9X aren't geared turbofans, but General Electric says they will burn 10 percent less fuel than the GE90-115 engines used on the Boeing 777, as well as offering 10 to 1 engine bypass ratios and proprietary, noise-reducing nacelles.

For its part, Airbus has opted for Pratt & Whitney's PW1100G-JM geared turbofan engines as one option for its upcoming two-engine Airbus A320neo. Pratt & Whitney says these have double-digit fuel burn reduction, create 50 percent less noise, and have lower emissions.

Pace of change

Aboulafia of Teal Group points to those geared turbofan engines as an example of what he sees as the glacial pace of technological deployment in a conservative industry like the airline sector. "Geared turbofans are huge breakthroughs that will give double-digit fuel burn improvements. On the other hand, we've had this technology since the '60s, and only now is it finally hitting the commercial sector big time."

REUSEABLE

Attempts to build spacecraft that can be flown more than once are littered with failures. But led by SpaceX, the commercial launch industry is trying again to find ways to reuse engines, stages and perhaps someday the entire vehicle by reassembling it after launch. Debra Werner explains the technical and economic hurdles.

A SpaceX Falcon 9 lifts off from Florida in 2013 with a payload of satellites. The rocket's first stage relit three of its engines, just as a reusable stage would have to do to land on its base.

SpaceX

ROCKET RENAISSANCE

Food, water and equipment for astronauts weren't the only casualties when a Falcon 9 v1.1 rocket disintegrated on its way to orbit in June. The accident also put on hold SpaceX's third attempt to land the first stage of a Falcon 9 on a barge off the Florida coast. No company or government has ever managed to land a spent rocket stage and reuse it, but that would be just a start. SpaceX eventually wants to reuse an entire rocket by recovering the upper stage too and reusing the Dragon cargo capsules. The result would be a reusable rocket, though not the futuristic spaceplane once envisioned by the U.S. Air Force and NASA. Company founder Elon Musk wants to start proving the feasibility of the concept, and apparently not just for the bottom line of his company.

"I think it's important that humanity become a multiplanet species," Musk said last year on the news program 60 Minutes. "I think most people would agree that a future where we are a spacefaring civilization is inspiring and exciting compared with one where we are forever confined to Earth until some eventual extinction event."

Regardless of the setbacks at the barge, SpaceX's efforts at reusability have sparked renewed interest in an arena historically littered with defeats, offset by only modest successes. The space shuttle orbiters required a small army of contractors to get them ready for their next missions. The shuttle's solid rocket motor casings were fished out of the ocean and refilled. The U.S. Air Force has flown four mysterious missions since 2010 with a spaceplane called the X-37B, but it is launched atop expendable Atlas 5 rockets. In the commercial world, every liftoff today ends just like those decades ago, with engines, cases and electronics burned up in the atmosphere, sent to a disposal orbits or dumped into oceans. That includes the 45.7-meter tall first stage of the Falcon 9, and the nine Merlin 1D engines that SpaceX has designed to be reusable.

SpaceX has now been joined in the reusability renaissance by two competitors: Airbus, which makes the French Ariane rockets, and United Launch Alliance, the joint venture of Boeing and Lockheed Martin that supplies Delta 4 and Atlas 5 rockets. Success on reusability could mean dramatically reduced launch costs, with Musk regularly predicting that prices could someday shrink to 100th of today's levels.

But achieving reusability will be no easy feat. The Falcon stages have crashed or toppled on two attempts. Airbus has a small prototype of the winged module it wants to build to whisk rocket parts from the fringes of space back to a runway. ULA plans to use a helicopter to grab parts in mid-air, but the concept has not yet been tested in a rocketry context. Perhaps most challenging, the economic underpinnings of reusability — buy it once, use it many times — have not been proven in practice.

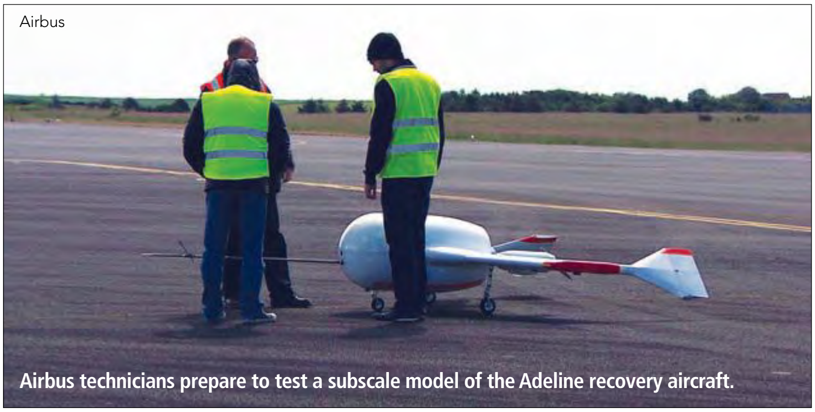
"The reason there are no reusable rockets in the world right now is because the business case is awfully tough to close," says George Sowers, ULA vice president for advanced concepts and technologies. "It's never been about the technology to recover and reuse stuff, it's whether you can do that and save money," he says.

How is the industry meeting the reusability challenge? For starters, by accepting some government research dollars but steering clear of the government's visions of spaceplanes roaring down runways and blasting to orbit powered by exotic engines. "We tried to make great jumps," says Daniel Dumbacher, who retired from NASA in

The U.S. Air Force's X-37B Orbital Test Vehicle taxis on the flightline in 2009 at Vanderberg Air Force Base, California. The secretive spaceplane is part of on-going efforts to develop reusable orbiters

by Debra Werner
werner.debra@gmail.com

Airbus

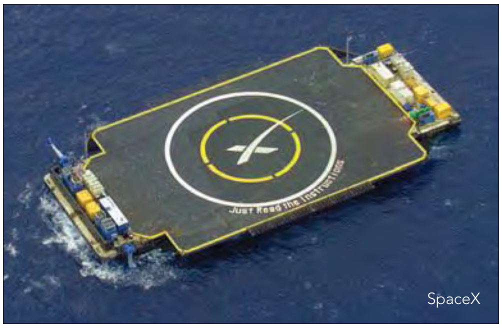


Airbus technicians prepare to test a subscale model of the Adeline recovery aircraft.

2014 and once oversaw the shuttle's propulsion systems, the X-37B when it was still a NASA project and initial work on the expendable Space Launch System. Today, "commercial industry is instead chipping away at the problem."

SpaceX's plans aren't as bold, but they retain the goal of reusing an entire launch vehicle. Airbus and ULA view the economics differently. They want to recover just the most valuable equipment: the rocket engines from the first stages of their future rockets, plus avionics in the case of Airbus.

A key cost driver will be the strategy for bringing the reusable stage or components home. Visionaries of the past wanted to circle Earth and use small rockets or engines to position the craft for reentry and landing back at the launch site or a runway of choice. Reserving fuel for recovery took up mass and volume that could have been dedicated for launch customers, and so reusability enthusiasts have had an epiphany: Why not let the rocket stages or modules fall toward Earth more or less where gravity takes them, and then use rockets, small wings or mid-air grappling techniques to recover them? The components could then be carried back to the launch site or factory by a far less expensive cargo plane, or a barge in the case of SpaceX



SpaceX

Unfulfilled goal: SpaceX's floating platform in the Atlantic Ocean is the intended landing site for the spent first stages of Falcon 9 rockets. Two attempts failed, a third was foiled by a launch failure.

"If you could land downrange, you'll have a lot more payload capacity," says aerospace design engineer John Livingston, who spent more than 40 years with the U.S. Air Force working on space and hypersonic flight projects.

Coming close

Musk's approach to reusability is an incremental one, starting with setting the first stage of a Falcon 9 onto a 52-meter-wide platform floating in the Atlantic Ocean about 200 miles from the Cape Canaveral launch site. The rocket stage has had no trouble finding the platform, but the end game has been trickier. On the first attempt, the booster crashed into the deck. The second time, it managed to touch down, but then tipped over and exploded.

By contrast, Airbus Defence and Space of France is designing Adeline, which stands for Advanced Expendable Launcher with Innovative Engine Economy. It will be a winged module that will carry the first-stage engine and avionics of a future rocket back to a runway landing. Two rotary motor-driven propellers will be unfolded to propel the module. Adeline won't be ready for the first Ariane 6 rockets, but it could be added to later versions.

United Launch Alliance plans to reuse just the two methane-fueled BE-4 engines built by the Jeff Bezos-owned Blue Origin. The engines will be expensive and powerful, providing a combined 1.1 million pounds of thrust for the first stage of the forthcoming Vulcan launcher that will succeed the Delta 4 and Atlas 5.

"The future for reusable rockets looks pretty darn bright after 25, 30 years of false starts," says Livingston. He predicts SpaceX will succeed in landing and reusing a first stage and, eventually, an entire rocket.

Economic questions

Landing on the barge would not answer questions about the economic logic of reusability, something that is far from a no-brainer. Companies would avoid throwing away expensive parts, but those parts would need to be more rugged and, therefore, more expensive to build than those on expendable versions. Plus, after each flight, engineers and technicians would need to test components and refurbish anything that might not last another trip. Reusing rockets or parts of rockets will mean building fewer of them, which tends to drive up unit costs.

Because reusable rockets cost more to build and fly, the idea only pays off if the rockets fly many times and keep up a swift tempo, says Mark Lewis, former U.S. Air Force chief scientist and director of the nonprofit Science and Technology Policy Institute, which is part of the Instiute for Defense Analyses in Washington, D.C. The specific number of flights required and tempo needed to make reusable rockets less expensive than expendables will vary with each launch vehicle. Lewis doesn't know if there is enough demand for all those flights, but he says some people in the space industry are convinced that if launch costs are low enough, new customers will appear.

There can also be surprises, not all of them good ones. NASA's Space Shuttle orbiters cost far more and flew far less frequently than engineers imagined at the outset. NASA wanted to fly shuttles 50 to 60 times a year, with each main engine lasting for 55 flights. Instead, the shuttle launch tempo peaked with nine flights in 1985, and it took a team of 10,000 people nine months to refurbish each orbiter before the next flight.

To operate economically, a reusable rocket will have to be far more rugged than the Space Shuttle, whose main engine components, including the high-pressure turbopumps, had to be removed and inspected after each flight. The ball and roller bearings that supported the turbopump shaft wore out quickly, which added wear and tear on the pump impeller and turbine, according to a 2001 article in the journal Lubrication Engineer. Future reusable rockets should be designed to handle loads "over and above" the ones they are expected to encounter in flight and should include "a propulsion system that can operate when you need it to and how you need it to without a whole lot of tender loving care between missions," says Dumbacher, now a professor of aeronautics and astronautics engineering at Purdue University. "It's not as easy as it looks."

Competing concepts

Airbus, which builds Europe's Ariance rockets, says it will harness unmanned aircraft flight control systems developed by the company's military aircraft arm to bring Adeline's engine module home for a horizontal runway landing. Airbus also will tap re-entry materials and heat shields from its Ariane rocket series. Before Adeline demonstrators begin flying around 2017 or 2018, Airbus engineers will need to develop an aeroshape capable of transitioning from su-

NASA, ULA collaborate on descent tech

NASA engineers looking for a better way to protect Mars landers from the heat of plunging toward the surface have settled on the same solution as engineers at United Launch Alliance, who need to protect the engines of the company's forthcoming Vulcan rockets as they fall back to Earth to be reused. Both camps plan to use inflatable heat shields.

Given their similar needs, ULA and NASA are now discussing a possible joint test in 2018 of the Hypersonic Inflatable Aerodynamic Decelerator technology developed at NASA's Langley Research Center in Virginia. Funding has not yet been identified, but if all goes as hoped, a five- to six-meter inflatable heat shield would be brought back from orbit at a speed of 7.5 kilometers per second.

"This would serve as a half-scale demonstration of what ULA would need for Vulcan and NASA need for the [Mars Entry, Descent, Landing Pathfinder] mission," says Neil Cheatwood, NASA Langley senior engineer for advanced planetary entry, descent and landing systems.

Both groups will need a heat shield of about 10 meters to 12 meters in diameter. ULA plans to use its shield to return the Vulcan's two first-stage BE-4 engines. NASA wants to use its version for the proposed unmanned pathfinder mission ahead of delivering crew and cargo to Mars in the 2030s. Those missions would require a slightly larger shield of 15 meters to 20 meters.

ULA began looking into the technology about six years ago when staff contacted NASA Langley to check out the hypersonic decelerators, long before ULA began work on the forthcoming Vulcan rocket it announced in April.

Debra Werner

NASA has been testing a prototype inflatable heat shield as part of the research to one day land humans and cargo on Mars.

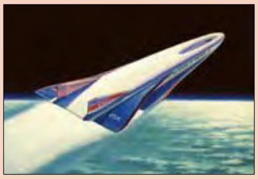
UNFULFILLED QUESTS

Plans for rockets and spacecraft rugged and economical enough for reuse have historically been derailed by high price tags, technical failures or lack of interest. Now, sparked in part by SpaceX, the industry is intensifying efforts to reuse rocket engines or entire first stages.

Here are some of the attempts from the 1960s to the present:

Boeing X-20 Dyna-Soar: *A delta-wing reusable spaceplane proposed by the U.S. Air Force but never flown. The hypersonic glider's nose cap was to be made of graphite and zirconia composite and would of had three retractable struts for landing. Boeing landed the contract in 1959, but the Pentagon killed the X-20 in 1963 for lack of viable military use.*

McDonnell Douglas DC-X: *A low-altitude experimental prototype that took off straight up and landed on its base. Dubbed the Delta Clipper, the DC-X was originally developed for the Pentagon. The conical-shaped, 39-foot unmanned rocket was built by McDonnell Douglas and made its first vertical takeoff and landing in August 1993. It flew 11 more times through 1996 before the technology was transferred to NASA. The agency eventually created the DC-XA (Delta Clipper Experimental Advanced) program but abandoned it in 2003.*



X-30 National Aero-Space Plane: *Secretive program announced in 1986 by President Ronald Reagan, who envisioned NASP as "a new Orient Express" that in two hours would fly from Washington, D.C., to Tokyo. The single-stage-to-orbit vehicle also was billed as a hypersonic space launch vehicle that would take off and land from a conventional runway for aircraft-like operations. Supporters argued that the X-30 would lead to civilian and military derivatives that would ferry cargo and humans to low-Earth orbit. Work on the X-30 ended in 1993 amid budget cuts before any flight demonstrations.*

X-33: *A proposed spaceplane demonstrator intended to clear the way for construction of a cheaper successor to the space shuttle fleet. NASA chose Lockheed Martin in 1996 to design and build the reusable launch vehicle. The agency scrapped the X-33 in 2001, after one of its two liquid hydrogen tanks ruptured during testing.*

Orbital Sciences X-34: *NASA began working on the X-34 in 1996 to build a reliable and reusable spacecraft that would be dramatically cheaper to operate. The unmanned X-34 was designed to travel 50 miles above Earth and reach up to eight times the speed of sound. It made three captive flights in 1999 attached to an L-1011 carrier plane, but never left the ground again. NASA ended the program in March 2001. A review by NASA and Orbital Sciences in 2000 had concluded that changes were needed to ensure the safety and success of the X-34 program.*

Boeing X-40 Space Maneuver Vehicle and X-37 Orbital Test Vehicle: *Boeing received a contract from the U.S. Air Force in 1996 to develop the X-40, a precursor to the X-37 unmanned Orbital Test Vehicle. The X-40, whose shape was reminiscent of the space shuttle, first flew in August 1998 after being dropped from a cradle below a UH-60 helicopter. The Air Force then turned the X-40 over to NASA to use as testbed for the larger X-37 space plane. Then in 2004, NASA transferred the program to DARPA. Two years later, the Air Force announced plans to develop its own variant, dubbed X-37B. The Air Force has shared few details about the X-37B, which in May made its fourth trip to orbit.*

SpaceX Grasshopper: *A 10-story, first-stage Falcon 9 rocket prototype built to test vertical-landing technologies. The Grasshopper was revealed in 2011 when SpaceX applied for an FAA permit to test an experimental reusable launch vehicle. Grasshopper had a single Merlin 1D engine, four steel landing legs with hydraulic dampers, and a steel support structure. Starting in September 2012, SpaceX conducted eight successively higher hops, with Grasshopper reaching 2,440 feet on its eighth and final flight in October 2013. SpaceX retired the Grasshopper that month, and moved on to developing the larger Falcon 9 Reusable Development Vehicle.*

personic to subsonic speeds and a propeller system that can be stowed during the rocket's ascent and unfolded for Adeline's descent, says Benoît Isaac, the Adeline program manager.

As for ULA, the first flights of the Vulcan are planned for 2019, but ULA doesn't plan to start reusing BE-4 Vulcan engines until about 2024, even though they are designed from the start for reusability. ULA will begin recovering BE-4 engines in 2023 to gain experience with the technique and inspect the engines in preparation for reusing them. ULA won't try to recover the Centaur RL-10 engine or the Advanced Cryogenic Evolved Stage engine that will replace it, because they are not designed to be reusable and recovering them would use too much fuel.

On a reusable mission, ULA's Vulcan booster will finish firing, separate from the second stage, and at about 750,000 feet the first stage will jettison a module containing its two BE-4 engines. The module will inflate a heat shield to slow its descent and minimize damage during atmospheric reentry. A parafoil and tether will be released closer to the ground and a heavy-lift helicopter will grab the tether. ULA hasn't determined which heavy lift helicopter it will use.

"Midair recovery is not very difficult," Sowers says. "We have follow-on recovery plans that we are not yet ready to reveal. This is the incremental approach to reusability."

ULA initially studied the pros and cons of recovering Vulcan's entire first stage — rather than just the two engines — and it found that approach would lead to higher costs than an expendable rocket.

"It doesn't payoff to recover the fuel tanks," Sowers says. Bringing back the BE-4 main engines does make sense because those engines comprise 25 percent of the booster's weight and 65 percent of its cost.

Midair recovery has been around since the 1960s when the Central Intelligence Agency's Corona spy satellite ejected 70-millimeter film in a reentry capsule. ULA and Airbus are drawing on state-of-the-art materials and technology to refine their competing techniques.

NASA's Langley Research Center in Hampton, Virginia, is working with ULA to develop inflatable heat shields to protect Vulcan's booster engines during multiple atmospheric reentries. The heat shields, which Langley has been developing for about a decade, look like a stack of donuts that peaks above the tip of the rocket. Each donut is comprised of a synthetic polymer covered with a layer of flexible, high-temperature insulation.

Funding

Airbus, ULA and SpaceX each receive some government funding for their launch programs, but they have largely conducted reusable rocket studies with internal research and develop funds. Airbus, for instance, has invested about 15 million euros on Adeline since the project began in 2010, Isaac says.

That private backing gives these ventures an important boost, rocket experts say, because while government is good at pushing the technology envelope, private enterprise is good at honing in on the problem and finding creative, cost-efficient solutions. Startups like SpaceX and Blue Origin tend to be more inventive, flexible, efficient and fast, Livingston says.

"That's the drive that's going to lead to reusable rockets in a reasonably short amount of time," he adds.

Anxious for reusable rockets

A SpaceX animation online shows two Falcon Heavy first stage boosters, the rocket's upper stage and the Dragon cargo and crew capsule launching and then landing separately on a cluster of pads at a seaside launch site. The parts then would be reassembled for the next launch. That scenario might be years away, but SpaceX already has leased landing pads for Falcon 9 and Falcon Heavy boosters at Cape Canaveral in Florida and at Vandenberg Air Force Base in California. SpaceX began flying a low-altitude experimental vehicle called Grasshopper in 2012 at its test range in McGregor, Texas, to practice landings. These flights that paved the way for the barge attempts.

Rocketeers are anxious to see the competitors make progress toward that type of fully reusable rocket, they concede that the incremental approach makes a lot of sense.

"One thing we've learned in aerospace writ large is crawl, walk, run," Lewis says. "If you try to run or even walk before you're ready, you fall."

25 Years Ago, September 1990

Sept. 29 The YF-22 Advanced Tactical Fighter flies for the first time when it takes off from the Lockheed Skunk Works plant in Palmdale, California. U.S.The Air Force subsequently awards an $11 billion contract to Lockheed/Boeing/General Dynamics to further develop and manufacture the plane that is to replace the F-15. The total program cost for manufacturing a planned 648 F-22 fighters is $60 billion. Flight International, October 10, 1990.

50 Years Ago, September 1965

Sept. 1 Frank Hearle, one of the leading early British aviation pioneers, dies at 78. He was the first associate of Sir Geoffrey de Havilland and helped design and build de Havlland's first airplane engine in 1908. During World War I, he worked in the aviation department of Vickers Ltd. and helped the company establish an aircraft factory near Weybridge, England. In 1920, he, along with four others, founded the de Havilland Aircraft Co. and he became managing director from 1930 to 1945 and chairman in 1950 until his retirement in 1954. Flight International, September 9, 1965, p. 448.

Sept. 2 The Paraglider makes its first successful manned free-flight, thereby demonstrating it can guide a spacecraft to a pre-selected landing site. The test pilot, Donald F. McCusker, lands a Gemini-type test craft carried by the Paraglider at Edwards Air Force Base, California. This test is conducted by North American Aviation for the NASA Manned Spacecraft Center. However, the Paraglider mode of recovering and landing U.S. spacecraft is not adopted. North American Aviation, Skywriter, September 3, 1965, p. 1.

Sept. 3 France launches the second of its two-stage Dragon sounding rocket from Skogasandur, Iceland, to a top altitude of 248 miles, carrying a payload with instruments to study protons and electrons in the Van Allen radiation belt. New York Times, September 5, 1965, p. 48.

Sept. 3 A Soviet SL-8 (U.S. Department of Defense designation) rocket carries a series of the first pre-operational tactical military communications satellites into orbit. The 110-pound satellites are designated Cosmos 80 to 84. One of the satellites has a radioisotope thermoelectric generator for generating electrical power. A second Soviet launch of four satellites with one vehicle is made on September 18. David Baker, Spaceflight and Rocketry, p. 184.

Sept. 10 Henri Mignet, famous French pioneer designer and builder of home-built aircraft from the 1930s, dies at 71. His most popular design was the Pou de Ciel (Flying Flea), with its tandem-wing concept. He also developed the H.M. 8 classic ultra-light monoplanes of which more than 200 were built. For his many accomplishments, Mignet received several distinguished awards. Flight International, September 23, 1965, p. 530.

Sept. 25 At its Dade County, Florida, test facility, Aerojet General test fires a half-length 260-inch diameter solid-propellant rocket motor that develops 3.6 million pounds of thrust and is the largest solid-propellant rocket in the U.S. at this time. The test is part of the national large solid-motor technology program, initiated in 1963. David Baker, Spaceflight and Rocketry, p. 184.

Sept. 28 In its 150th flight, the X-15 rocket research aircraft is flown by NASA research pilot John B. McKay to 295,600 feet and at a top speed of 3,682 mph (Mach 5.53). This is the fourth-highest altitude reached by the plane. The mission of the flight is to measure the boundary layer noise, test a horizontal scanner, and measure aerodynamic and structural loads on the horizontal tail surfaces. NASA Release 65-310.

Sept. 29 American Jerrie Mock sets a new speed record for single-engine aircraft over a 500 kilometer (304 miles) course when she reaches

Past

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

203.85 mph in her flight that lasts one hour, 31 minutes, and 27 seconds. The previous record was 178 mph set in 1956 by Czech pilot Lubos Stastny. Washington Post, September 30, 1965, p. D6.

Also During September 1965

— Wendell F. Moore of Bell's Aerospace Systems Co., is named the recipient of The Franklin Institute's John Price Wetherill Medal for his invention of the "small rocket lift device," popularly called the rocket "jet belt." The basic concept of a "rocket belt" goes back far earlier and appeared in Buck Rogers comic strips in the late 1920s. Aviation Week, September 13, 1965, p. 23.

— An upgraded version of the U.S. Navy's RF-8A photo reconnaissance planes, dubbed the RF-8G, takes off from Hensley Naval Air Station in Dallas for the first flight of the new planes. Ling-Temco-Vought, the manufacturer, is awarded $13 million by the Navy to modernize the RF-8As to this new configuration for general fleet duty. Aviation Week, September 13, 1965, p. 31.

75 Years Ago, September 1940

Sept. 7 The giant six-engine Blohm and Voss BV 222 flying boat makes its first flight. Later called Wiking, it becomes one of the largest flying boats used during World War II. J.R. Smith and Antony Kay, German Aircraft of the Second World War, pp. 75-81.

Sept. 8 It is announced that Marshal of the Reich Hermann Goering, air minister and commander-in-chief of the German air force, has assumed command of Luftwaffe operations for the first time since the outbreak of World War II. Interavia, September 10, 1940, p. 16.

Sept. 9 Viennese-born German aircraft designer Edmund Rumpler dies at age 68 in Mecklenburg, Germany. Rumpler is credited with designing one of the first German automobiles, in 1897. He entered aviation in 1908 and soon created a series of prize-winning airplanes. In 1912, he built the first airplane in Germany with an enclosed cabin and "V" eight-cylinder engine. By 1918, Rumpler's factory had built 1,400 planes for the Imperial German Army. In 1927 Rumpler designed an enormous twin-hull flying boat weighing 250,000 lb and capable of carrying 170 persons, but could not find financial backers. New York Times, September 10, 1940, p. 23; Edmund Rumpler file, National Air and Space Museum.

Sept. 20 The first production model of the Lockheed P-38 twin-engined interceptor-fighter ordered by the U.S. Army makes its first trial flight. The Army orders approximately $52 million worth of these planes. Interavia, October 4, 1940, p. 7.

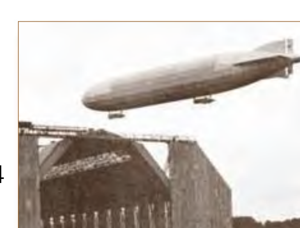
Sept. 24 By this date, the German Luftwaffe counts two fighter pilots with 40 downed-enemy aircraft each. Maj. Werner Molders and Maj. Adolf Galland earn Oak Leaves to the Knight's Insignia of the Iron Cross. Molders is the first to be awarded this distinction by Hitler. He does not survive the war. By 1941, at age 29, Galland becomes a general and commander of the fighter arm. He is also the best known German ace in the war, with a total of 104 victories. Interavia, Sept. 25, 1940, p. 11; RAF Flying Review, August 1961, pp. 27-28.

Also During September 1940

— An order for 600 Hawker Hurricane fighters is placed with Canadian Car and Foundry in Ontario by the British government. The planes are built here because the Hawker factories in the U.K. are within range of German bombers. Flight, September 5, 1940, p. 189; Profile Publications, The Hawker Hurricane 1, pp. 7-8.

100 Years Ago, September 1915

Sept. 8 In the most destructive raid against London during World War I, a German Navy rigid airship, Zeppelin L13, begins its attack at 10:40 p.m. .Airship commander Heinrich Mathy drops bombs all over the city, including the first use of a 660-pound explosive device. A total of 26 people are killed with another 94 injured. David Baker, Flight and Flying: A Chronology, p. 80.



Also During September 1915

— Aviator Fred Hoover delivers the Chicago American newspaper between Chicago and Elgin, Illinois, in 28 minutes while the same trip takes an hour by ground. Later, by the 1920s, planes become a standard means of delivering papers and special devices are invented to drop the bundles to the ground. Aerial Age, September 13, 1915, p. 624.

Tenure Track Faculty Position

Assistant Professor of Aerospace – Space Engineering

The Division of Engineering and Applied Science at the California Institute of Technology invites applications for a tenure-track position in the Department of Aerospace (GALCIT). Our department is a unique environment where innovative, interdisciplinary, and foundational research is conducted in a collegial atmosphere and in strong collaboration with the Jet Propulsion Laboratory (JPL). We are looking for candidates who have demonstrated exceptional promise in a field related to **Space Engineering**. Research areas of particular interest include but are not limited to **dynamics, guidance and autonomous control of distributed spacecraft systems, space mission architecture and implementation**. A commitment to teaching and mentoring is expected.

Candidates should submit an online application at **https://applications.caltech.edu/job/galcit**.

CALIFORNIA INSTITUTE OF TECHNOLOGY

Division of Engineering and Applied Science

Caltech is an Equal-Opportunity/Affirmative-Action Employer.

Women, minorities, veterans, and disabled persons are encouraged to apply.

Caltech

UNIVERSITY OF CENTRAL FLORIDA

MECHANICAL AND AEROSPACE ENGINEERING

The University of Central Florida (UCF) announces multiple tenure / tenure track faculty positions at all ranks to be filled by the Department of Mechanical and Aerospace Engineering (MAE) in the College of Engineering and Computer Science (CECS). This hiring program is part of a comprehensive growth plan to significantly increase the faculty size. Candidates with backgrounds in any area of mechanical or aerospace engineering or related disciplines will be considered. Exceptionally well-qualified candidates will be considered for endowed chair positions. For information about the department, please visit our website at www.mae.ucf.edu.

The MAE department offers B.S., M.S. and Ph.D. degree programs. Both BSAE and BSME programs are ABET-accredited. The MAE Department is home to 31 full-time faculty members, several adjuncts, and the Center for Advanced Turbines and Energy Research (CATER). The reputation of the department is continually growing with numerous faculty achievements including NSF CAREER awards, an ONR Young Investigator Award, and fellowships in professional societies.

Located in Orlando, FL, UCF is one of the nation's most dynamic metropolitan research universities, having been recognized as a "very high research activity" institution by the Carnegie Foundation. UCF is ranked consistently in the top 10 in the country in the impact of its patents and on the top list of "Up-and-Coming Schools" by U.S. News & World Report.

Review of applications will begin immediately and continue until the positions are filled. We expect the selected candidates will start in August 2016 or earlier.

UCF is an equal opportunity/affirmative action employer. All qualified applicants are encouraged to apply, including minorities, women, veterans and individuals with disabilities.

For more information on the positions and to apply, please visit http://www.jobswithucf.com/postings/42399.

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of Electronic and Computer Engineering and Department of Mechanical and Aerospace Engineering Joint Faculty position

The Department of Electronic and Computer Engineering (ECE) and the **Department of Mechanical and Aerospace Engineering** (MAE) invite applications for a joint faculty position at the rank of Assistant Professor in the interdisciplinary area of modern avionics. Applicants should have a PhD with demonstrated strength in research with a strong commitment to teaching. Successful candidates are expected to lead an active research program, and to teach both graduate and undergraduate courses in the area of avionics such as the command and control, navigation, electronics, communication and electric power of modern aircrafts. The appointee is expected to supervise graduate students and provide a link between faculties in ECE and MAE to nurture the avionics area into the aerospace program. Areas of research and interests may include: high-performance embedded systems and sensors, automatic flight control and navigation systems, intra and inter-aircraft communications, as well as other related areas in modern Integrated Modular Avionics (IMA).

The Hong Kong University of Science and Technology is a world renowned, international research university in Asia's most vibrant city, Hong Kong. Its Engineering School has been consistently ranked among the world's top 25 since 2004. The high quality of our faculty, students and facilities provide outstanding opportunities for faculty to pursue highly visible research programs. All formal instruction is given in English and all faculty members are expected to conduct research and teach both undergraduate and graduate courses. The Departments of ECE and MAE have excellent computing resources, and state-of-the-art teaching and research laboratories. Currently the Department of ECE has 40 faculty members, over 800 undergraduate students and 350 postgraduate students. The Department of MAE has 27 faculty members, over 400 undergraduate students and 350 postgraduate students. The University is committed to increasing the diversity of its faculty and has a range of family-friendly policies in place.

Starting salary will be commensurate with qualifications and experience. Fringe benefits including medical and dental benefits, annual leave and housing will be provided where applicable. Initial appointment will normally be on a three-year contract. A gratuity will be payable upon successful completion of contract. Re-appointment will be subject to mutual agreement.

Applications including full curriculum vitae, list of publications, names of five referees addressed to Professor Vincent Lau, Chair of the Search Committee, should be sent by email to eesearch@ust.hk. Applications will be considered until the position is filled.

More information about the departments is available on the websites:www.ece.ust.hk and www.mae.ust.hk.

(Information provided by applicants will be used for recruitment and other employment-related purposes.)

AEROSPACE ENGINEERING

UNIVERSITY of MICHIGAN ■ COLLEGE of ENGINEERING

Faculty Search - Aerospace Engineering, University of Michigan

The Department of Aerospace Engineering at The University of Michigan invites applications for multiple tenure-track/tenured faculty positions in all areas of Aerospace Engineering. We are seeking exceptional candidates who will develop a world-class research program and innovative educational experiences for our students. This is a broad search, and while we will be considering all levels, preference will be given to junior-level applicants.

The Aerospace Engineering Department completed its 100th anniversary last year and our undergraduate and graduate programs continue to be among the very best in our nation. Research interests of the faculty cover a broad spectrum of topics including high-performance multiphysics computational sciences, aerostructures, smart structures and materials, flight dynamics and control, avionics and software systems, multidisciplinary design optimization, propulsion, combustion, and sustainable energy with a mix of air and space applications. More information about the department can be found at aerospace.engin.umich.edu. Applicants should have earned a doctoral degree in Aerospace Engineering or a closely related field. The successful candidate will be expected to participate in all aspects of the Department's mission, including the development of a strong and relevant externally funded research program, the teaching of undergraduate and graduate courses, and the supervision of graduate students.

Applicants should send an email with an attached single PDF file that contains their curriculum vita, statements of research and teaching interests, three representative publications, and the names and contact information of five references to the Faculty Search Committee, c/o Prof. Carlos Cesnik, Department of Aerospace Engineering, University of Michigan at aero-search@umich.edu. The evaluation process will start on November 1, 2015 and will continue until the positions are filled.

The University of Michigan is an equal opportunity/affirmative action employer with an active dual-career assistance program. The college is especially interested in candidates who can contribute, through research, teaching, and/or service, to the diversity and excellence of the academic community.

AIAA Bulletin

The AIAA Los Angeles-Las Vegas Section held an Aerospace Career Mentoring event on 9 April, where five high-profile individuals from the industry spoke about how they managed their careers at different stages; how to start a business; what were the best decisions they made; and what are the right times to ask for a raise/promotion or look for a new job. From left: Nicola Sarzi-Amade, section chair; Debbie McKenna, director of Engineering Intelligence, Surveillance and Reconnaissance Division, Northrop Grumman; Dr. Claire Leon, director of the Launch Enterprise Directorate, U.S. Air Force; Dr. Garrett Reisman, former Shuttle astronaut and director of Crew Operations, SpaceX; Dr. Ivan Rosenberg, president and CEO, Frontier Associates, Inc.; Ninh Le, Workforce and Career Development Chair and event organizer; and Dr. Kent Tobiska, president and chief scientist, Space Environment Technologies. (*Photo credit: Michael Todaro*)

See what else the AIAA Los Angeles-Las Vegas Section has been busy with on page **B10**.

SEPTEMBER 2015

AIAA Directory

AIAA HEADQUARTERS
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
www.aiaa.org

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

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

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

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

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

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

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2015			
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)	
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)	
12–14 Oct†	**24th International Meshing Roundtable**	Austin, TX (Contact: Kathy Loeppky, 505.844.2376, kloeppk@sandia.gov, www.sandia.gov/imr)	
12–16 Oct†	**66th International Astronautical Congress**	Jerusalem, Israel (Contact: www.iac2015.org)	
26–29 Oct†	**International Telemetering Conference USA**	Las Vegas, NV (Contact: Lena Moran, 951.219.4817, info@telemetry.org, www.telemetry.org)	
27–29 Oct†	**Flight Software Workshop**	Laurel, MD (Contact: http://www.flightsoftware.org)	
11–14 Nov†	**31st Annual Meeting of the American Society for Gravitational and Space Research (ASGSR)**	Alexandria, VA (Contact: Cindy Martin-Brennan, 703.392.0272, executive_director@asgsr.org, www.asgsr.org)	
2016			
2–3 Jan	**2nd AIAA CFD Aeroelastic Prediction Workshop**	San Diego, CA	
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**
25-28 Jan†	**Annual Reliability and Maintainability Symposium (RAMS)**	Tucson, AZ (Contact: Sean Carter, seancarter67@gmail.com, www.rams.org)	
14–18 Feb†	**26th AAS/AIAA Space Flight Mechanics Meeting**	Napa, CA (Contact: Ryan Russell, 512.471.4190, ryan.russell@utexas.edu, www.space-flight.org/docs/2016_winter/2016_winter.html)	
8–10 Mar	**AIAA DEFENSE 2016 (AIAA Defense and Security Forum)** **Featuring:** **AIAA Missile Sciences Conference** **AIAA National Forum on Weapon System Effectivenss** **AIAA Strategic and Tactical Missile Systems Conference**	Laurel, MD	
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)	
19–21 Apr†	**16th Integrated Communications and Surveillance (ICNS) Conference**	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, http://i-cns.org)	
16–20 May†	**SpaceOps 2016: 14th International Conference on Space Operations**	Daejeon, Korea	**30 Jul 15**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
30 May–1 Jun†	**23rd Saint Petersburg International Conference on Integrated Navigation Systems**	Saint Petersburg, Russia (Contact: Ms. M. V. Grishina, +7 812 499 8181, icins@eprib.ru, www.elektropribor.spb.ru)	
13–17 Jun	**AIAA AVIATION 2016 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **34th AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **8th AIAA Atmospheric and Space Environments Conference** **16th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference** **46th AIAA Fluid Dynamics Conference** **17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **47th AIAA Plasmadynamics and Lasers Conference** **46th AIAA Thermophysics Conference**	Washington, DC	**5 Nov 15**
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** **AIAA Complex Aerospace Systems Exchange**	Long Beach, CA	
25–30 Sept†	**30th Congress of the International Council of the Aeronautical Sciences (ICAS 2016)**	Daejeon, South Korea (Contact: www.icas.org)	**15 Jul 15**
25–30 Sept†	**35th Digital Avionics Systems Conference**	Sacramento, CA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)	
26–30 Sept†	**67th International Astronautical Congress**	Guadalajara, Mexico (Contact: http://www.iafastro.org/guadalajara-to-host-iac-2016)	

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

LIFE, IT'S FOR LEARNING!

Jim Albaugh, AIAA President

In July, the U.S. Department of Labor and the American Association of Engineering Societies (AAES) announced the "Engineering Competency Model," (**http://www.careeronestop.org/CompetencyModel/competency-models/engineering.aspx**) developed jointly with the assistance of a generous grant from the United Engineering Foundation. The document details, for the first time, a collection of competencies, ranging from basic social skills to higher level managerial skills, that engineers—in any discipline—should possess if they plan on advancing through their careers in meaningful and rewarding ways. The model's development is especially critical as the engineering profession is projected to grow "8.6% over the next ten years, with 544,000 new engineers entering the [work force]," according to AAES.

Encompassing six specific skill levels in a pyramid, with categories ranging from "Initiative" and "Professionalism" at the bottom, "Industry Wide Technical Competencies" in the middle, to Management Competencies like "Networking" and "Staffing" at the top, the model at first can appear daunting. However, it is a framework that we all can use, from young professionals to seasoned veterans like myself, to measure our careers and ascertain what we have to "work on next" to advance in our profession. Indeed, the common theme and most clear message of the competency model is the importance of lifelong learning. Having this framework is important. In aerospace engineering, there is no code requiring professional certification, nor are there professional engineering certification programs for aerospace engineers. Typically our own initiatives guide our ongoing quest for knowledge and skills as we seek out the professional development programs that will help us learn more. Our profession is not like others, such as medicine, where discrete, well-understood pathways are defined for professional development. The Engineering Competency Model is a construct that will guide all engineers, including aerospace professionals, in the pursuit of knowledge and skills. Most of all, it answers the question: "What must I know to move ahead?"

"Lifelong learning" has been defined as learning that is "ongoing, voluntary, and self-motivated," and we, as engineers, can't help but engage in that type of learning. Not a day goes by where we do not learn a new axiom, fact, or method that will aid us tomorrow in our jobs. At its heart, the Engineering Competency Model reminds us that we are all lifelong learners. It highlights the fact that a wide variety of skill sets are required to produce a solid engineer, and that we need to learn, reassess, refine, and enhance our skill sets constantly. The model reminds us that if you don't learn, you can't advance – can you imagine only possessing the skills you had on the day you left college 30 years into your profession? Can you imagine if the Wright Brothers had walked away from Kitty Hawk saying, "well, that's that, nothing more to learn here"; or if we had simply given up after the Apollo 1 disaster, instead of asking what we could learn from that tragic incident? We have moved forward solely because we are willing to learn from our mistakes. We are willing to take what we learned yesterday and apply it to the challenges of today and tomorrow because we know that our community's future advances often depend on past lessons learned. In short, we are lifelong learners naturally by being engineers.

The Engineering Competency Model does more than remind us as engineers that we must be learners. It also helps educators, managers, human resources departments, and the C-suite realize as well that engineers are lifelong learners. With a defined competency model highlighting the important skills necessary for professional growth for engineers, these communities can design and offer appropriate development courses for our community regardless of our experience level. Programs such as tuition reimbursement, cross-discipline training, and, ideally, support of employee attendance at forums—like those offered by AIAA and other engineering societies—can be targeted at development goals outlined in the model. We do not learn in a vacuum, and we can't learn if the proper support networks or programs are not there to help us. Every one of us, regardless of our years in the industry or our position, should be able to take advantage of opportunities geared toward teaching new concepts, allowing for collaboration with community peers, and advancing our education to the next level possible. In supporting these activities, the community would be making wise investments of capital and time—investments that can be justified by referring to the competency model, and that will continuously pay dividends throughout the years. The Engineering Competency Model is a guide for workforce development.

If we stop learning, we stop advancing; if we stop advancing our engineering community suffers. We should embrace the Engineering Competency Model, but more importantly, we should embrace the knowledge that we are all lifelong learners and get out there and learn!!

CONGRATULATIONS!

AIAA congratulates the following winners of student paper competitions that were held during the AIAA Aviation and Aeronautics Forum and Exposition (AIAA AVIATION 2015).

Aeroacoutics Student Paper Competition

First Place: Francisco Lajus Jr., The Federal University of Santa Catarina, Florianopolis, Brazil

Atmospheric Flight Mechanics Student Paper Competition

First Place: Wendy Okolo, University of Texas at Arlington, Arlington, Texas

Computational Fluid Dynamics Student Paper Competition

First Place: Devina Sanjaya, University of Michigan, Ann Arbor, Michigan

Second Place: Pieter Boom, Institute for Aerospace Studies, Toronto, Canada

Third Place: Marc Henry De Frahan, University of Michigan, Ann Arbor, Michigan

Multidisciplinary Design Optimization Student Paper Competition

First Place: Yuxiang Zhou, TU Kaiserslautern, Aachen, Germany

Second Place: Ricardo Maiko Vehoka Entz, Airbus Group, University of Bremen, Munich, Germany

Atmospheric and Space Environment Student Paper Competition

First Place: Wendy Okolo, University of Texas at Arlington, Arlington, Texas

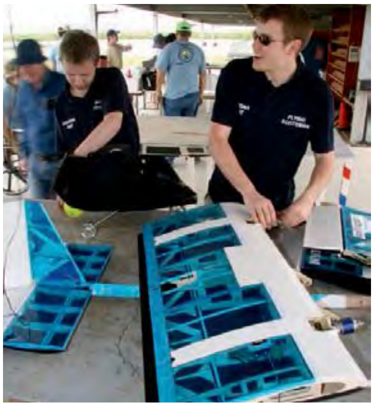
TWENTIETH ANNIVERSARY OF DESIGN/BUILD/FLY COMPETITION

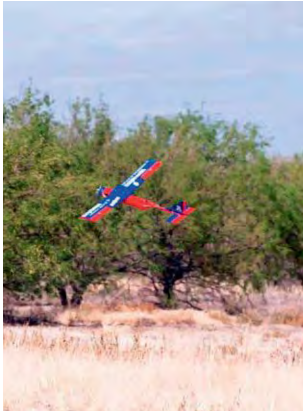
This academic year will mark the twentieth anniversary of the Design/Build/Fly (DBF) Competition. The competition was an idea outlined by the AIAA Applied Aerodynamics and Aircraft Design Technical Committees. These committees worked with the AIAA Student Activities Committee and the AIAA Foundation to formalize the competition as a regular event. The AIAA Design Engineering and Flight Test Technical Committees soon joined the effort to organize the contest each year.

Cessna Aircraft Company and the Office of Naval Research were the original corporate sponsors of the competition. Each took a turn hosting the event. One year it would be in Wichita, KS, at Cessna airfield, and the next year it would be in southern Maryland.

The first ever competition was hosted by BAI Aerosystems of Easton, MD, at the UAV flight test facility on Ragged Island. Eleven teams showed up to compete that year, and only five were successful in completing laps. The next year the competition was held in Wichita, KS. Seventeen teams showed up for this event, and eight were able to successfully complete laps.

During the 2006–2007 academic year, Raytheon Missile Systems came on board as a corporate sponsor, and the organizing committee of the competition gratefully thanked the Office of Naval Research for their many years of service and dedication to the competition.





The competition has grown and evolved quite a bit over the years. Originally there was a single mission profile. Teams were challenged to design an RC plane that could meet that one objective. Over the years, additional profiles were added to challenge students. In the last competition, teams had three different mission profiles that their plane needed to be able to complete. Ground missions have been incorporated in some recent years. These are missions that do not involve the flight of the students' aircraft, but are concerned with loading payloads, assembling the aircraft, or some other task.

The number of schools and teams has continued to increase over the years. The 2014–2015 academic year had over 100 schools that wanted to participate; and over 1,300 students were involved. Each year the students' success exceed the year before in both their ability to prepare a technical report on their aircraft and design a successful competitive aircraft.

While not every school can get the funding to attend the flyoff each year, there have been as many as 70 teams that have shown up to fly their aircraft. And several years every team that has shown up has successfully completed the technical inspection and been able to go to the flight line to attempt a mission.

To find out what the competition organizers have planned for the twentieth anniversary, visit the DBF website, **www.aiaadbf.org**. The website has the rules for this year, what the mission profiles are, and a look through the history of the competition.

MEMBERSHIP ANNIVERSARIES

AIAA acknowledges the following membership anniversaries.

50-Year Anniversaries

Donald L. Hide	North Texas
James L. Williams	North Texas
Donald R. Wilson	North Texas
Denny S. Chaussee	Iowa
Marc L. Sabin	Rocky Mountain
John W. Sunkel	Rocky Mountain
Paul B. Tucker	St. Louis
Alva L. Addy	Twin Cities
Douglas E. Ferguson	Wichita
Larry D. Frutiger	Wichita
Daryl G. Timmerman	Wichita
Robert L. Wethington	Wichita
George Sitterle	Antelope Valley
Timothy K. Hasselman	Los Angeles-Las Vegas
Marcus J. Jacobson	Los Angeles-Las Vegas
Walter C. Yeager	Los Angeles-Las Vegas
James G. Mc Comb	Orange County
Roberto J. Cittadini	Pacific Northwest
Robert D. La Prete	Pacific Northwest
Paul E. Rubbert	Pacific Northwest
Robert J. Buehler	San Diego
Alojzy A. Mikolajczak	San Diego
Ya-Tung Chin	San Fernando Pacific
Anthony F. Messina	San Fernando Pacific
Daniel P. Bencze	San Francisco
David Bushnell	San Francisco
Joseph G. Marvin	San Francisco
Joseph Mullen	San Francisco
John J. Rodden	San Francisco
Charles O. Wallin	San Francisco
Robert A. Jacobson	San Gabriel Valley
Peter T. Lyman	San Gabriel Valley
Angus D. McRonald	San Gabriel Valley
Bryan E. Richards	International

60-Year Anniversaries

James D. McBrayer	Central Florida
J. S. Przemieniecki	Central Florida
Marion L. Laster	Tennessee
Walter C. Roman	Columbus
Earl J. Slanker	Dayton/Cincinnati
Julian I. Palmore, III	Illinois
William B. Brooks	Albuquerque
Donald J. Rigali	Albuquerque
Peter D. Tannen	Albuquerque
Robert H. Page	Houston
Dale A. Anderson	Oklahoma
William G. Schweikhard	Southwest Texas
Richard C. Rozycki	Rocky Mountain
Verlan E. Edwards	Twin Cities
Edwin R. Berry	Los Angeles-Las Vegas
Ronald M. Gibb	Los Angeles-Las Vegas
Arthur B. Griffin	Los Angeles-Las Vegas
Ellis M. Landsbaum	Los Angeles-Las Vegas
Paul A. Lord	Los Angeles-Las Vegas
Robert R. Dow	Orange County
Norman R. Oxhorn	Orange County
George E. Bean	Pacific Northwest
Joel Godston	Pacific Northwest
John W. Herbert	Pacific Northwest
Charles W. Hurter	Pacific Northwest
John A. Paulson	Pacific Northwest
E. Roberts Wood	Point Lobos
Arnold Otchin	San Diego
Miles A. Nesman	San Fernando Pacific
William W. Regnier	San Fernando Pacific
Edmund Bruski	San Francisco
Gerald T. Chrusciel	San Francisco
Lars E. Ericsson	San Francisco
James H. McVernon	San Francisco
Harold O. Svendsen	San Francisco
Robert Sherman	International

70-Year Anniversaries

Herbert E. Peitzer	Northern New Jersey
Leonard E. Stitt	Northern Ohio
Laurence R. Soderberg	Rocky Mountain
Norman R. Bergrun	Sacramento
Arthur E. Bryson	San Francisco
Richard D. Fitzsimmons	San Francisco
George S. James	San Gabriel Valley
Samuel Kraus	Los Angeles-Las Vegas
Leslie M. Mack	San Gabriel Valley
John K. Wimpress	Pacific Northwest

FIFTEEN AIAA MEMBERS INDUCTED INTO LANGLEY RESEARCH CENTER HALL OF HONOR

The Langley Research Center NACA and NASA Hall of Honor was developed to honor individuals "whose contributions have had the most sustained and far-reaching influence on the leadership, direction, mission and capabilities of the NACA Langley Memorial Aeronautical Laboratory and NASA Langley Research Center and/or whose work at Langley enabled unprecedented and fundamental advancements in either a scientific or engineering field and made significant contributions to the United States' aerospace industry for commercial and military aircraft and/or spacecraft" (**http://www.nasa.gov/langley/hall-of-honor**).

The first 19 members were inducted into the Hall of Honor in August and included 15 AIAA members, eight Honorary Fellows and seven Fellows. The AIAA inductees were:

AIAA Honorary Fellows
Maxime Faget
Robert Gilruth
John Houbolt
Robert Jones
Christopher Kraft
John Stack
Fred Weick
Richard Whitcomb

AIAA Fellows
Ira Abbott
John Becker
Eastman Jacobs
Eugene Love
Max Munk
W. Hewitt Phillips
John Reeder

The Hall will induct members again in 2017, as part of the celebrations for NASA Langley's 100th anniversary.

AIAA EXECUTIVE DIRECTOR VISITED AIAA ADELAIDE AND AIAA SYDNEY SECTIONS IN MAY

In mid- to late May, Dr. Sandy Magnus, AIAA executive director, spent time in five Australian cities, meeting with members of the AIAA Adelaide and AIAA Sydney sections.

The AIAA Sydney Section planned a series of presentations called “Perspectives from Space—2015 AIAA National Lecture Tour,” where Dr. Magnus gave talks on her time as a NASA astronaut. She also had a chance to meet with local scouts as part of the tour.

Dr. Magnus had two full days planned in Adelaide, and the section made the most of her visit. An informal lunch was hosted by the Student branch members at the local market, and then it was straight to Adelaide High School for the first STEM outreach event. This was followed by a very successful AIAA Adelaide Section event where 20 AIAA members and Student Members met with Dr. Magnus in an informal setting to discuss various issues about AIAA and the opportunities it presents.

The next morning started with a visit to a local primary school for the second outreach event. After the school visit, Dr Magnus was taken to a local wildlife park to see and interact with Australian animals. In the evening, Dr. Magnus presented her “Perspective from Space” talk, which was well received by several hundred audience members. At the event, Dr. Magnus was able to meet Tony Hutchison, who is a Radio HAM from Kingston SE in South Australia. He acted as a relay station for Dr. Magnus to communicate with a primary school back in the United States while she was on-orbit over Australia. This activity initiated a contact between Tony and the U.S. school that has continued.

CALL FOR PAPERS
ICNPAA 2016 World Congress: Mathematical Problems in Engineering, Sciences and Aerospace
La Rochelle, France, 5–8 July 2016

On behalf of the International Organizing Committee, it gives us great pleasure to invite you to the ICNPAA 2016 World Congress: 11th International Conference on Mathematical Problems in Engineering, Aerospace and Sciences, which will be held at the University of La Rochelle, France.

Please visit the website, **http://www.icnpaa.com**, for all the details. This is an AIAA, IFIP cosponsored event.

AIAA WILL BE THE NEW PUBLISHER OF *AIR TRAFFIC CONTROL QUARTERLY*

Air Traffic Control Quarterly (ATCQ), currently published by the Air Traffic Control Association Institute, will transition to AIAA in 2016, starting with Vol. 24, No. 1. Under a new name, the *Journal of Air Transportation* (*JAT*) will focus on new developments in air traffic management and aviation operations of all flight vehicles, including unmanned aerial vehicles (UAVs) and space vehicles, operating in global airspace.

AIAA’s ScholarOne manuscript site will open for submissions in the fall. Papers already in progress for publication in *ATCQ* will transition to AIAA’s manuscript tracking system at that time. For more information, go to **http://www.aiaa.org/jatform**.

AIAA LOS ANGELES-LAS VEGAS SECTION'S BUSY SPRING

"Perspectives from Space"

On 25 March, the AIAA Los Angeles-Las Vegas (LA-LV) Section held a dinner with special guest AIAA Executive Director Sandy Magnus, former shuttle astronaut on Atlantis and Endeavour. Dr. Magnus spoke about the lessons learned—the experiences that shaped her as a person. She noted how each step in her education broadened her horizons and made her want to learn more. What defined her career, however, was the ISS—a very powerful lesson in cooperation. She noted that it is especially important to teach the next generation that space is reachable for all.

Career Mentoring Event

The LA-LV Section held a very successful Aerospace Career Mentoring event on 9 April, with approximately 75 attendees. For professionals at all stages of their career, this event was a unique opportunity to meet five well-known, high-profile individuals in the aerospace industry in person and learn from their career stories The program included time for general networking, as well as a panel discussion where each speaker described their career experiences and lessons learned and two 30-minute group mentoring sessions. The mentors included: Garrett Reisman (director of Crew Operations, SpaceX, and former NASA astronaut), Lessons learned from a nontraditional career in aerospace; Claire Leon (director of the Launch Enterprise Directorate, U.S. Air Force), Managing your career; Debbie McKenna (director of Engineering Intelligence, Surveillance and Reconnaissance Division, Northrop Grumman Information Systems), The best decisions I have made; Kent Tobiska (president and chief scientist, Space Environment Technologies), Advancing your career in space weather; and Ivan Rosenberg (president and CEO, Frontier Associates, Inc.), What I've learned during 7 careers.

Col. Hodgkiss (left) with Dr. Sarzi-Amade.

Additionally, at this event, Dr. Nicola Sarzi-Amade, the section chair, presented a Section's Honorable Merit award to an outstanding leader of the Los Angeles Air Force Base, Col. William Hodgkiss, who recently retired from his position as director of the Launch Systems Directorate at the Space and Missile Systems Center, at Air Force Space Command. Our Section recognized him for his service and leadership to our aerospace community.

Awards Dinner Meeting

On 21 May, LA-LV held its Annual Awards Dinner. Dr. Sarzi-Amade, started the evening by presenting three Special Service Citations and two Section Performance Awards to deserving Council members. He also presented a Certificate of Appreciation to Dr. James and Alice Wertz from Microcosm, for providing a headquarters location to our Section for five years. Dr. Sarzi-Amade and the Membership Co-Chair Rick Garcia honored some of our Section's long-time members with award certificates; in attendance we had eight members who spanned from 36 years to an astounding 75 years of membership.

Dr. Sarzi-Amade (left) presents Special Service Citations to Enterprise Program Co-Founder and Co-Chair Guido Frassinelli (middle) and to Enterprise Program Co-Chair Dr. Dennis Wonica (right).

Mr. Garcia and Dr. Sarzi-Amade recognize Herbert H. Halperin for his 75 years as a member of AIAA.

Then, Dr. Sarzi-Amade, the Education Chair Brian Franz, and Dr. James Wertz presented our section's first James Wertz Scholarship Award to Joshua Klyde, a student at Whitney High-School. Our keynote speaker, Dr. David Gorney, executive vice president, The Aerospace Corporation, also presented awards to the winners of the 2015 Palos Verdes Peninsula Science and Engineering Fair selected by our judges. The students displayed their projects at the dinner and discussed them. The last set of awards went to students from our section who participated in the 2015 AIAA Space Systems Middle-School Essay Contest, organized by the AIAA Space Systems Technical Committee (SSTC). Three 8th graders from Palos Verdes Intermediate School and one 7th grader from Manhattan Beach Middle School received awards from our sponsor, SpaceX. The 8th grade first-place winner also went on to win the national SSTC contest.

Lars Hoffman from SpaceX also presented the Technical Excellence Award to Glen Fountain, project manager of NASA's New Horizons mission. Mr. Fountain gave a short presentation about New Horizons and took several questions. The evening ended with Dr. Gorney's keynote presentation about the role of complexity in shaping future space architectures.

From left to right: Mr. Franz; Dr. James Wertz; James Wertz Scholarship recipient Joshua Klyde; and Dr. Sarzi-Amade.

Palos Verdes Peninsula Science and Engineering Fair AIAA winners. From left to right: Dr. Sarzi-Amade, Shannon Chen, Stephen Schatz, Akira Higaki, Cheolmin Im, Rei Landsberger, and Dr. Gorney.

Important Announcement: New Editor-in-Chief Sought for the *Journal of Propulsion and Power* (*JPP*)

AIAA is seeking an outstanding candidate with an international reputation to assume the responsibilities of Editor-in-Chief of the *Journal of Propulsion and Power*. *JPP* is devoted to the advancement of the science and technology of aerospace propulsion and power through the dissemination of original archival papers contributing to advancements in airbreathing, electric, and advanced propulsion; solid and liquid rockets; fuels and propellants; power generation and conversion for aerospace vehicles; and the application of aerospace science and technology to terrestrial energy devices and systems. The chosen candidate will assume the editorship at an exciting time as new features and functionality intended to enhance journal content are added to Aerospace Research Central, AIAA's platform for electronic publications.

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

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

Heather Brennan
Director, Publications
American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
Fax: 703.264.7551 • Email: heatherb@aiaa.org

A minimum of two letters of recommendation also are required. The recommendations should be sent by the parties writing the letters directly to Ms. Brennan at the above address, fax number, or email. **To receive full consideration, applications and all required materials must be received at AIAA Headquarters by 1 October 2015, but applications will be accepted until the position is filled.**

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

CALL FOR 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, *JGCD* Editor-in-Chief (plu@iastate.edu)
Guest Editors: Panagiotis Tsiotras (tsiotras@gatech.edu) and Mehran Mesbahi (mesbahi@uw.edu)

OBITUARIES

AIAA Associate Fellow Vlay Died in March

George J. Vlay Sr. died on 7 March 2015. He was 87.

After high school, Mr. Vlay enlisted in the Army Air Corps. Stationed at Tinker Air Force base in Oklahoma City, he rose to the rank of Staff Sergeant. Mr. Vlay then earned his B.S. in Electrical Engineering from the University of Buffalo (UB) in 1953. He pursued his education at UB with graduate work in electronics and mathematics.

While working for a technical publications house, Mr. Vlay wrote the Operations Manual for the total electrical system from the nuclear reactor to the propulsion motors for the first four nuclear submarines. Mr. Vlay worked for Aero Commander in Norman, OK, and was also certified as a Designated Engineering Representative for the FAA. He moved to New York to work with Sylvania Electronic Systems.

In 1966, Mr. Vlay joined Philco-Ford (later Ford Aerospace) in Palo Alto, holding a number of increasing responsibilities. He began as Manager of Communications Systems Activity, then held a number of Director positions, including Business Development & Planning; Technical Affairs; and Product Assurance. Mr. Vlay's last assignment with Ford Aerospace was as Director of Systems Management, to review and improve the division's processes to maintain the the high reliability of the Divisions products.

Mr. Vlay established Systems Management Associates, a consulting firm to electronics companies throughout Silicon Valley. He was especially proud to be selected as the CODSIA (Council of Defense and Space Industries Association) representative for a year-long program to streamline the RFP process with the U.S. Air Force.

He was an active participant in many organizations, including AIAA (Associate Fellow and Distinguished Lecturer); Institute of Electrical and Electronic Engineers (Senior Member); and International Council of Systems Engineers (Founding Member).

AIAA Associate Fellow Lempert Died in April

Walter Lempert died on 11 April 2015.

Professor Lempert was a faculty member in The Ohio State University's Department of Mechanical and Aerospace Engineering and co-director of the Non-Equilibrium Thermodynamics Laboratory (NETL), a major research laboratory containing state-of-the-art computational and experimental facilities among the most advanced at any U.S. university.

Professor Lempert led research and education focused on analytical, computational and experimental techniques for achieving these goals. His primary research was on the application of atomic and molecular spectroscopy to problems of engineering interest, inherently interdisciplinary, combining such diverse subjects as nonlinear optics, fluid mechanics, plasma physics and energy transfer. He was the author of numerous publications, papers and presentations.

An AIAA Associate Fellow, Lempert was honored with the 2010 AIAA Aerodynamic Measurement Technology Award, which was given "In recognition of innovative and significant contributions to the development of aerodynamic measurement techniques and technology, and for its novel application to aerodynamic and plasmadynamic flows."

AIAA Honorary Fellow Myers Died in May

Dale Myers, former deputy administrator of NASA, died on 19 May. He was 93 years old.

After graduating from the University of Washington, Seattle in 1943 with a B.S. degree in Aeronautical Engineering, he began his career working various aircraft and missile development projects. In 1963, Mr. Myers went to work for Rockwell International, which led to contract work with NASA. He was vice-president and program manager, Apollo Command/Service Module Program, North American-Rockwell from 1964 to 1969. From 1969 to 1970, Mr. Myers served as vice-president/program manager, Space Shuttle Program, Rockwell International.

Promoted to associate administrator for Manned Space Flight at NASA in 1970, his first launch was Apollo 13, which he later recalled as a "very educational experience." In a NASA oral history, Mr. Myers recalled, "It was almost a death experience," he said. "This balancing of all this stuff, and then taking the chance on having not enough battery power to take care of the separation, but it worked."

After Apollo 13, Mr. Myers' teams sent four more missions to the moon and launched Skylab, America's first space station. He also helped orchestrate the meeting of U.S. and Russian astronauts in space with the Apollo-Soyuz mission.

From the mid-1970s to mid-1980s, Mr. Myers held positions of president, North American Aviation Group and Jacobs Engineering; and vice-president of Rockwell International. He was also Under Secretary of the U.S. Department of Energy from 1977 to 1979.

In October 1986, 11 months after the Challenger shuttle explosion, Mr. Myers became deputy administrator of NASA. He stayed until May 1989, and NASA historian Roger Launius credited him with returning a sense of optimism to the agency following the disaster.

Despite his age, he gave generously of his time to the local AIAA San Diego Section. He received the San Diego Section's highest award, the Lifetime Achievement Award, in 2013. Later that year, he gave his last public address on the space program at an AIAA Section meeting that was held in conjunction with the annual AIAA SPACE 2013 Conference.

AIAA Fellow Lumley Died in May

John L. Lumley, the Willis H. Carrier Professor Emeritus of Mechanical and Aerospace Engineering at Cornell University, who made seminal contributions to engineering in the study of turbulent fluid flow, died on 30 May. He was 84.

Prof. Lumley received his M.S.E. (1954) and doctoral (1957) degrees from Johns Hopkins University. He began his career at the Pennsylvania State University, where he became Evan Pugh Professor of Aerospace Engineering. In 1977, Prof. Lumley joined Cornell University as the Willis H. Carrier Professor of Mechanical and Aerospace Engineering.

In the late 1960s, he proposed a mechanism that explained drag reduction in terms of the relaxation time of polymers in turbulence—that is the time it takes polymers to uncoil. His explanation still is considered to be the most plausible, despite many other competing theories proposed over the years. He also made important contributions regarding buoyant plumes and smokestacks, turbulent dispersion of pollution in the atmosphere, the propagation of waves in the atmosphere and oceans, turbulence in the presence of atmospheric inversions, the flow of air over objects, the diffusion of salt in water known as "salt-fingering," and the effects of electromagnetic fields on turbulence.

Prof. Lumley's theoretical contributions that are key to our modern knowledge of turbulence include statistical processes, the identification of structures in turbulence, the cascade dynamics of turbulence, and modeling of generic fluid flows, such as jets and wakes and turbulent flows near walls. In particular, he pioneered the use of "proper orthogonal decomposition" in turbulent flows. Although turbulent flows appear to be random, they also have structures, such as in the wake of an aircraft.

His publications include his 1972 book with Henk Tennekes, *A First Course in Turbulence*, which was the first book to place dimensional analysis and scaling arguments as central to the subject, and the 1964 *The Structure of Atmospheric Turbulence* with Hans Panofsky.

In 1990, Prof. Lumley received the American Physical Society Fluid Dynamics Prize of. Other awards included the 1982 AIAA Fluid Dynamics Award, the 1993 Timoshenko Medal, and the 1996 AIA Dryden Lectureship in Research Award. He was a fellow of AIAA and the American Academy of Arts and Sciences, and a member of the National Academy of Engineering.

AIAA Fellow Tabakoff Died in June

Widen Tabakoff—founder of the University of Cincinnati's College of Engineering and Applied Science aerospace engineering graduate and GE cooperative education programs—passed away on 6 June.

After being invited by the U.S. Army to join Wernher von Braun's world-renowned team of rocket scientists, Prof. Tabakoff worked at the U.S. Army Engineering Division Laboratory testing materials for use in the nozzle of the Saturn V complex, when he first became acquainted with University of Cincinnati (UC) faculty. Prof. Ray Murray, the acting department head for aerospace, jumped at the opportunity to incorporate Tabakoff's wealth of knowledge into the university by offering him a position.

Upon his arrival at UC, Prof. Tabakoff was the only aerospace faculty member to have earned a Ph.D. degree. He obtained his Doktor-Ingenieur in aerospace engineering from the University of Berlin in 1945. In 1959, he collaborated with mathematics, physics, and astronomy faculty members to form the Institute of Space Sciences. In the meantime, he single-handedly taught numerous new graduate and undergraduate courses to allow the rest of the aerospace faculty to receive their doctoral degrees. The Institute of Space Sciences was the conduit for Prof. Tabakoff to establish the M.S. and Ph.D. Aerospace Engineering programs. In 1966, Tabakoff established the prestigious co-operative education program between the aerospace engineering department and General Electric. By the year 2000, over 1,000 GE engineers graduated with M.S. and Ph.D. degrees.

In the midst of supporting a great number of graduate students' research, Professor Tabakoff created the College of Engineering and Applied Science Engineering Research Center's (ERC) first gas dynamic & propulsion laboratories' infrastructure that is still in use today. He also implemented the first externally funded research program at UC, raising over $100 million during his career. Today, the Gas Dynamics and Propulsions Lab is permanently named for Prof. Tabakoff.

Prof. Tabakoff was affiliated with many organizations, including ASME: Fellow, Chairman of the ASME Gas Turbine Education Committee (1980–1982); International Gas Turbine Institute Coal Utilization Committee: Chairman (1989–1991); and AIAA: Fellow. Along with many awards for best research papers, his work was recognized by many awards, including two NASA-Lewis Recognition Awards for Creative Development of Technology in the area of Turbomachinery (1977 and 1983); the National Science Foundation Award for Organizing Research Programs with Indian Universities (1983); ASME Fluid Machinery Design Award (1993); and the AIAA and AFRL award for "Outstanding Sustained Contribution to Air Breathing and Rocket Propulsion Research" (January 1998).

AIAA Fellow Schutz Died in June

Dr. Bob E. Schutz, professor of Aerospace Engineering and Engineering Mechanics (ASE-EM) at the University of Texas at Austin, died on 7 June.

Dr. Schutz received his doctorate from the University of Texas (UT) at Austin in 1969. He held his position in the ASE-EM department and as Associate Director for the UT Center for Space Research until his death. Dr. Schutz was passionate about his roles as teacher and researcher, and valued the relationships formed with colleagues. During his tenure, he held the Joe J. King Chair in Engineering and the FSX Professorship of Space Applications and Exploration.

He was honored as a Fellow in the American Astronautical Society, the American Geophysical Union, AIAA, and the International Association of Geodesy. In 2008, Dr. Schutz received the Dirk Brouwer Award from the American Astronautical Society in recognition of his years of educational and professional contributions to astrodynamics and the aerospace profession. He is best known as co-founder of the International Laser Ranging Service and as Science Team Leader for the Geoscience Laser Altimeter System (GLAS). In 2014, he was inducted into the National Academy of Engineering for his contributions to satellite laser ranging and global positioning systems used to study Earth system dynamics.

AIAA Senior Member Struth Died in June

CDR Robert G. "Prof" Struth Jr. (USN, Ret.) died on 22 June 2015. He was 61 years old.

CDR Struth earned his Bachelor of Science degree in Aeronautics and Astronautics from the Massachusetts Institute of Technology, graduating first in his class. He had attained five Master's Degrees in National Security, Defense System Management, and Aeronautical Engineering.

He proudly served in the United States Navy from May 1976 to his honorable discharge in October 1997 as a Commander, with over 21 years of dedicated service. Passionate about flying, he logged in excess of 10,000 flight hours throughout his lifetime in over 150 types of aircraft. Struth flew F-14 Tomcats for the Navy as a Fighter Pilot. In his career he logged over 2000 flight hours in the F-14, and made 399 carrier landings, with 99 of them being at night. He graduated first in his class from primary flight training, and also graduated from the Naval Fighter Weapons School, "Top Gun." He later participated in the advisement team for the film *Top Gun*. At one point he was also a Mission Specialist candidate in the NASA Space Shuttle program.

CDR Struth was also selected for and graduated from the United States Naval Test Pilot School. He held the unique distinction of being "the first and last to land a fixed wing aircraft at Camp David" in an ultralight aircraft during the Reagan administration. Among other posts, he participated in cruises with the VF-114 "Fighting Aardvarks" Squadron, performed flight tests at the Pacific Missile Test Center at Point Mugu, CA, was Deputy Chief Test Pilot on the F-14D Super Tomcat program in Calverton, NY, and later held a command with the PMA(F)-224 detachment of NADEP in Norfolk, VA.

After retirement CDR Struth worked for multiple government contractors, including The Boeing Company, Rockwell/Collins/Jacob Technologies/Planned Systems International, and Booz Allen Hamilton. Most recently he was employed by RED Inc., as a Lead Project Engineer.

He had several publications, including "Joint Strike Fighter, the Flagship Program for Acquisition Reform" (1999), "Global Communications, Navigation, and Surveillance System" (2003) and "GCNSS II" (2004).

CDR Struth was a member of several professional organizations, including the Society of Flight Test Engineers, AIAA, and the International Council of Systems Engineering. He owned a Christen Eagle Aerobatic Biplane and wanted to share his love of flying with anyone that was interested. He also had life memberships in many civilian aviation organizations, including the Aircraft Owners and Pilots Association (AOPA) and the Experimental Aircraft Association (EAA).

AIAA FOUNDATION PRESENTS GRADUATE AND UNDERGRADUATE AWARDS

The AIAA Foundation annually awards financial aid to graduate and undergraduate students in science or engineering programs related to aerospace. Its graduate scholarship program presents awards to graduate students doing excellent research in the air and space sciences. The Foundation also offers scholarships to college sophomores, juniors, and seniors each year, and recipients can apply to renew their scholarships annually until they graduate.

Graduate Awards for the 2015–2016 Academic Year

Each year the AIAA Foundation presents the Orville and Wilbur Wright Graduate Awards. These $5,000 awards, given in memory of the Wright brothers' contributions to the evolution of flight, are presented to students pursuing master's degrees or doctoral thesis work. The 2015–2016 winners are:

- **Brent Pomeroy**, University of Illinois at Urbana-Champaign: Mr. Pomeroy is a Ph.D. candidate studying aerodynamics under Dr. Michael Selig. He received his B.S. in aeronautical engineering from Clarkson University in 2010, and completed his M.S. in 2012 at Illinois.
- **Matthew Reilly**, Georgia Institute of Technology: Mr. Reilly is currently pursuing a graduate degree in aerospace engineering. He received his undergraduate degree in mechanical engineering at Rowan University.

The AIAA Foundation also presented its $1,000 *John Leland Atwood Graduate Award* to **Byron Patterson**, Massachusetts Institute of Technology. The Leland Award is presented to a student actively engaged in research in the areas covered by the technical committees of AIAA. Mr. Patterson is a Master's degree candidate at the Massachusetts Institute of Technology for aerospace engineering, and returned to school after working for The Boeing Company for two years in the Vertical Lift division. He received his B.S. in Mechanical and Aerospace Engineering from West Virginia University in 2012.

The Guidance, Navigation, and Control (GNC) Technical Committee's $2,500 *Guidance, Navigation, and Control Award* was presented to **Brandon Cook**, University of Cincinnati. The GNC Award is presented to a student engaged in work relating to the committee's subject area. Mr. Cook is currently a fifth-year aerospace engineering student at the University of Cincinnati in the Accelerated Engineering Degree Program. After completing his MS this summer, Mr. Cook will be returning to the University of Cincinnati to pursue a Ph.D. in Aerospace Engineering with a concentration on Intelligent Systems under the advisement of Dr. Kelly Cohen.

The $1,000 *Gordon C. Oates Air Breathing Propulsion Graduate Award* was presented to **Ciprian Dumitrache**, Colorado State University. Mr. Dumitrache received his Bachelor degree in Aerospace Engineering from the University "Politehnica" of Bucharest, Romania, in July 2010. His undergraduate research topic was the development of a Roe approximate Riemann solver to study the unsteady flow inside a liquid rocket engine. In 2011, Mr. Dumitrache received a nine-month Fulbright grant from the U.S. Department of State to pursue a Master's degree at Georgia Institute of Technology. As a Master's student, he conducted research at the Ben T. Zinn Combustion Laboratory where he worked on the active control of combustion instabilities in liquid rocket engines. He joined Prof. Yalin's group at Colorado State University in January 2013, to pursue a Ph.D. degree.

The $1,000 *William T. Piper, Sr. General Aviation Systems Graduate Award* was presented to **Imon Chakraborty**, Georgia Institute of Technology. He is a Ph.D. student at the Aerospace Systems Design Lab, School of Aerospace Engineering, Georgia Tech. He received his Master of Science in Aerospace Engineering degree from Georgia Tech in 2011, and his Bachelor's degree in Mechanical Engineering from NIT Tiruchirappalli, India.

The $1,250 *Martin Summerfield Propellants and Combustion Graduate Award* was presented to **Robert Fievisohn**, University of Maryland. Mr. Fievisohn received his Bachelor's degree from Clarkson University in 2008, and was commissioned as a 2nd Lieutenant in the U.S. Air Force. He then went on to the Air Force Institute of Technology to complete his Master's degree. Afterward, Mr. Fievisohn worked at the Air Force Research Labs in the Aerospace Systems Directorate. In 2013, he separated from the Air Force as a Captain and came to the University of Maryland to pursue a Ph.D.

Undergraduate Scholarships for the 2015–2016 Academic Year

The AIAA Foundation have awarded nine AIAA Foundation undergraduate scholarships for the 2015–2016 academic year.

- The $5,000 *George and Vicki Muellner Scholarship for Aerospace Engineering* was presented to **Miles Bengtson**, Embry-Riddle Aeronautical University.
- The $5,000 *David and Catherine Thompson Space Technology Scholarship* was presented to **Samantha Rawlins**, California Polytechnic State University, San Luis Obispo.
- The $1,250 *Leatrice Gregory Pendray Scholarship*, awarded to the Foundation's top female scholarship applicant, was presented to **Abigail Spohn**, The University of Dayton, Ohio.

Six AIAA Foundation undergraduate scholarships were presented by AIAA Technical Committees (TC) to students performing research in the TC's area:

The *Liquid Propulsion TC* presented a $2,500 scholarship:

- **Erik Ballesteros**, University of Texas at Austin.

The *Space Transportation TC* presented a $1,500 scholarship:

- **Aadil Pappa**, University of Texas at Austin.

The *Digital Avionics TC* presented four scholarships:

- The $1,500 *Dr. James Rankin Digital Avionics Scholarship* was presented to **McKenzie Kinzbach**, University of Cincinnati.
- The $1,500 *Dr. Amy R. Pritchett Digital Avionics Scholarship* was presented to **Nicole Whiting**, The Ohio State University.
- The $1,500 *Ellis F. Hitt Digital Avionics Scholarship* was presented to **Stephen Higgins**, University of Cincinnati.
- The $1,500 *Cary Spitzer Digital Avionics Scholarship* was presented to **Alex Strange**, University of Wisconsin–Madison.

For more information on the AIAA Foundation Scholarships and Awards program, please contact Rachel Dowdy at 703.264.7577 or racheld@aiaa.org.

AIAA Scholarships and Graduate Awards site opens **1 October 2015**, to accept applications for the 2016–2017 academic year.
The application deadline is **31 January 2016**.
For more information visit us online: **www.aiaa.org/Scholarships**.

AIAA NEW JERSEY SECTION HOSTS PAPER AIRPLANE CONTEST AT COMMUNITY EVENT

The AIAA Northern New Jersey section hosted its third annual paper airplane contest at the Picatinny Community Day on 9 July. Three qualifying heats were held, and then there was a final heat at the end of the day. Approximately 50 participants attended during the day. AIAA New Jersey Section members set up three tables for constructing planes, and two volunteers created posters with suggested designs. A bullseye and two "runway" led light sets were set up to fly the paper airplanes.

At the qualifying heat, participants flew their planes and the top two qualifiers were determined in both distance and accuracy categories. These winners received a prize.

Four of the six winners came back for the final heat. Two separate events were held: first accuracy was tested, and each participant was allowed to throw their airplane twice. The first child had his nose a few inches from the bullseye center (a clear winner). Then we measured distance and again each participant was allowed to throw their airplane twice. Many of the longer flights fell outside the boundary lines. The winner's plane landed on the stage, but within the boundary.

Each participant's name was announced, and the crowd cheered. The winners received a certificate, Nolan Ryan Bobble Head, and an Ultralight plane kit.

CALL FOR AWARD NOMINATIONS

Recognize the achievements of your colleagues by nominating them for an award! Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 October**.

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

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

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

Premier Awards & Lectureships

Distinguished Service Award gives unique recognition to an individual member who has provided distinguished service to the Institute over a period of years.

Goddard Astronautics Award, named to honor Robert H. Goddard—rocket visionary, pioneer, bold experimentalist, and superb engineer—is the highest honor that AIAA bestows for notable achievement in the field of astronautics.

International Cooperation Award recognizes individuals who have made significant contributions to the initiation, organization, implementation, and/or management of activities with significant U.S. involvement that includes extensive international cooperative activities in space, aeronautics, or both.

Reed Aeronautics Award is the highest award that AIAA bestows for notable achievement in the field of aeronautics. The award is named after Dr. Sylvanus A. Reed, the aeronautical engineer, designer, and founding member of the Institute of Aeronautical Sciences in 1932.

Dryden Lectureship in Research was named in honor of Dr. Hugh L. Dryden in 1967. The lectureship emphasizes the great importance of basic research to the advancement in aeronautics and astronautics and is a salute to research scientists and engineers.

von Kármán Lectureship in Astronautics honors Theodore von Kármán, world-famous authority on aerospace sciences. The award recognizes an individual who has performed notably and distinguished himself technically in the field of astronautics.

Technical Excellence Awards

Aeroacoustics Award is presented for an outstanding technical or scientific achievement resulting from an individual's contribution to the field of aircraft community noise reduction.

Aerodynamics Award is presented for meritorious achievement in the field of applied aerodynamics, recognizing notable contributions in the development, application, and evaluation of aerodynamic concepts and methods.

Aerodynamic Measurement Technology Award is presented for continued contributions and achievements toward the advancement of advanced aerodynamic flowfield and surface measurement techniques for research in flight and ground test applications. (Presented even years)

Aerospace Communications Award is presented for an outstanding contribution in the field of aerospace communications. Candidates are individuals or small teams (up to 4 members) whose achievements have had a positive impact on technology and society.

Aircraft Design Award is presented to a design engineer or team for the conception, definition, or development of an original concept leading to a significant advancement in aircraft design or design technology.

Chanute Flight Test Award recognizes significant lifetime achievements in the advancement of the art, science, and technology of flight test engineering. (Presented even years)

Engineer of the Year recognizes an individual member of AIAA who has made a recent significant contribution that is worthy of national recognition. Nominations should be submitted to your AIAA Regional Director.

F. E. Newbold V/STOL Award is presented for outstanding creative contributions to the advancement and realization of powered lift flight in one or more of the following areas: initiation, definition and/or management of key V/STOL programs; development of enabling technologies including critical methodology; program engineering and design; and/or other relevant related activities or combinations thereof which have advanced the science of powered lift flight. (Presented every 18 months)

Fluid Dynamics Award is presented for outstanding contributions to the understanding of the behavior of liquids and gases in motion as related to need in aeronautics and astronautics.

Ground Testing Award is presented for outstanding achievement in the development or effective utilization of technology, procedures, facilities, or modeling techniques or flight simulation, space simulation, propulsion testing, aerodynamic testing, or other ground testing associated with aeronautics and astronautics.

Hap Arnold Award for Excellence in Aeronautical Program Management is presented to an individual for outstanding contributions in the management of a significant aeronautical or aeronautical related program or project.

Hypersonic Systems and Technologies Award recognizes sustained, outstanding contributions and achievements in the advancement of atmospheric, hypersonic flight and related technologies. (Presented every 18 months)

Jeffries Aerospace Medicine & Life Sciences Research Award is presented for outstanding research accomplishments in aerospace medicine and space life sciences.

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

Multidisciplinary Design Optimization Award is presented to an individual for outstanding contributions to the development and/or application of techniques of multidisciplinary design optimization in the context of aerospace engineering. (Presented even years)

Otto C. Winzen Lifetime Achievement Award is presented for outstanding contributions and achievements in the advancement of free flight balloon systems or related technologies. (Presented odd years)

Piper General Aviation Award is presented for outstanding contributions leading to the advancement of general aviation. (Presented even years)

Plasmadynamics and Lasers Award is presented for outstanding contributions to the understanding of the physical properties and dynamical behavior of matter in the plasma state and lasers as related to need in aeronautics and astronautics.

Jay Hollingsworth Speas Airport Award is presented to the person or persons judged to have contributed most outstandingly during the recent past toward achieving compatible relationships between airports and/or heliports and adjacent environments. The award consists of a certificate and a $7,500 honorarium. Jointly sponsored by AIAA, the American Association of Airport Executives, and the Airport Consultants Council. (Nominations due **1 November**)

Theodor W. Knacke Aerodynamic Decelerator Systems Award recognizes significant contributions to the effectiveness and/or safety of aeronautical or aerospace systems through development or application of the art and science of aerodynamic decelerator technology. (Presented odd years)

Thermophysics Award is presented for an outstanding singular or sustained technical or scientific contribution by an individual in thermophysics, specifically as related to the study and application of the properties and mechanisms involved in thermal energy transfer and the study of environmental effects on such properties and mechanisms.

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

Service Award

Public Service Award honors a person outside the aerospace community who has shown consistent and visible support for national aviation and space goals.

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

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.