June 2016

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Ambition: Europa

NASA might find more than life in this moon's ocean. It could find a new strategy for exploring other worlds.

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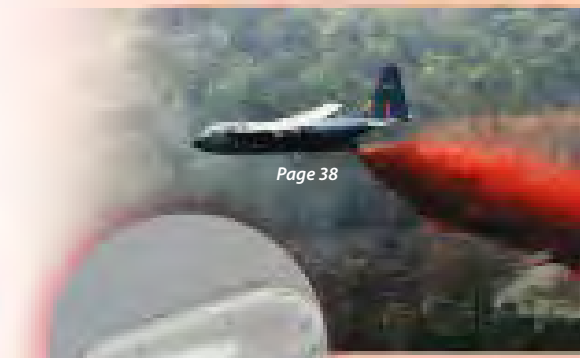

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ON THE COVER
An artist's rendering of Europa's surface.
Credit: NASA

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AIAA
Shaping the Future of Aerospace

Editor's Notebook

Congress's dynamic aerospace duo

We spent some time in this edition talking with U.S. Reps. John Culberson, R-Texas, and Jim Bridenstine, R-Oklahoma. Inevitably, not everyone will agree with them on some core issues, from their doubts about the human role in climate change to Culberson's push to increase funding for exploring Europa. But the two are a dynamic duo when it comes to injecting fresh thinking about matters of aerospace into lawmaking. They are not merely overseeing plans put forth by the White House, NASA and NOAA. They are determined to direct them and inspire them.

The ideas they propose can sound outlandish, but even outlandish concepts have a way of forcing change that can be rational in its final form. At least, that's the hope.

Bridenstine is a big advocate for the companies that plan to gather and sell weather forecasting data by encircling Earth with cubesats to receive GPS signals and measure how far they bend as they cross though the atmosphere along the curve of the Earth. The concept might sound hokey when you first hear it, but NOAA forecasters don't think Bridenstine is crazy. From the data they've received so far, they'd like more of this GPS radio occultation data, as long as that doesn't come at the expense of NOAA's weather satellites. Culberson addresses that concern in our interview on page 8.

The other half of the dynamic duo, Culberson, has inserted himself into NASA exploration planning in something of a Kennedy-like way. John F. Kennedy gave NASA before the end of the 1960s to land humans on the moon. Under language Culberson shepherded into law in December, the Jet Propulsion Laboratory is supposed to launch a robotic orbiter and a lander toward Europa by 2022. The Kennedy comparison shouldn't be taken too far. JFK was president of a nation of 180 million people. Culberson has 770,000 people in his Houston district. But members of Congress are allowed to put bold ideas on the table, too.

I don't know that Culberson's timeline or vision will prove realistic in the end, but I do know that his passion for Europa has experts at JPL working in overdrive to find out. If you're an advocate of space exploration, perhaps that's not a bad process to see set in motion.

Near the end of my conversation with Bridenstine, I mentioned that the nuance in his views about weather forecasting and climate change surprised me.

"That's the way politics is. Everybody wants to create a picture of who they think you are and not who you really are," he said.

One of the values of Aerospace America is that we go beyond personalities to dig into the logic underlying debates over such issues as the role of privately operated weather satellites, Europa exploration and climate change. We will continue to do that.

Ben Iannotta
Editor-in-Chief

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Printing a quadcopter out of plastic

Specialized missions require specialized aircraft, and designing a custom unmanned aircraft can be expensive and time consuming.

Engineers at the John Hopkins University Applied Physics Laboratory are working to solve that problem by 3-D printing aircraft to meet customers' needs.

APL engineers demonstrated the technique by additively manufacturing an unmanned aircraft out of plastic and flying it in an unusual way. The 6-kilogram Corrosion Resistant Aerial Covert Unmanned Nautical System, or CRACUNS, rose from the bottom of a flooded quarry, and took off, carrying a GoPro camera to demonstrate low-altitude surveillance.

CRACUNS is designed to be stationed on the bottom in shallow water for months down to a depth of about 46 meters. When it receives an acoustic signal, a launch container releases the quadcopter, which floats to the surface and lifts off, reaching a speed of 30 kph.

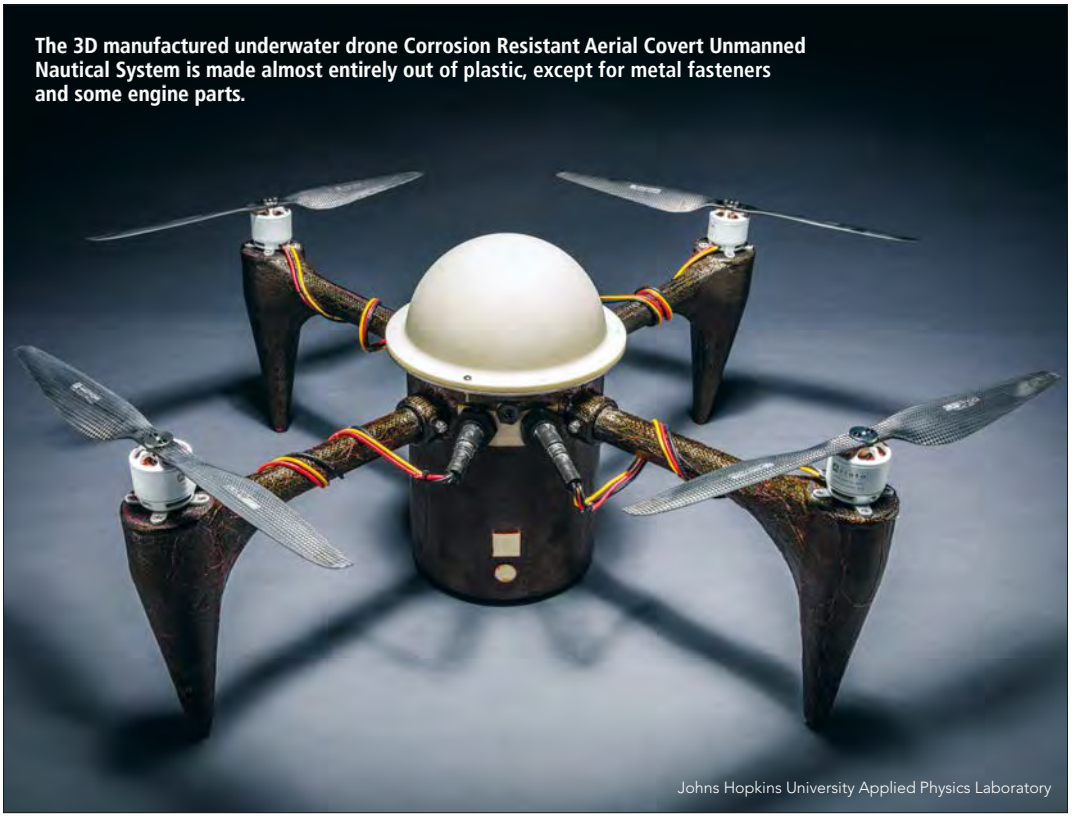
A smaller version, the 3-kilogram Mini-CRACUNS, will be compact enough to be launched from an unmanned underwater vehicle, but will require some fiberglass parts that can't be additively manufactured.

CRACUNS was built almost entirely out of plastic, the exception being some metal fasteners and engine parts. A pressure vessel made of plastic protects electronic components from corrosion, while the craft's motors are sheathed in commercially available protective coatings.

The APL team says it took the aircraft from concept to flight in four months, which is unusually fast for a custom aircraft. The quadcopter could have been bigger or smaller, faster or slower, weaponized or unarmed, depending on the requirements.

"Gone are the days when you have to buy an expensive UAV and shove your 10-pound payload into its one-pound volume," says CRACUNS project manager Tom Murdock. Using off-the-shelf parts and additive printing shows how "you can create an airframe specific to your mission much faster and much more cheaply than buying a commercial off the shelf UAV and retrofitting it."

The CRACUNS team estimates that if the 15.2-centimeter-diameter pressure vessel were cast out of metal, that part alone would have cost $50,000 and taken 10 weeks to build. The team would not disclose the cost of CRACUNS, noting that any figure would have to include research as well as materials, but they did say the materials part of the project cost in the thousands of dollars.



The 3D manufactured underwater drone Corrosion Resistant Aerial Covert Unmanned Nautical System is made almost entirely out of plastic, except for metal fasteners and some engine parts.

Johns Hopkins University Applied Physics Laboratory

The success of CRACUNS does not mean that hobbyists can just start developing custom unmanned aircraft off their home 3-D printers, Murdock cautions.

"The craft's underwater and aerial capabilities reflect the expertise and experience of its designers. More important, CRACUNS is a demonstration of rapid prototyping rather than cheap manufacturing," Murdock says; until industrial 3-D printing costs come down, the process isn't economical for mass production.

Michael Peck
michael.peck1@gmail.com
@Mipeck1

Former directors chime in on private management for NASA Ames

Rep. John Culberson, R-Texas, is pushing to turn operating control of NASA's Ames Research Center over to a university, partly in order to lift salary caps to better attract talent.

NASA

Rising housing costs in the San Francisco Bay Area make it hard for NASA Ames Research Center to attract and retain top scientists and engineers, because the federal pay scales require NASA to follow hard caps.

U.S. Rep. John Culberson, R-Texas, the chairman of the House subcommittee that sets NASA's annual budget, is the latest to raise the possibility of involving local universities in running Ames, and possibly other NASA centers, in a manner similar to the way the California Institute of Technology manages NASA's Jet Propulsion Laboratory in Pasadena, California. JPL is a Federally Funded Research and Development Center, or FFRDC, operated for NASA by Caltech. The FFRDC arrangement gives JPL freedom to establish a competitive pay scale.

The question is whether the latest discussion about management of Ames will meet the fate of efforts during the tenures of three previous directors to change the structure. I wasn't able to get anyone at NASA Ames to weigh in, but I spoke to two of those past directors.

"I was able to recruit some of the best and brightest who thought working on space stuff was beyond cool," says Scott Hubbard who directed Ames from 2002 to 2006 and is now a professor at Stanford University. "But when they started to have kids and buy a house, they went to work for Google or Microsoft."

Hubbard's conversion effort and those of two of his predecessors, Hans Mark and William Ballhaus, Jr., failed for two main reasons: It is illegal for a government employee to leave his or her job and take the same job as a private contractor. And even if Congress were to pass legislation waiving the criminal statute for a group of NASA employees, a local university or corporation would have to agree to manage Ames, which employs 2,480 people and has an annual budget of about $900 million.

Ballhaus, who directed Ames from 1984 to 1989, says it's worth approaching universities again about running the center. As an FFRDC, Ames would be free from civil-service employment rules. When Ballhaus wanted to establish Ames as a super computing center in the 1980s, the civil service system didn't have a category for computer scientists. The only related category was payroll processors, whose salaries were far too low for computer scientists.

Conversion is "a really good idea. It should have been done long ago," he says.

Hubbard would go further and turn all NASA centers into FFRDCs. That "would make more sense ... than doing it piecemeal," he says.

NASA headquarters appears cool to the idea, possibly because of the independence that FFRDCs like JPL can at times exhibit. At a March hearing, Culberson said he was "keenly interested" in the idea of converting Ames and possibly other centers, but NASA Administrator Charles Bolden responded that he was "leery," although open to studying the idea.

Bolden explained that when the time comes to plan a mission, he likes to "bring all the center directors together and hear all the dissenting opinion." Then, he said, "I make a decision and we all go in that direction. The Journey to Mars, for example, you could not do that with a bunch of FFRDCs."

Debra Werner
werner.debra@gmail.com

Repair manuals get smart

For aircraft mechanics, especially for less experienced ones, finding the right information to address the problem in front of them can be extremely challenging. Digital manuals or other documents are stored, organized and updated in ways much different than the way most people think, speak or read.

Airbus Helicopters Chief Engineer Greg Myer holds a binder of maintenance documents at Airbus Civil Helicopter facilities in Sydney, Australia. Airbus has digitized most of these documents and is now making the data more easily accessible to mechanics with natural-language software.

The maintenance-software company 1Ansah of Sidney has taken on that problem. The company has devised natural-language processing software, or NLP, that ingests digital maintenance manuals and related documents and then applies artificial intelligence and machine learning to iteratively learn from past search results. A mechanic working on a plane will type in search terms or a question, and the appropriate information will be displayed.

The software is not yet fully operational, but 1Ansah is collaborating with Airbus Group Australia Pacific to apply it to the company's helicopter maintenance. To date, relevant data has been ingested and a Google-like search capability has been implemented. Next comes the ability for mechanics to type in questions and receive answers. Siri-like speech recognition may be added someday.

Airbus Chief Engineer Greg Myer says his shop now performs 12 to 18 scheduled heavy maintenance visits a year, with increasing modifications and customizations. Airbus digitized its maintenance data six years ago, well before 1Ansah's involvement. Even so, Myer says, "it is hard to find information in the same place in the manual and hard to communicate subtle differences in document logic to other people. This hurts turnaround time and has real effects on efficiency."

NLP first ingests digital maintenance manuals, component manuals, service bulletins, airworthiness directives and fault-isolation manuals into its memory. NLP then breaks down related sentences and analyzes their grammar. It creates an index, like a book index, but specific to the maintenance domain. The NLP algorithms were chosen from an open-source library and were then optimized for speed and the specific maintenance task.

A mechanic who types in "hydraulic power control" might be asked to choose from a list of observed faults or errors. Selecting one would generate several possible corrective actions, as well as probabilities of success. The mechanic tries each fix and then reports what worked.

Machine learning applies statistical techniques to retain and build on the knowledge from users. If mechanics consistently select a particular fix to a problem, then that solution will be rated the highest.

In addition to adding the question-and-answer capability, Airbus and 1Ansah will add illustrations to parts catalogues.

1Ansah CEO Anant Sahay says his toughest challenges were finding enough people with the right NLP skills. Apart from Stanford, few universities teach NLP. The specialty is in high demand due to consumer applications, and workers command high salaries and fees. "These people are not cheap."

Sahay has worked with other maintenance aids but says the shortcoming of those tools is that they assume they know all the questions that can be asked.

"We had to tinker if there was a new problem. These systems cannot retain new knowledge, and we are trying to move beyond them."

Henry Canaday
htcanaday@aol.com

Up next for NASA's mini-airliner

The best way to test new aviation technology is to actually fly it. But testing on an aircraft, especially larger ones, is expensive and time-consuming.

Unless the testbed is a NASA mini-aircraft that looks and flies just like a full-sized airliner. The Prototype-Technology Evaluation Research Aircraft, or PTERA, is an unmanned, subscale aircraft that resembles a twin-engined passenger jet, except that it's one-tenth the size. Built by the aviation technology company Area-I of Kennesaw, Georgia, NASA's 59-kilogram PTERA is 3.4 meters long and has a span of 3 meters. It can fly at 220 kph with landing gear extended, has a ceiling of 3,000 meters, and can carry a 27-kilogram payload.

PTERA is helping NASA get at some of aviation's thorniest challenges, such as a project by a team of NASA, Boeing and Area-I to develop adaptive wings, made of shape-memory alloy, that would change their shape during flight. Initially testing such technologies on a subscale aircraft is quicker and cheaper than with a full-sized plane, while generating more insight into aircraft stall and flight characteristics than with a wind tunnel model.

PTERA was conceived in 2006, when NASA put out a research proposal for a subscale aircraft that could test circulation control wing technology in which streams of high pressure generate more lift. But by the time Area-I had built a prototype in 2011, the focus of NASA researchers had shifted away from circulation control wings. Still, NASA's Armstrong Research Center in California wanted a medium-range, narrow-body, twin-jet airliner for aerodynamics research, while the agency's Langley Research Center in Virginia needed a subscale aircraft that resembled a regional jet, had a T-tail empennage and a rear engine mount.

As it turned out, Area-I's prototype could be modified to fit both needs. So in 2014, the company built two PTERAs: The Armstrong aircraft has a cross-shaped tail that can be made smaller to conduct drag reduction research, while the Langley model has a T-tail to examine loss of control issues with that tail configuration.

NASA's Armstrong Research Center is using a Prototype-Technology Evaluation Research Aircraft, a subscale model that resembles a twin-engine jetliner, to research drag. In the rear is a NASA F-18 Hornet.

Bruce Cogan, NASA's PTERA project manager, says the little aircraft is extremely configurable.

"Wing trailing and leading edges are non-structural, allowing evaluation of almost any high lift device concept," Cogan says. "The wing is also completely reconfigurable to provide testing of many advanced aerodynamical technologies."

PTERA is fitted with two Jet Cat micro-turbine engines, which also propel NASA's X-48 and X-56 subscale test aircraft. The PTERA's engines can be mounted above or below the wing, or on the tail. Or, other types of engines can be mounted on the aircraft for a particular research project.

"For example, distributed electric propulsion could be studied by installing several electric motors in PTERA's wing," Cogan says.

So far, PTERA has been conducting test flights to establish the aircraft's baseline performance. But NASA has already tested a surface airflow sensor on PTERA's wing. NASA, Boeing and Area-I are also developing a shape adaptive wing in which the outer wing panels, made of shape memory alloy, change their shape to control the aircraft. The technology could reduce or eliminate aircraft rudders.

Michael Peck
michael.peck1@gmail.com
@Mipeck1

Change agent

U.S. Rep. Jim Bridenstine, R-Oklahoma

U.S. Rep. Jim Bridenstine, R-Oklahoma, introduces his American Space Renaissance Act in Colorado Springs, Colorado, in April.

Space Foundation/Tom Kimmel

Jim Bridenstine is unusual for a U.S. congressman. References to aerospace technologies and the companies that build them flow easily and accurately from him, perhaps because of his history as a Navy pilot and now an Oklahoma Air National Guard pilot.

Bridenstine is not ruffled when pressed on his skepticism about human-induced climate change, and he relishes making his cases that NOAA should make more use of weather data from privately owned satellites, and that the U.S. is financing Russian military programs.

Bridenstine came to office in 2013 determined to lift the U.S. from what he sees as its declining stature as a space power and to make Oklahoma safer from the tornadoes that ravage the state every year. He may get only 2 ½ more years to do that, because he believes members of Congress should serve no more than three terms. He says this November's election will be his last race for Congress.

Bridenstine spoke with ***Ben Iannotta*** *by phone from his office in Oklahoma.*

for aerospace

Interview by Ben Iannotta
beni@aiaa.org

Why is it you believe so strongly in term limits?

This kind of public service was intended to be temporary. I believe that's what the Founding Fathers envisioned, that's what they intended.

You seem like a man in a rush to get a lot done in a short time. Is that one of the effects, too? Motivating?

The rush has absolutely nothing to do with term limits. It has to do with the fact that this country has threats, and we need to make sure that we're doing the right things to mitigate those threats.

I see the word renaissance in [your bill] American Space Renaissance Act. Can you diagnose how the U.S. lost its edge in space?

It's not so much that the United States lost its edge. It's that technology has changed. We now see the miniaturization of electronics. We see that the cost of launch is coming down. Now you've got companies like SpaceX and Blue Origin and ULA [United Launch Alliance] that are initiating reusable launch vehicles. Access to space is now pervasive. If we're going to remain the preeminent spacefaring nation, we have to make adjustments. That's the intent of this bill.

Does the 1967 Outer Space Treaty still make sense?

We have heard the State Department tell members of Congress that they don't believe they have the authority to give the green light for some of these non-traditional space activities: asteroid mining, or in-space servicing of satellites. We need to update our regulatory authorities to make sure that the State Department can't at the last minute say no to those entities that are trying to accomplish those objectives.

Article 2 says a sovereign can't appropriate a celestial object by claim or occupying it. Does that restrict a private company's ability to mine asteroids?

No. We passed the space act [the Space Launch Competitiveness Act] not too long ago. It clearly states that we believe that we have those authorities, that we can extract resources from celestial bodies and it's not a violation of the Outer Space Treaty.

How big a problem is orbital debris?

Absolutely huge. It's a problem that cannot be ignored any longer. It is not just about debris, it is about protection of space. The Chinese have tested direct-ascent anti-satellite missiles all the way up to geostationary orbit, which is where our communication architecture is. Space is no longer a benign environment where nobody can threaten. On top of all of this, there are 23,000 pieces of trackable orbital debris. We have already hit something called the Kessler Syndrome [which] says that even if you launch nothing new into space, we will continue to create orbital debris just from collisions that are happening.

Why can't the Defense Department just stay in charge of watching all of that?

DoD will always do space situational awareness, and DoD will always protect space assets. I don't want to change that at all. But I will also tell you that DoD needs its men and women at the JSPOC [Joint Space Operations Center at Vandenberg Air Force Base, California] to be focused on fighting and winning wars and not doing conjunction analysis for the next time a weather satellite is going to run into a communications satellite. At the JSPOC, they get up in the morning and they spend the first couple of hours trying to determine if a screw that was launched in 1974 is going to run into the International Space Station. That's critically important work, but it's not what the Department of Defense ought to be doing.

What's your favored solution to reliance on the Russian RD-180s rocket engines?

We're over here focused on the RD-180 engine, but in the meantime we're spending billions of dollars flat out launching our assets on Russian rockets and our astronauts on Russian rockets. If you look at Orbital ATK with their Antares rocket and they're using the RD-180 engine [designated RD-181]. That in itself is funding Russian space-based military operations.

The issues are much bigger than the RD-180, but we [do] need to get off the RD-180, and we need to do it as soon as possible. I am not somebody who would suggest that we need to cut off our nose to spite our face. We need to do it smartly. We need to have assured access to space, and we need to do it in a way that doesn't break the budget. Which means, temporarily, we will be dependent on the RD-180. This in itself is a failure of government in Washington, D.C.

How much of a priority should NASA or NOAA give to gathering climate-related readings?

I'm a guy that comes from Oklahoma and I have absolutely no problem studying the climate. That's what these assets do. They study the climate. There's nothing wrong with that.

Is there any data that would change your view that fossil fuels and human activities aren't warming the climate?

If you look at the Chinese and the Russian and the Indian production of carbon emissions, it is

overwhelmingly massive compared to the carbon footprint of the United States of America. If we unilaterally damage our economy while they continue to grow their economy by damaging the environment, then we're not serving ourselves well. The United States does not have a big enough carbon footprint to make a difference when you've got all these other polluters out there. So why do we fundamentally want to damage our economy even more when nobody else is willing to do the same thing?

Couldn't the U.S. be a leader in that case?

That's what we have been. That's the irony of the whole thing. We have this huge economy by comparison to all these other countries, [and] our carbon foot print is smaller than theirs by massive amounts. So we have led. The question is, "Who's following?"

Tell me your view on human contributions, if any, to what's happening with the climate.

I would say that the climate is changing. It has always changed. There were periods of time long before the internal combustion engine when the Earth was much warmer than it is today. Going back to the 1600s, we have had mini Ice Ages from then to now.

But isn't it like you've rented a car. You're going downhill, and gravity, a natural force, is making you go faster, or it could be because you've got your foot on the accelerator, a human force.

That's why we need to continue studying it. Again, I am not opposed to studying it. What you'll find though is that the space-based assets that are studying climate change are not in agreement with the terrestrial assets that are studying climate change. In fact, the space-based assets are not corroborating some of the data.

How is the drone business going in Oklahoma after being turned down as an FAA test site?

There are capabilities that we can use, unmanned aerial vehicles, that can help us predict tornadoes hours in advance instead of minutes in advance. In Oklahoma, we have a program called the Oklahoma Mesonet and every county has a tower that is collecting boundary-layer data. The boundary layer is about 4,000 feet [1,200 meters] and below. The boundary-layer data is very important for knowing the energy levels so that we can better predict severe thunderstorms and tornadoes:

If we had a quadcopter that could go straight up and straight down and collect the data in the atmosphere all the way up to 4,000 feet and then come down, you're getting temperature, pressure, and humidity for the entire boundary layer across the entire state of Oklahoma.

Because of privately owned weather satellites, do you foresee NOAA getting out of buying satellites?

I don't. I'll tell you why. Nobody cares more about that government backbone than the guy who represents constituents in Oklahoma. But I will also say that we can augment the data with new sources and more resilience. The more we can disaggregate the architectures, the more resilience there will be. The quickest way to do that is to take advantage of commercial operators. Remember, the Chinese shot down a weather satellite. It was their own weather satellite, but it was a weather satellite.

Jim Bridenstine

Title: *U.S. Representative, R-Oklahoma*

Elected: *November 2012*

Committee assignments: *Chair, Environment subcommittee of the House Science, Space and Technology Committee; member, Strategic Forces and Seapower & Projection Forces subcommittees of the House Armed Services Committee*

Age: *40*

Birthplace: *Ann Arbor, Michigan*

Education: *B.S. in Economics, Business and Psychology, Rice University; MBA, Cornell University*

Notable: *Pilots MC-12 reconnaissance planes as a major in the Oklahoma Air National Guard; flew counterdrug missions in Central and South America in 2010-2012 for the Navy Reserve; piloted Navy E2-C Hawkeyes off the USS Abraham Lincoln during wars in Iraq and Afghanistan; piloted F/A-18 Hornets.*

Family: *Wife Michelle and three children ages four to 10*

Interests: *Flying, spending time with family*

Favorite quote: *Isaiah 40:31 "But they who wait for the Lord shall renew their strength; they shall mount up with wings like eagles; they shall run and not be weary; they shall walk and not faint."*

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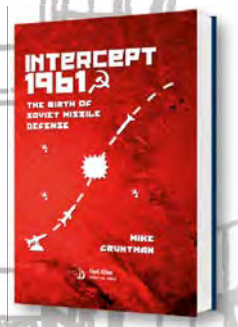

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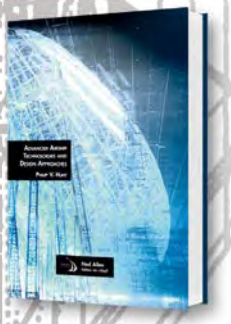

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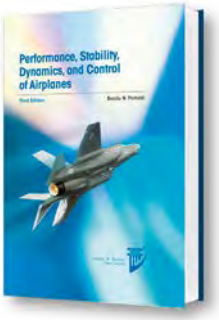

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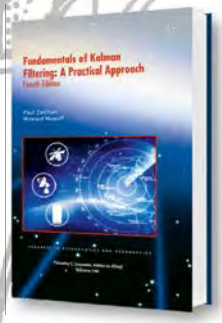

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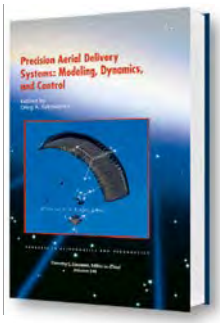

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AIAA
Shaping the Future of Aerospace

Preventing more MH370s

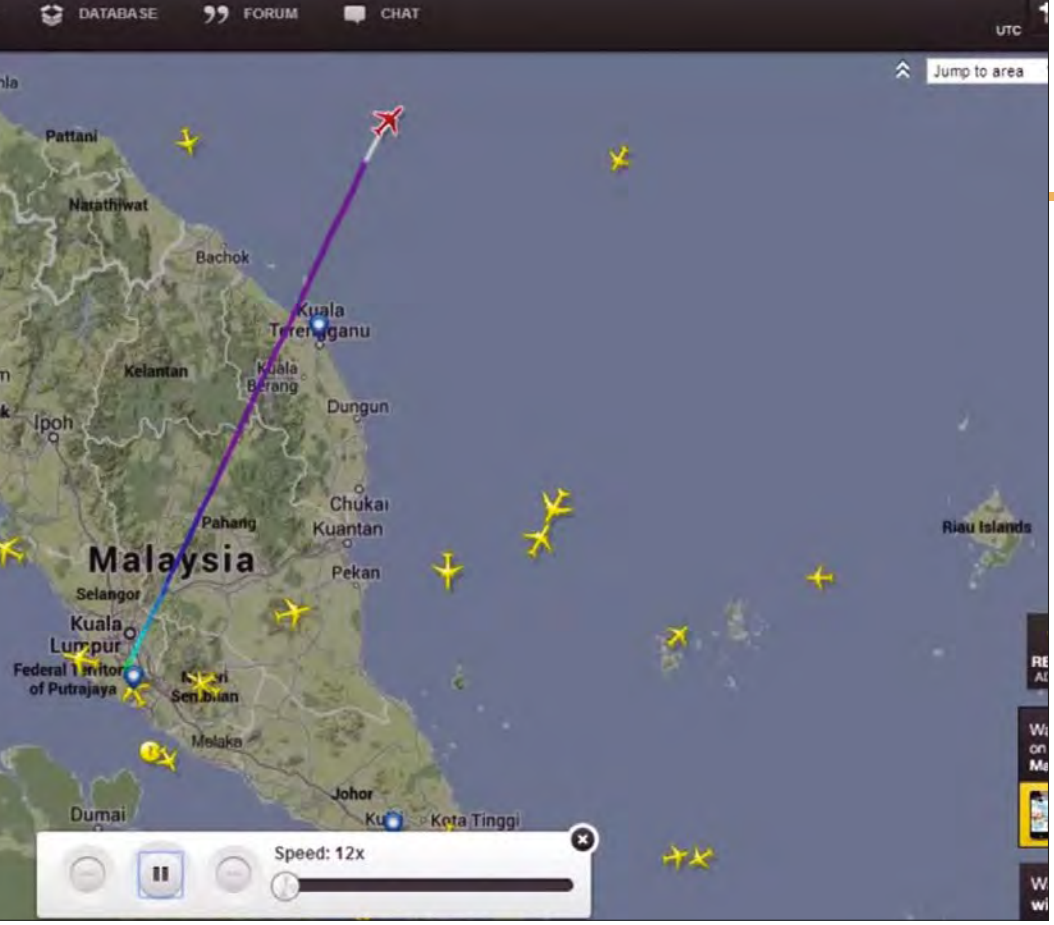
Conventional wisdom says it is too expensive to stream black box data from aircraft while they are in flight. AlulA Aerospace, a startup in Doral, Florida, says it has a strategy for affordably streaming information normally stored in the aircraft's black boxes. Founder Thomas Byrd explains the company's concept and how his team plans to bring it to market.

I was on a ski vacation in Austria in March 2014 when I saw the headlines about a missing Boeing 777.

As an amateur pilot and an aviation enthusiast, I study air disasters as a way to improve my flying skills and my understanding of aircraft technology. The lessons for MH370 never came. Hours, months and now years have gone by, and the world is still in the dark about the event that led to its disappearance. My friend, and now business partner, Jason Keasler, and I wondered: How could we lose a massive, modern jetliner in a world driven by the Internet of Things?

Inspired by MH370, Jason and I founded AlulA Aerospace. Our team is creating a streaming service that will, if a key component is certified by the FAA, feed cockpit audio and data to first responders in emergencies, while most of the time streaming live performance and weather

This Gulfsteam 4 corporate jet was fitted with a demonstration AlulA Heart antenna, inset, underneath the fuselage. Such antennas would broadcast encrypted weather or predictive maintenance data to aviation enthusiasts working with a flight tracker app service.



Malaysia Airlines Flight 370 disappeared from radars 40 minutes after taking off from Kuala Lumpur on March 8, 2014. The last contact was about 140 kilometers northeast of Kuala Terengganu.

data to airlines or contractors to improve maintenance efficiency and sharpen route planning.

As a Marine, I was taught to think outside the box to solve problems regardless of how restrictive the environment. So what is the problem that has led to our inability to solve the MH370 mystery?

If you ask an industry expert about MH370, he or she may argue that its disappearance was a statistical anomaly: Planes do not disappear. In reality, planes do disappear each and every night. Over the North Atlantic region that my wife and I crossed on our way home, over 2,500 aircraft drop from air traffic control screens for hours each night. They reappear once they are in range of radars on the other side of the ocean. Most airliners today do not have radios capable of streaming voice and flight data, because emergencies are rare and investing in them is largely unjustified. The one existing radio that does stream data in emergencies costs more than most customers would be willing to spend on a single-purpose device. Our strategy to solve this problem calls for developing an FAA certified multipurpose digital radio, called the AlulA Heart.

Each AlulA Heart will have a capability of transmitting voice and data by satellite communications in SOS mode, but most of the time will transmit flight data and the basic telemetry data the FAA has mandated all airliners in U.S.-controlled airspace to broadcast by 2020. The AlulA Heart will cost several times less than single purpose emergency radios currently on the market, and about the same as other radios capable of transmitting this automatic dependent surveillance-broadcast, or ADS-B, data.

Another innovation is the ability for the AlulA Heart to serve multiple purposes simultaneously. We'll use satellite communications for the SOS mode and to cover gaps, but most of the time the AlulA Heart will transmit predictive maintenance data using crowd-sourced aircraft data receivers via a flight tracking app provider, or FTA. We are currently negotiating a key partnership with one of these FTAs. We believe this strategy will entice the airline industry to stream data in real time, not just for emergencies but also for a variety of needs. In fact, we see many demand signals for data streaming.

Search and rescue agencies want the ability to respond to emergencies immediately. We plan to accomplish this by providing them with highly accurate position information of a distressed aircraft's last known position regardless of the location of the incident. Additionally, with the SOS mode, investigative agencies will receive black-box data in near-real time, rather than waiting for the physical recovery of the recorders. The MH370 recorders are still missing, and in the case of the Air France Flight 447 crash in the Atlantic Ocean off Brazil in 2009, investigators needed 23 months to find the wreckage and to retrieve the recorders.

Demand signals include more than accidents and investigations. Airlines want predictive maintenance data in real time to improve operational efficiencies. Many airlines are assisted by automated systems that define routes for hundreds of aircraft flying thousands of routes. This process becomes very complicated when aircraft unexpectedly require maintenance, or weather impedes scheduling. Live data will directly plug into these systems, and allow more fluid and accurate decision-making. Aircraft, engine and component manufacturers have been pleading for the ability to capture this data affordably in real time in order to get the most out of their predictive maintenance programs, in which they are already investing millions of dollars.

Our partnership with an FTA will

solve that affordability issue. Today, the FTAs — Flight Aware; FlightRadar24 and PlaneFinder.net — offer live views of most flights around the world. You can literally see an incoming flight live on a map and its projected arrival time. Following MH370, I was curious as to how the FTAs received this data. For some time now, the world has been shifting to a modernized air traffic control network. The U.S. portion of this network is the FAA's NextGen air transportation system, which includes the ADS-B 2020 mandate. Some aircraft are already sending ADS-B transmissions, and aircraft enthusiasts on the ground have been placing small antennas in their windows to capture this data as a hobby. Each FTA aggregates the hobbyist data and posts a live world map of aircraft in flight. In just a few short years, the FTAs have tapped into the ADS-B broadcasts to form the most extensive land-based aircraft data communications network ever seen.

Aboard each of our customers' aircraft will be an AlulA Heart in the equipment bay or perhaps in a variety of other locations on corporate jets. The AlulA Heart will weigh no more than 4.5 kilograms, and it will be no larger than your average briefcase. Each will transmit encrypted flight data over the FTA network so that only authorized users can decode it. Voice will only be sent over the satcom SOS mode. What Weather Underground has done for meteorology, we believe we are doing for the aviation industry. The data exists. The network exists. Data rates can now be cheap enough for airliners to be willing to immediately act and buy into this service.

We are rapidly prototyping and seeking FAA certification for the AlulA Heart. It will retrieve data en route to the aircraft's black boxes and stream the encrypted data into the global network of crowd-sourced receivers. The AlulA Heart will supplement existing systems, rather than replace any of them.

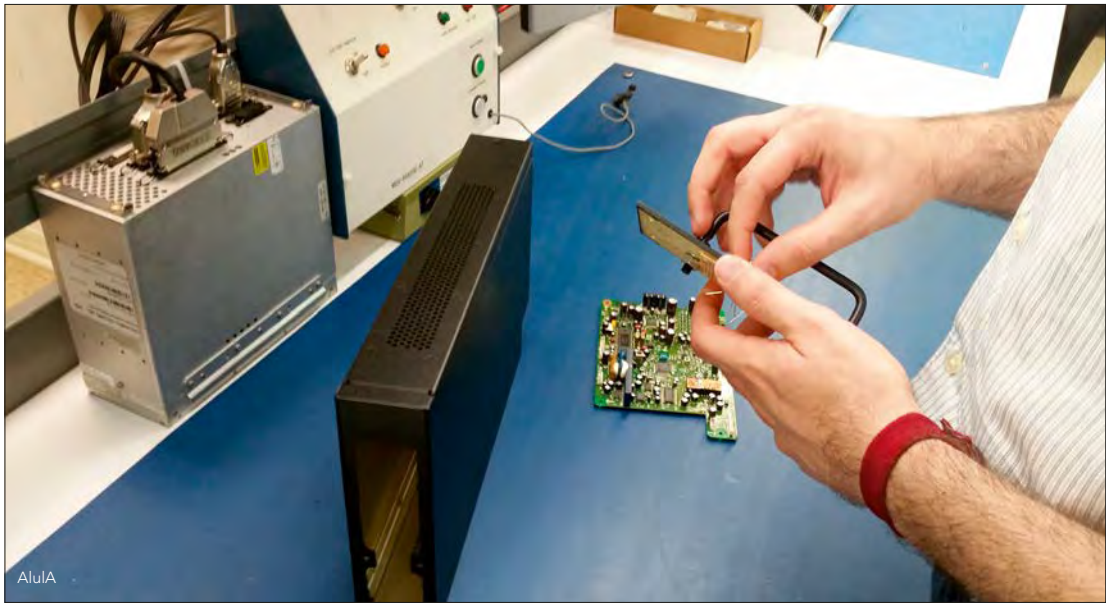
In normal mode, the AlulA Heart will continually stream data to fill the needs of various airlines, aircraft manufacturers and scientific agencies using the FTA network as a low-cost foundation. A sudden change in altitude or airspeed or other sensor exceedance would trigger the SOS mode in which data and cockpit audio would be transmitted via satcom. Additionally, the airline operator or authorities such as the FAA or FBI can remotely activate SOS mode.

Also while in normal mode, the AlulA heart will shift to an alternate broadcast method when the aircraft crosses over a remote region where crowd-sourced receivers are not present. To fill coverage gaps, data could be daisy chained by linking to other AlulA Heart-enabled aircraft; it could be transmitted via satellite communication; or it could be integrated into the in-flight Wi-Fi. The AlulA Heart hardware design will be inherently versatile to meet the sole purpose of getting the data into the hands of those who want or need it as quickly and as affordably as possible. This allows the AlulA system to be highly adaptable to fit the needs of its customers simultaneously.

Each AlulA Heart will constantly transmit detailed aircraft and engine sensor performance data to our future operations center. Customers will subscribe to receive this data so they can get a jump on an aircraft's specific maintenance needs before the plane lands. Fewer surprises mean more on-time departures. The industry (namely aircraft and engine manufacturers) has estimated the potential savings from predictive maintenance to be about 30 to 40 percent annually. This equates to nearly $1.2 billion dollars every year for an airline the size of American Airlines, since maintenance often rivals fuel as the highest overhead cost for carriers. We are also excited to provide meteorological agencies with the turbulence, wind speed, temperature and icing readings gathered by airliners in flight. With an AlulA Heart aboard, every plane becomes a collector of live weather data. This will lead to more efficient and comfortable routing for all.

Simply put: Our SOS capability is why we matter, charging for data and enabling predictive maintenance is how we will make our money and why the airlines will finally buy into this capability.

April was an encouraging month



AlulA is working with partner companies to reduce the size of the circuitry for its Alula Heart digital radio, which is waiting for its first customer.

for us. We won the top prize in the graduate-student category of the University of Miami's Business Plan Competition. We were also invited to showcase at eMerge Americas technology forum in Miami. CNBC included us on its list of "8 hot global start-ups to watch in 2016."

We are now about to undertake our greatest challenge. We must meet the FAA's strict certification requirements for installing a new piece of radio equipment on a passenger aircraft. We plan to begin environmental certification testing of the AlulA Heart in September. We are building two test radios and have contracted with an FAA-licensed designated engineering representative. It should take us about three to six months to earn a supplemental type certificate for the AlulA Heart. Once we pass environmental ground testing, we will be permitted to modify an aircraft for a series of demonstration flights to test the functionality of the AlulA Heart, as well as the function of the ADS-B.

We also understand that pilots, unions and crash investigative agencies around the world will want assurance that flight data recordings will not be leaked or accidentally transmitted by the AlulA Heart. These recordings will only be made public as a result of legal procedures for doing so. We will avoid this issue by encrypting the data. Cockpit voice recordings will only be broadcast via satcom in SOS mode. When the data is routed through one of our future FTA partners, an enthusiast who relays the data will not be able to read or see the data the end user deems as confidential. They can only automatically relay it, just as they do today with the basic flight information that airliners are already transmitting via ADS-B.

Cybersecurity is also of utmost importance, and a ground-up design priority. Within the aircraft, the AlulA Heart device will be an isolated system.

In the months and years ahead, the crowd-sourced network that already exists will only get better with added incentives for the enthusiasts. We aim to work with them to disrupt an archaic system of retrieving black boxes after crashes so that the air-travel industry can be fully connected to the modern, digital world.

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U.S. Marine Capt. Thomas Byrd is assigned to U.S. Southern Command in Doral, Florida. He is trained in Marine aviation and joint strategic intelligence planning and will leave active duty later this year.

Making a money saver

Engineers in Australia are working on what could be the world's first reusable launch vehicle exclusively targeting small satellites. But they must first overcome technical hurdles, including figuring out how to fire up airbreathing scramjet engines at lower Mach speeds. And they need to attract investors to start the business. Keith Button explains the challenges.

Launching a small satellite can cost $30,000 to $60,000 per kilogram delivered to orbit, and customers sometimes have to wait three years to launch. A group of Australian engineers are building and testing components of two versions of a multistage, partially reusable launch vehicle in hopes of solving those problems.

While the two satellite launch vehicles have some components in common, they also represent competing ideas from the group's engineers about how to solve the dilemma of delivering cheaper and quicker rides into space for small satellites. One of their satellite launch vehicles — SPARTAN, for Scramjet Powered Accelerator for Reusable Technology Advancement — would blast off vertically powered by a first-stage rocket. Supersonic combustion ramjet engines in the second stage would cull oxygen from the air to accelerate the vehicle on a horizontal path. A disposable third stage would push the 150 kilogram payload of satellites to an altitude of 550 kilometers. Meanwhile, wings and a propeller will pop out from the first stage to power it to a runway, while the second stage glides back on the same wings that provided lift during the acceleration.

First flight: The Austral Launch Vehicle-0, a one-quarter scale stage one test rocket, made a subsonic flight in December from Brisbane, Australia. ALV-0 is testing the subsonic aerodynamics of a flyback booster.

Heliaq Advanced Engineering

SPARTAN: To reduce launch costs, Australian engineers will need to fire up the airbreathing stage of the Scramjet Powered Accelerator for Reusable Technology Advancement at a relatively low supersonic speed, something they are still mastering.

A second version of the rocket, called the Austral Launch Vehicle, or ALV, would be powered by the same first stage as the SPARTAN and a disposable rocket for the third stage, like the SPARTAN. But in lieu of SPARTAN's airbreathing second stage, ALV would have a disposable rocket. Having to carry oxygen for stage two instead of using oxygen from the atmosphere, as SPARTAN does, would confine ALV's payload capacity to just 20 kilograms, but its designers are counting on getting to market quicker by skipping the technical hurdles posed by the airbreathing stage.

The SPARTAN project engineers hail from the University of Queensland, Australian Droid and Robot, and Heliaq Advanced Engineering, both small companies based in Queensland.

They aim to shake up a small-satellite launch market dominated by big launchers that squeeze small satellites aboard as secondary customers. To do it, they'll need to show that they can start up airbreathing engines at Mach 5 and return the reusable stages in shape to be refurbished and launched again. They'll also need to attract venture capital investors to help start a business.

Because SPARTAN consumes oxygen from the atmosphere, the liquid oxygen that other rockets must carry can be replaced by payloads for paying customers, which should lower the cost per kilogram for those customers. ALV would shave costs by reusing stage one, which accounts for about 75 percent of the weight and cost of the entire launch vehicle. According to their builders, SPARTAN and ALV would be the only launch vehicles with reusable stages for satellites weighing 100 kilograms or less.

Scramjet engines

Michael Smart, head of the SPARTAN project and chairman of hypersonic propulsion at the University of Queensland, ranks starting up the supersonic combustion ramjet, or scramjet, engines as the biggest technical challenge. The stage two vehicle will have four of the 5-meter-long scramjet engines.

Scramjet engines burn fuel — for SPARTAN, that's hydrogen — mixed with air rushing through the engine at supersonic speeds. Scramjet engines, unlike turbine jet engines, have no fans or other moving parts. The shape of the scramjet engine determines how much thrust is produced. The inlet compresses incoming air for combustion and a nozzle at the back of the engine accelerates the heated air from the combustion chamber.

SPARTAN's second stage will ignite as the first stage drops off, at Mach 5, or about 6,200 kph, and accelerate to Mach 10, or about 12,300 kph, while climbing to an altitude of 35 kilometers from 27 kilometers. SPARTAN's engineers have two main hurdles in lighting, or starting up, the scramjet engines. The first is that the air flow isn't as hot as it is at the higher speeds later in the stage. Hotter air makes ignition easier. The second is that the air resists moving through the engine ducts at Mach 5. That's an issue because the air flow is necessary for combustion. Establishing the supersonic airflow through the engine is difficult at that relatively slow speed, since the engine has been designed to maximize thrust at up to Mach 10.

SPARTAN's engineers have tested subscale versions of their scramjet engines in a wind tunnel at the University of Queensland's scramjet simulation lab in Brisbane. Air was accelerated through a series of pistons and tubes, culminating in a burst of air through a nozzle that created hypersonic conditions for 3 milliseconds. Results show that the SPARTAN engines will perform in the Mach 6 to Mach 10 range, and engineers plan to test the engines at Mach 5.

The solution to the ignition problem will probably come through tweaks to the engine shape design and the location of the fuel mixing in the engine, Smart says. The engineers have resisted one potential solution — adding a moving door to the front of the engine inlet — because it would add an unwanted level of complexity to the design and add more potential problems.

"Moving things in a hot scramjet, that's 1,500 degrees Celsius, it's a massive engineering problem," he says. "We've attempted to, and we think we can, come up with a design that doesn't require seals and moving parts and other funky things. We just get around that by understanding the fluid mechanics, and adjusting where the fueling is — getting the air flow to do what you want it to do — without having to move anything physically."

SPARTAN's engineers are incor-

porating findings from the HIFiRE, or Hypersonic International Flight Research Experimentation, an Australian-U.S. program that aims to complete a horizontal flight of a scramjet-powered vehicle for 30 seconds. So far, HIFiRE scientists have flown six of 11 planned flights of scramjet-powered vehicles, with two flights reaching Mach 8.

"SPARTAN is built on top of HIFiRE. If we hadn't done HIFiRE, we wouldn't have any idea how to do SPARTAN. All the issues that are the tricky ones for SPARTAN, we're learning about them in HIFiRE," Smart says.

Melting temps

Another big technical hurdle with SPARTAN is building the second stage vehicle with materials capable of withstanding extremely high temperatures, up to 2,000 degrees Celsius (3,600 Fahrenheit), for the 2.5-minute acceleration to Mach 10 from Mach 5, Smart says. The engineers will have to incorporate ceramic matrix composite materials, such as carbon-silicon-carbon and carbon-carbon composites, integrating them with the metals of the internal structure of the vehicle.

For some hot spots, such as the nose and the engine nozzles and combustors where temperatures could exceed the 2,000-degree-Celsius threshold, the engineers may have to use tungsten. It has an even higher temperature resistance than the ceramic materials but is extremely heavy — 1.7 times heavier than lead. Temperatures will be regulated by utilizing the cooling effect of the liquid hydrogen fuel carried aboard for scramjet combustion, circulating it through tubing under the hot surfaces, which would also serve the purpose of gasifying the hydrogen prior to combustion.

Engineers must also be concerned with the re-entry period, because the longer the SPARTAN flies at supersonic speeds, the more deeply the heat can seep into the vehicle, Smart says.

To protect the reusable rocket engine in the first stage from heat, SPARTAN and ALV are using a design by engineers from the German Aerospace Center. The rocket engine, which burns kerosene and liquid oxygen, could be used dozens of times, says Adriaan Schutte, Heliaq's chief engineer and founder. The engineers chose kerosene instead of hydrogen for the fuel because kerosene is easier to work with and helps make the design simpler, Schutte says. The chamber wall is a porous ceramic compound, so the wall siphons kerosene through it and then retains a thin layer of kerosene — a fraction of a millimeter — which means the hot gases from combustion never actually touch the wall.

A rocket lifts off from Hawaii as part of an Australian-U.S. project called HIFiRE, short for Hypersonic International Flight Research Experimentation. The results are helping Australian engineers design SPARTAN, the Scramjet Powered Accelerator for Reusable Technology Advancement.

U.S. Air Force Research Laboratory

Remote piloting

For the reusable stages of SPARTAN and ALV, engineers are designing them to turn into drones after they drop off and decelerate from Mach 5, for stage one, and Mach 10, for SPARTAN's stage two. Deploying the wing and propeller motor for the stage one spent rocket is complicated. Engineers need to ensure that the wing and propeller motor deploy before the stage-one vehicle drops too close to the ground, but not at a speed above 150 kph, which could damage them, Smart says. The second stage, which is reusable only with SPARTAN, likewise will be remotely piloted back to a runway landing, but it will land more like the space shuttle and glide in instead of using propeller power.

In December, the project's engineers flew a one-quarter-scale version of the planned 12-meter-long first-stage as it would appear coming back to Earth after accelerating to Mach 5, but their test did not include a rocket-powered launch and acceleration. Instead, they flew the cigar-shaped, simulated spent rocket shell via remote control, taking off and landing at a Brisbane runway and flying for 10 minutes, testing stall points, checking the tail fin rudder controls and the ailerons, and testing the landing gear, says Dawid Preller, co-head of Australian Droid and Robot, who remotely piloted the flight. Preller's company helped design and build the stage one vehicle, with a top-mounted single wing that pivots 90 degrees from its stowed position and nose-mounted propeller, driven by a kerosene-fueled piston engine, both of which will pop out when the actual stage one has decelerated to 150 kph.

Timing

The business case for SPARTAN is appealing, Smart believes. Currently, a company that wants to put its small satellite into orbit is faced with the launch industry's version of carpooling: booking a flight with planned launches dedicated to clients with large satellites, using any available leftover payload space, a practice called ridesharing.

"They'll toss them out as they go

up. The smaller clients can't choose their orbits very well, or their timing. They have no flexibility at all," he says.

Elon Musk's SpaceX and Jeff Bezos' Blue Origin have demonstrated launches and returns for rocket-powered large-payload space vehicles, and Airbus is proposing its winged Adeline vehicle that would fly back the main engines and avionics for refurbishment after a rocket delivers large payloads. But of the 15 to 20 groups currently developing launch vehicles for payloads of 100 kilograms or less, SPARTAN and ALV would be the only ones with reusable stages, says Heliaq's Schutte.

If SPARTAN wins the government and private financing that its managers are seeking, the program's engineers could build technology demonstrators and fly them in about five years, and then begin flying SPARTAN as a commercial launch enterprise in about eight years, Smart says.

ALV, because it is much simpler and cheaper to design and build, should be running commercially by the end of 2018 or early 2019 if its funding comes together, Schutte says. The goal of ALV's managers is to test the stage two rocket and fly stage three by the end of the year.

"The three-stage rocket [launch vehicle] will be quite a bit faster and simpler to develop because we don't have to develop all of these exotic technologies that the SPARTAN would require," Schutte says.

Of the total SPARTAN vehicle structure at launch, 80 percent will be reusable. The payload will be 1.3 percent of the total launch mass, compared to 0.3 percent for comparable small-scale launch systems that are rocket-only. Without the scramjet technology, ALV's payload will be 0.7 to 0.8 percent of the total launch mass, because it will have to carry all of its oxygen.

"As long as you can reuse these vehicles at least 10 times without major refurbishment, the [first stage] and the main vehicle, we expect to make a lot of money," Smart says.

Keith Button
buttonkeith@gmail.com

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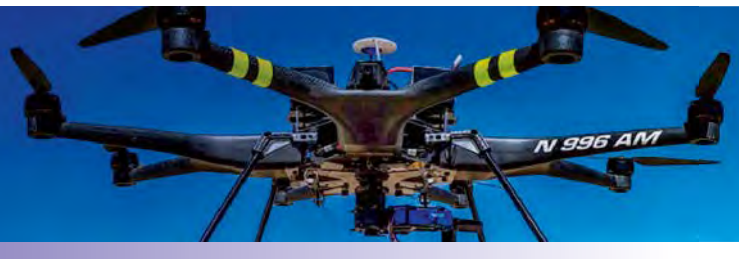

Program

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Applications for autonomous systems are myriad as technology continues to improve. What advancements need to occur in order for unmanned systems and technologies to transform flight and air transportation? Radio-controlled aircraft have not received the same level of attention and anxiety as UAS. What's different now? How much of the response is due to media hype? What steps need to be taken to change public perception?

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—**Mike Francis**, Chief, Advanced Programs & Senior Fellow, United Technologies Research Center

The Autonomy "Dream"

As is pointed out in *Autonomy Research for Civil Aviation: Toward a New Era of Flight*, published by The National Academies Press, civil aviation is on the brink of potentially revolutionary improvements in aviation capabilities and operations. Hurdles and substantial barriers to be overcome for UAS integration into the national airspace system will be discussed.

Technology Roadmaps for Intelligent Autonomous Systems

Discover roadmaps to the future for technology, operations, and implementation with representatives from NASA Aeronautics Research Mission Directorate, The Robotics Institute at Carnegie Mellon University, and the Department of Defense.

Transformation in the National Airspace System

The National Airspace System stands on the verge of transformation. The convergence of robotics, intelligent machines, autonomy, hybrid-electric propulsion methods, advanced aeronautic design, and work-anywhere, be-anywhere culture is driving our society into a new era. This panel will discuss the transformations being driven by UAS, and potential outcomes from the convergence of these driving technologies, issues and events in our increasingly connected society.

ASSURE: The FAA's Center of Excellence for UAS Research

Panelists from ASSURE: The FAA's Center of Excellence for UAS Research, the FAA's UAS Focus Area Pathfinders Initiative, and Center for Unmanned Aircraft Systems will provide updates.

UAS Traffic Management System

End users engage with the research, development, and test community to communicate challenges and needs of small UAS users and missions.

Visions of the Future

Speakers will address their visions for Robotics, UAS missions, UAS design, and the NextGen air traffic management systems.

DEMAND for UNMANNED Student Competition Alpha Test

Teams from the University of Michigan, University of Maryland, and McKinley Technology High School in Washington, D.C. will use a UAV quadrotor to participate in a two-part competition that includes autonomy and manual flight skills.

AIAA
Shaping the Future of Aerospace

Ambition Europa

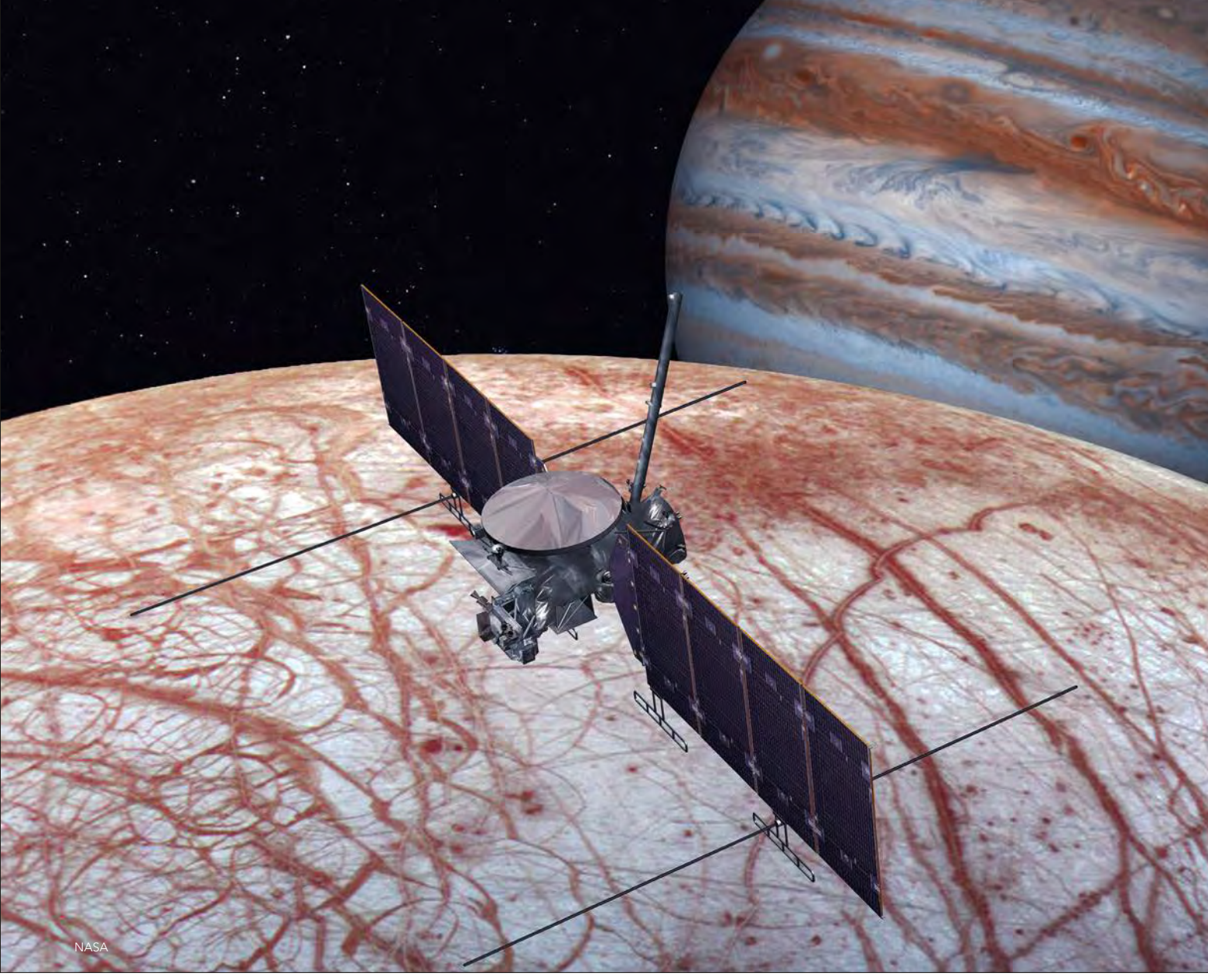
Scientists have known for more than a decade that Jupiter's moon Europa could have life in the ocean under its shell. NASA got to work drafting a cautious, step-by-step plan **to find out, perhaps sometime in the 2020s. Then, along came a congressman from Texas.** Debra Werner spoke to U.S. Rep. John Culberson and scientists about the push for a bolder Europa mission.

The year was 1972. Scientists at NASA's Langley Research Center were poring over reams of Martian surface photos taken by the Mariner probes, trying to figure out which region would be scientifically interesting but also safe for landing Viking 1 and 2, the first U.S. spacecraft to touch down on Mars. A year earlier, the Soviet Union achieved the first soft landing with its Mars 3 spacecraft after crashing its Mars 2 lander. With the Apollo program winding down, Congress was keeping a tight rein on NASA funding. Viking had been scaled back from one-year to a 90-day mission, and scientists eager to search for signs of extraterrestrial life did not want either of the $180 million landers to arrive somewhere boring, tumble over or vanish in a crevice.

This year, a much different dynamic is playing out among Congress, NASA headquarters and the Jet Propulsion Laboratory in California, where scientists are formulating plans to find out whether bacteria or other life could exist in the ocean under the icy crust of Jupiter's moon Europa. Instead of demanding austerity and caution, Congress has directed NASA to break with the tradition of scanning a world for years before deciding whether and where to send a lander.

Specifically, the 2016 appropriations law directs NASA to send "an orbiter with a lander" to Europa and to launch "no later than 2022." Questions linger about the wisdom of launching two expensive spacecraft on one rocket and about the feasibility of launching six years from now. JPL describes 2022 as "the earliest possible launch date," and it is studying multiple options for getting an orbiter and lander to Europa. NASA headquarters has approved studying the design of a Europa lander but has not yet agreed to order construction of it.

by Debra Werner
werner.debra@gmail.com



One possible orbiter design for NASA's Europa mission, which Congress has directed should be launched by 2022. NASA considers 2022 the "earliest possible launch date."

Wanted: Electrifying discovery

Few would question that Europa is among the solar system's most intriguing worlds. Salt water is the Holy Grail in the search for environments capable of supporting extraterrestrial life, and Europa should have lots of salt water. Magnetic field data gathered 16 years ago by the Galileo spacecraft showed that a vast ocean lies under its surface. The findings were so intriguing that in 2011, U.S. planetary scientists and technologists named a Europa mission as their second-highest priority through 2022, behind additional robotic missions to Mars that eventually would culminate in returning a sample to Earth.

"Europa has heat and liquid water. If there are organic compounds, we have a chemistry set that is primed for primitive or prebiotic development," explains geophysicist Laurence Soderblom. "Some people believe it's even possible there are organisms there. That would be startling."

Soderblom was vice chair of the National Research Council committee that published the planetary decadal survey, "Visions and Voyages for Planetary Science in the Decade 2013-2022."

On Capitol Hill, one lawmaker took special note of the survey's finding. Rep. John Culberson, R-Texas, has emerged as the Europa mission's most ardent supporter.

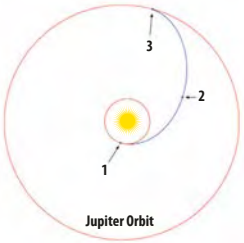
"We need an event, a discovery that will electrify the public and solidify the already immense support for NASA," Culberson tells me in a phone interview. That discovery could be finding life in Europa's ocean: "It will galvanize the country to take NASA funding even further so NASA can achieve all that's expected of them

Reaching Europa

NASA wants to find out if Jupiter's moon Europa could support life. The agency is weighing different trajectories that would send an orbiter and possibly a lander into a looping orbit around Jupiter and by Europa. Here are some options:

FLY DIRECT

Arrive in 2.9 years



EVENTS

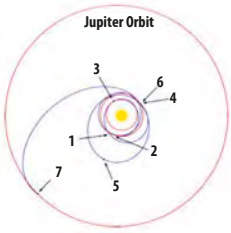
1. ***Launch:*** June 17, 2022
2. ***Deep space maneuver:*** March 22, 2023
3. ***Jupiter orbital insertion:*** May 1, 2025

Tradeoffs: Requires NASA's Space Launch System rocket, which is still being developed. Can't launch orbiter and lander together.

GRAVITY-ASSIST OPTIONS

EVEEGA *(Earth Venus Earth Earth Gravity Assist):*

Arrive in 7.6 years



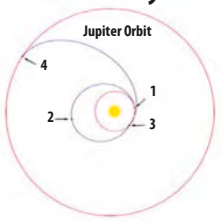
EVENTS

1. ***Launch***: May 25, 2022
2. ***First Earth gravity assist:*** May 24, 2023
3. ***Venus gravity assist:*** Nov. 22, 2023
4. ***Second Earth gravity assist:*** Oct. 21, 2024
5. ***Deep space maneuver:*** Oct. 22, 2025
6. ***Third Earth gravity assist:*** Oct. 22, 2026
7. ***Jupiter orbital insertion:*** Jan. 15, 2030

Tradeoffs: Does not require still-to-be flown Space Launch System rocket, but if SLS is chosen, orbiter and lander could be launched together.

Delta-V EGA *(Delta-Velocity Earth Gravity Assist):*

Arrive in 4.7 years



EVENTS

1. ***Launch:*** Sept. 22, 2022
2. ***Deep space maneuver:*** Oct. 28, 2023
3. ***Earth gravity assist:*** Aug. 7, 2024
4. ***Jupiter orbital insertion:*** May 24, 2027

Tradeoffs: Orbiter and lander could "most likely" be launched together, if Space Launch System rocket is ready, NASA says. Avoids hotter environment of Venus, but requires more propellant for deep space maneuver.

Source: NASA Jet Propulsion Laboratory

and maintain our world leadership in space exploration, both manned and unmanned," he predicts.

Fortunes began to turn toward a more ambitious Europa mission and schedule in 2014 when Culberson became chairman of the House subcommittee that recommends appropriations for NASA. The agency asked for $15 million in fiscal 2015 to continue planning for construction of a probe to be called Europa Clipper that would have sailed repeatedly by Europa from an orbit around Jupiter. Culberson proposed septupling that figure to $100 million; the Senate signed on, possibly because the launch looked like a job for NASA's yet-to-fly Space Launch System rocket and its Exploration Upper Stage. President Barack Obama signed the $100 million into law as part of the $18 billion for NASA in the omnibus spending bill for 2015. Congress went further in the Consolidated Appropriations Act that Obama signed in December, specifying the launch date of 2022 and requiring NASA to use SLS. NASA's $30 million request was boosted to $175 million. Thus was born the Europa Multiple Flyby mission.

Of the lander, Culberson jokes: "There might be some frozen shrimp or frozen krill or who knows what else in that frozen snow." What he's not joking about is his hope that NASA will find something beyond organic molecules on Europa.

Unique strategy

The congressionally directed Europa plan stands in stark contrast to NASA's traditional, methodical approach for exploring new worlds. First, a spacecraft gathers imagery as it flies by an unexplored world, as NASA's Galileo spacecraft did with Europa in the 1990s from its orbit around Jupiter. Years later, another spacecraft might be sent specifically to map the surface and study its geology, as NASA planned to do with the Europa Clipper. Only after all that would scientists dare to launch a robotic lander packed with scientific instruments.

Culberson is determined to compress that process for Europa. Scientists would

scan images sent home by the orbiter and then direct the lander, which may already be orbiting Jupiter, where to touch down. The congressional directive tells NASA to launch "an orbiter with a lander," which sounds like two spacecraft on one rocket. In reality, there has been lots of discussion this year about whether that is the best approach. NASA sent a statement when Aerospace America asked if the agency saw wiggle room in the congressional language: "NASA has directed JPL to study options on how best to send a lander to Europa. These studies will be used by NASA, the Administration, and Congress to determine what is the best approach to getting a lander safely to Europa."

Earlier this year, NASA Administrator Charles Bolden told a House subcommittee that his "strong recommendation" would be to "separate the orbiter and lander to optimize the chances of being successful with both."

Charles Elachi, director of NASA's Jet Propulsion Laboratory, told the subcommittee two weeks earlier that the decision did not need to be rushed. "Three years from now, we can decide to launch them together or separately," he said. For sure, NASA will develop them separately.

Of that discussion, Culberson, who presided over those hearings, says it's important to adequately fund the Europa mission while leaving the details to NASA planners. "The orbiter may go first. There may be a second launch of the lander," he tells me. But technology-wise, NASA "could certainly handle both on the same launch. I've already had multiple detailed briefings on the technology. But I'll follow the best advice of the engineers and the scientists. It's up to them to figure it out," he adds.

If NASA engineers and scientists are feeling micromanaged, they are giving no hint of that in public. The agency is forming a team to establish scientific goals and select instruments for the Europa lander, which will draw heavily on technology NASA developed for recent Mars landers. "It will look very much like some of the technology we have developed before," Elachi told the subcommittee. "We are very confident technologically that with appropriate funding that mission could be done at an acceptable risk," he said.

Rendering of plume of water vapor arising from Europa's frigid surface. Magnetic field data gathered 16 years ago by the Galileo spacecraft showed that a vast ocean lies beneath.

Cost worries

Some scientists worry that an ambitious Europa mission could siphon funding from other worthwhile exploration goals. That was the concern with a failed 2008 proposal to build a Jupiter Europa Orbiter that would have made multiple flybys of Jupiter's four moons before spending nine months in Europa's orbit. When the decadal survey members saw that project's $4.5 billion to $5 billion price tag, they urged NASA to come up with a way to study Europa for half the cost.

That's when NASA devised the Europa Clipper plan. By making looping orbits far

out into space during each trip around Jupiter, the clipper would spend relatively little time in the planet's intense radiation environment. That would reduce the shielding required for its electronics and science instruments. Shielding adds weight, and additional weight means higher launch costs. The probe would fly close enough to Europa every two to three weeks to gather data on its chemical composition, topography, magnetic field and the thickness of its crust of water ice.

Scientists were happy with the clipper plan. The mission offered "way above 90 percent of what the Jupiter Europa Orbiter could have delivered for half the cost," says Soderblom, the vice chair of the decadal survey committee.

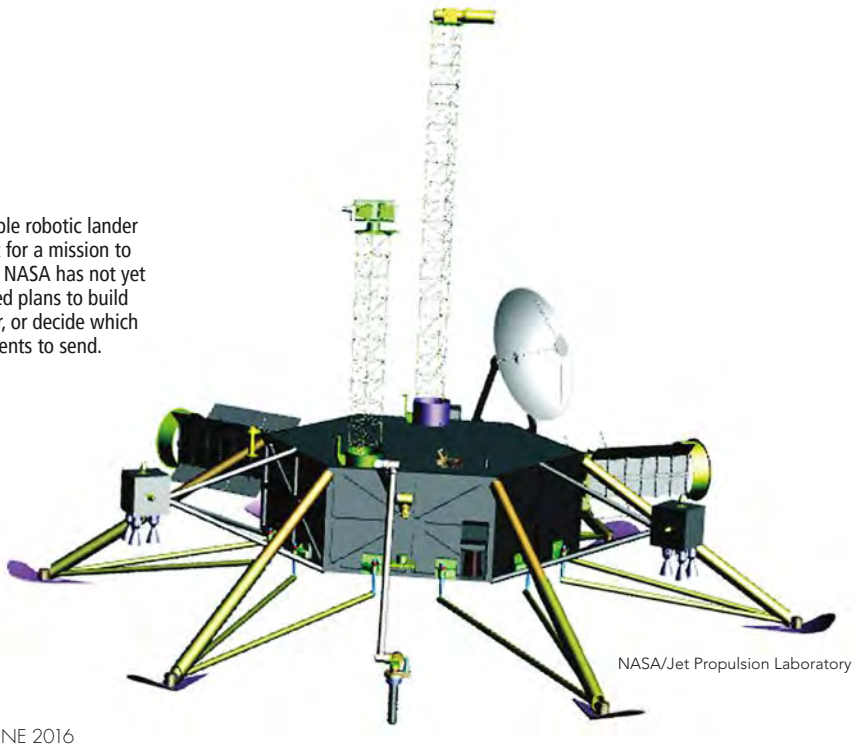
The congressionally directed Europa Multiple Flyby Mission will be more ambitious. It adopts a similar approach of long, looping orbits that take the clipper by Europa, but adds the lander and aims for an earlier launch date. NASA hasn't decided exactly how to get the lander and orbiter into space, despite the congressional direction to launch "an orbiter with a lander." Under the old plan, the clipper would have spent 6.5 years traveling to Jupiter after launching on an existing rocket. The SLS creates the option of putting the orbiter alone on a direct trajectory with an arrival date in 2024 or 2025. A lander sent separately could follow that same path. If both were launched on one SLS rocket, their weight would rule out a direct route. The two spacecraft would arrive in 2027 or 2030, depending on the chosen trajectory.

A question is whether SLS will be ready and proven by 2022. The first SLS launch will be unmanned and it is scheduled for 2018; a second flight and the first with an astronaut crew, is schedule for 2023.

The Government Accountability Office estimated in March that even without a lander, the Europa Multiple Flyby mission would cost $3 billion to $4 billion over its lifespan, including the rocket to launch it but not including the lander. NASA has not yet projected what a Europa lander would cost because the agency has not yet approved plans to build it or decided exactly which instruments to send to Europa's surface.

"I worry that we are right back where we were with an unaffordable mission," says a scientist who, like many people I spoke with, asked not to be named.

NASA finds itself caught between enthusiastic supporters in Congress and the White House Office of Management and Budget. During deliberations over the fiscal 2016 budget, OMB Director Shaun Donovan complained in a letter to Rep. Hal Rogers, R-Kentucky, that Congress was directing "an impractical level of funding toward the Jupiter Europa mission." Rogers is chairman of the House Appropriations Committee. The bill, which Obama signed in December, also cut $200 million from other NASA science programs and $100 million from space technology.



A possible robotic lander concept for a mission to Europa. NASA has not yet approved plans to build a lander, or decide which instruments to send.

NASA/Jet Propulsion Laboratory

Bolden, at the hearing in March, cited NASA's approach to Mars exploration as a more sensible template for Europa. NASA's

NASA

NASA hasn't decided how to get an orbiter and possibly a lander to Europa. An orbiter launched alone could reach Europa in as little as 2.5 years following a direct trajectory.

Mariner 4 spacecraft gathered the first images of Mars in 1965. Eleven years later, NASA's Viking 1 and 2 spacecraft obtained photographs of the surface that allowed mission managers to pick the specific sites where the Viking landers touched down in 1976. The Mariner images narrowed the options to certain regions. "We made sure we understood it fully before deciding on a place for a lander," he said.

An unfamiliar moon

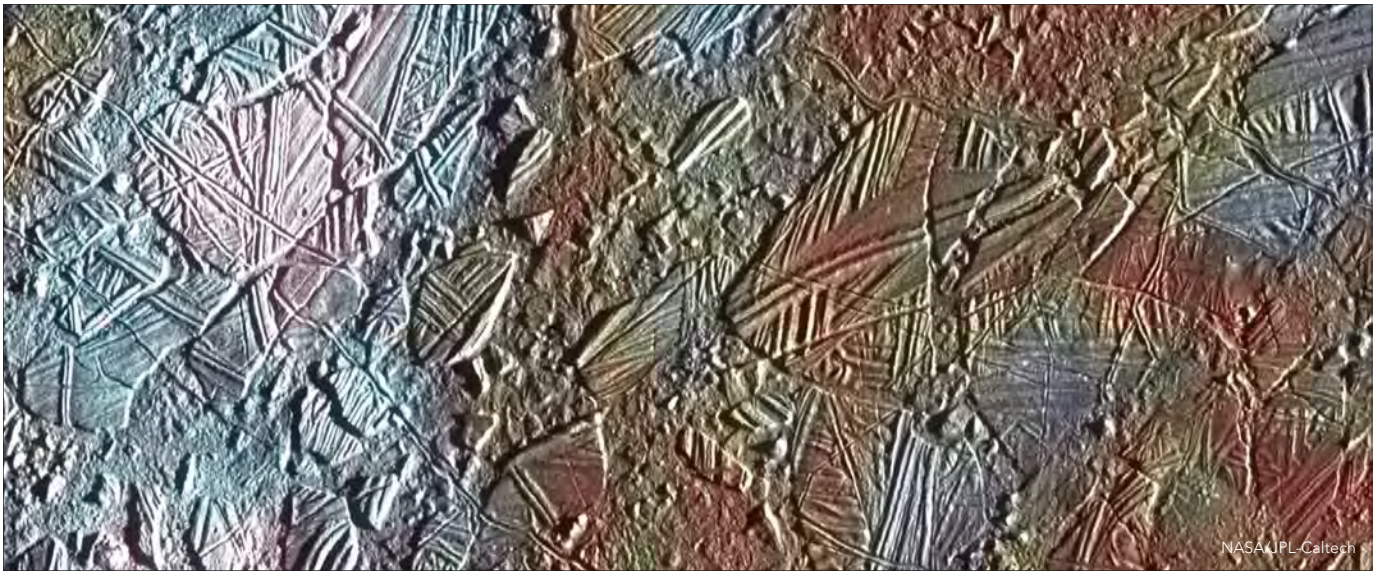
NASA's best images of Europa come from 11 trips Galileo made past it in the 1990s. The best of those images show a small portion of Europa's surface with a resolution of 10 to 20 meters per pixel. NASA captured additional lower resolution images of Europa with cameras on its New Horizons mission to Pluto in 2007; the Cassini Saturn mission in 2001 and Voyager 2's 1979 journey past Jupiter, Saturn, Uranus and Neptune.

"We don't know what the surface of Europa looks like at the scale of a lander, if it's smooth, if it's incredibly rough," Curt Neibur, NASA's Europa program scientist, said in 2015 during a press conference to announce scientific instruments for the Europa spacecraft. "Without knowing what the surface looks like, it's difficult to design a lander that could survive."

Those concerns have not stymied engineers at the Jet Propulsion Lab. They've applied the extra funds from Congress to study concepts for landers that would be sturdy enough to survive harsh terrain. Instead of standing on metal legs, the Europa lander will be shaped like a polygon and be capable of landing on any side, says Culberson, who gets periodic briefings from JPL engineers. NASA used a similar approach for the 1997 Mars Pathfinder landing on Mars. An airbag bounced to a halt and deflated as planned. Three triangular metal petals opened to serve as solar arrays, and the Sojourner rover rolled out.

NASA is identifying sites on Earth where the terrain is thought to be similar to what is expected on Europa. They'll go to those sites to evaluate potential landers and the difficulties they would face. "We specifically look for Earth analogs to the images which we do have for Europa, choosing the worst of these, and then to be more conservative design to pathological worst case scenarios," says Barry Goldstein, NASA's Europa project manager at JPL, by email.

Before the new Europa lander touches down, NASA will have far more imagery to study, Culberson says. If a



The possibility that life forms might exist under Europa's icy crust makes Jupiter's moon one of the solar system's most intriguing worlds.

lander travels to Jupiter at the same time as the orbit, it would remain in a very high orbit to limit its radiation exposure while the orbiter spends a year or two mapping Europa and obtaining extremely high resolution images of potential landing sites near the cracks in its surface. Scientists suspect these cracks might be hydrothermal vents that bring material from Europa's ocean up to its surface. Jupiter's radiation would destroy organic molecules that remain on the surface too long, but material near the cracks might give scientists a glimpse into the chemistry of the underlying ocean. Once scientists settle on a location to land, the second spacecraft will carry the lander toward the surface of Europa. A sky crane will unspool a tether to set the lander onto Europa, similar to the way the sky crane set NASA's Mars Science Laboratory onto the surface. Culberson predicts "a very soft, safe landing in the most favorable location."

"Brown gunk"

Once it touches down, it is anyone's guess what the lander's instruments will discover. Scientists would be excited with organic molecules, although Culberson and others are hoping for more.

If Europa has water plumes shooting from its surface, which the Hubble Space Telescope may have detected with an imaging spectrograph in 2012, the orbiter will fly through those fog-like plumes and use its onboard mass spectrometers to look for organic molecules. If no plumes are spotted, NASA will attempt to land near cracks in Europa's surface that show fresh deposits of whatever is coming from the water below. For now, NASA refers to the stuff visible around the cracks as "brown gunk."

"We'll look for places on the surface where there are fresh deposits around cracks," says Jonathan Lunine, director of the Cornell Center for Astrophysics and Planetary Science and a co-investigator for one of the Europa mission's mass spectrometers.

With a seismometer on the lander, NASA also will gauge the depth of the ice because the best way to find out what is under Europa's icy shell is to drill through it. NASA does not yet know exactly how it would do this, but Culberson wants engineers to get started developing technology to melt a hole in the ice.

"This will probably be after I'm dead and gone, but I'll make certain that the ground work is laid for us to land a penetrator and use some kind of very hot source to melt through that ice, drop out into the Europa ocean, use sensors to sniff out black smokers on the bottom and transmit signals back up to an antenna that's left dangling below the ice sheet," Culberson says. "It's absolutely achievable."

Culberson is similarly confident NASA's near-term mission to Europa will proceed. "Europa is the only mission it is illegal for NASA not to fly," he says.

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Designing a winner

AIAA's Design/Build/Fly contest gives college students a chance to pit their engineering smarts against international competitors in a remote-controlled aircraft flyoff. This year's event, the 20th annual competition, was arguably one of the most challenging. Joe Stumpe decloaks the winning design and explores the event's value to students.

Andy Ghosh/San Jose State University

John Paul Dela Cruz, above, holds down San Jose State University's production aircraft to keep it from blowing away in high winds before the final flight of the competition. At right is pilot Tyler Sanders and spotter Kevin Surban. Inset: Dela Cruz and Sanders celebrate after the plane lands.

Two decades ago, Dave Levy and his fellow aerospace engineers recognized a common shortcoming among new college graduates joining their ranks.

The young people's skills were "all book smarts, it was all theory," recalls Levy, a principal engineer with Textron Aviation in Wichita, Kansas. The students "really didn't have any practical knowledge."

Thus was born AIAA's annual Design/Build/Fly competition, which since its start in 1997 has become one of the largest international flyoffs for college teams. Each year, professional engineers dream up fresh missions for radio-controlled aircraft. Teams of students must conceive, build and fly their planes by remote control, gaining real-life lessons as their designs face off against dozens of competitors.

The challenge for this year's competition in Wichita was to mimic distributed manufacturing, in which aircraft ferry components of other aircraft to manufacturing locations. The San Jose State University design vanquished entries from 68 other colleges across four continents — not to mention 40-kph wind gusts — for the win.

Regardless of their finish, Levy says, all teams benefited from the real-life experience.

"It's gratifying for things to work out, but also to learn the things you didn't think about," says Levy, who was an early volunteer in efforts to organize the contest. "You learn, 'Hey, I don't really know everything.'"

Winning design

San Jose State prevailed due in part to the school's familiarity with the competition, numerous practice flights, design modifications and a key piece of paternal design advice.

Teams had to build two planes — a carrier aircraft and a smaller production aircraft. The carrier plane had to first fly by itself, then had to carry the second aircraft in one piece or in more flights if a team chose to deliver it in components. The production aircraft then had to complete a flight carrying a liter (32 ounce) bottle of Gatorade as the payload.

A fourth "bonus" mission required teams to assemble the production aircraft, if disassembled, perform a tip test and systems check within two minutes. Teams could significantly increase their score by having a low "rated aircraft cost," a measure of size and cost created by the organizers. The rated aircraft cost was calculated by multiplying the weight of the production aircraft by the weight of its batteries and the number of components the aircraft was broken into, and adding that figure to the weight of the carrier aircraft multiplied by the weight of its batteries.

Through the history of Design/Build/Fly, schools with previous experience in

AIAA/Karen Berry

Students from the University of Texas celebrate as their carrier aircraft lands with a second plane inside. UT was one of only 12 teams out of the field of 69 to complete all three missions during Design/Build/Fly. From left: Jake Janssen, Ryan Bradley (seated), Akshay Naik, Riasat Alam and Anuj Chauhan.

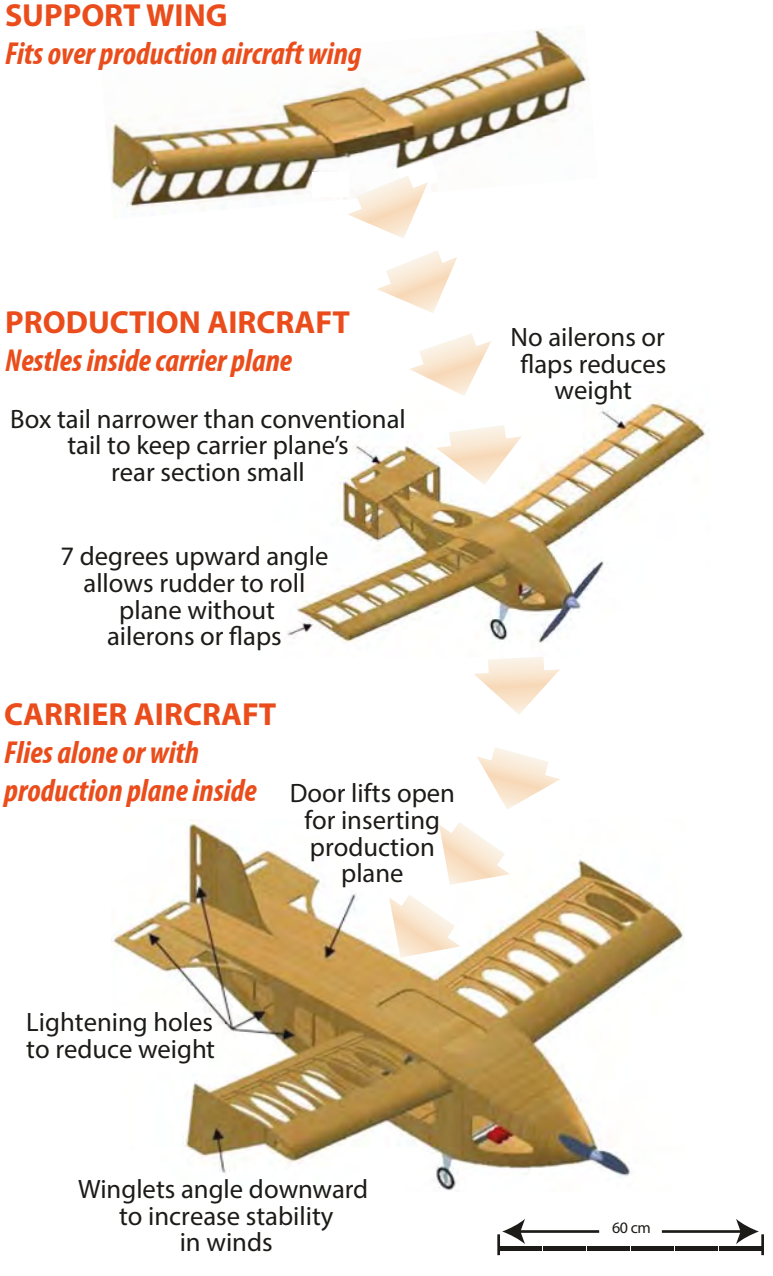
AIAA/Karen Berry

The University of Southern California team watches its production aircraft plummet to the ground during the final mission of the competition. The USC team had assembled the plane from scavenged parts after a crash the day before.

by Joe Stumpe
jstumpe@cox.net

The winning design

Teams in this year's Design/Build/Fly competition had to build a carrier plane capable of carrying a smaller production plane in its entirety or in pieces. Here's how the winning team from San Jose State University solved the problem:



Drawings by Christopher Dickason of the San Jose State team

the competition have tended to do well. San Jose State, a perennial top contender and the 2012 winner, was led by Tyler Sanders, a senior aerospace engineering major and a member of last year's team.

"From a logistics standpoint, this was a little bit harder," Sanders says. "Last year's was a little more dynamic. You got more points for speed. This year really came down to being able to fit one airplane fully assembled into another one, then really nailing the weight and getting it as light as you could."

The team's first move was to analyze the scoring system. Textron's Levy says the most successful teams focus on maximizing their scores, sometimes in ways that wouldn't be used in the real world.

"It's still valuable for them to explore these design spaces. It stretches their brain cells," he says.

San Jose State quickly tossed out any approach that required disassembling the production aircraft, which would increase the rated aircraft cost and thus lower the overall score. Instead, the team opted for a "Russian nesting doll" design so that the production aircraft would nestle snugly in whole inside the carrier aircraft. Several other teams also took that approach.

San Jose State drew on outside expertise as well. Sanders's father suggested a box tail, like those on some World War I-era planes, in order to reduce the width of the smaller plane's tail. That in turn would enable shrinking the larger plane's rear section. But the tradeoff, the students found, was that the plane didn't handle as well as they hoped.

The team consulted its academic advisor, Textron engineer Gonzalo Mendoza, who suggested enlarging the box tail to improve stability during flight.

Fatherly advice

Sanders and his teammates followed another piece of paternal advice by conducting at least two dozen test flights, far more than most teams.

"You go to races to race, you don't go to test," Sanders says, quoting a bit of advice from his father: "To finish first, first you have to finish."

During the competition, Sanders says San Jose State's two aircraft "got beat up a little" by Wichita's notorious

The Colorado School of Mines made its first appearance at Design/Build/Fly this year. Flying in high winds, the team's radio-controlled aircraft ran out of battery power about 400 meters from finishing the competition's final lap. Team members Nicklaus Smith, back to camera, Calvin Swanson and Joshua Pelz prepare the larger carrier plane during an earlier round.

winds. But Sanders, who flew the aircraft by radio link, says the design performed as expected.

In the end, San Jose State was one of just 12 teams out of 69 to receive full scores on all three flight rounds.

San Jose State's larger aircraft was about 1 meter long and weighed about 91 kilograms, making it one of the smaller models in the competition. At the other end of the spectrum, "Big Bertha" from Embry-Riddle Aeronautical University's Daytona Beach campus was nearly three times longer and four times heavier. Also unlike San Jose State, Embry-Riddle students chose to disassemble the smaller plane into two pieces to fit inside the carrier aircraft.

The group knew that decision would hurt their rated aircraft cost because the weight of the production aircraft and its batteries would be multiplied by two. Team leader Trevor Perrott says Embry-Riddle stuck with that approach anyway as a better embodiment of the spirit of the mission. The students believed it better reflected distributed manufacturing in the real world, where production aircraft are not transported whole.

Embry-Riddle finished 11th overall, its best showing in the competition. It also was one of only nine teams to complete all three missions plus the bonus mission. Perrott, a senior engineering major who was making his third appearance at the competition, says the experience will serve him well in his career.

Fabrizio Caruso, student aerodynamics leader for Sapienza University of Rome, agrees. Caruso's team believed it had a shot at finishing in the top three. But voltage problems resulted in a 10th place finish.

Nonetheless, Caruso declared his team thrilled to be in Wichita.

"We don't want to just pass our days on books, we want to apply ourselves to something," he said. "This competition is one of the best in the world."

Top finishers for Design/Build/Fly 2016

1. ***San Jose State University***
2. ***Georgia Tech*** *(also won best written report)*
3. ***University of California, Irvine***
4. ***Virginia Tech***
5. ***University of Oklahoma***
6. ***Oregon State University***
7. ***FH Joanneum*** *(Austria)*
8. ***Cornell University***
9. ***Hebei University*** *(China)*
10. ***Sapienza University of Rome*** *(Italy)*

Statistics matter, NOW more than ever

by Dave Finkleman
dfinkleman@comcast.net

All measurements are imprecise. All initial and boundary conditions are erroneous to a degree. All numerical integrations suffer numerical and analytical approximation errors. Every technical analysis, carried to enough decimal points, is uncertain. If it were possible to answer technical questions with intuition, we would not need scientists or engineers. Simply put, engineers and scientists must understand probability and statistics in order to make sound technical decisions.

A good maxim in our profession is to trust only those who acknowledge uncertainty. Trust more those who quantify the uncertainty. Most political polls state uncertainties. Weather forecasts state probabilities, not certainties. I believe in global warming, but few climate predictions reveal uncertainties that might be as large as the estimated temperature rise. The major-

VIEWPOINT

University aerospace engineering curriculums are packed with foundational courses, but statistics is not typically one of them. It's time to fix that, says Dave Finkleman, an AIAA emeritus fellow. Students, and ultimately policy makers, must have accurate data about the risks of collisions between drones and airliners or the odds of collisions in space.

ity of us don't know or ask about that.

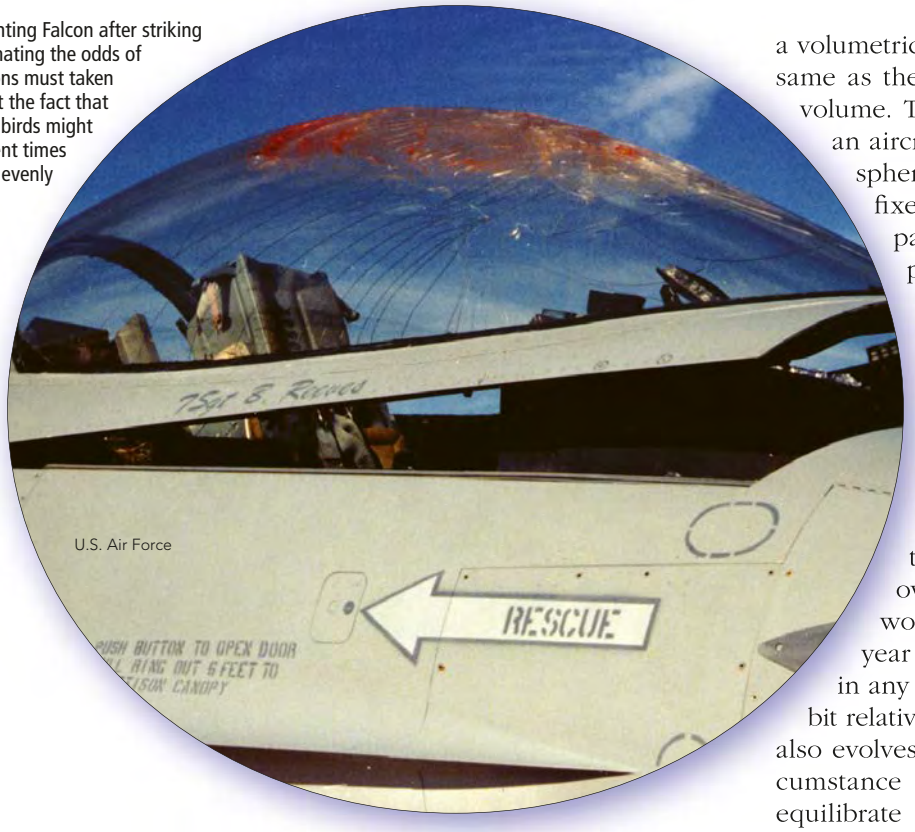
Engineers and scientists must be taught early to appreciate probability and statistics. The trouble is, few of the already jam-packed curricula include relevant instruction.

Fundamentals

Noted statistician and political-election forecaster Nate Silver exposes and describes most of the relevant issues in his 2012 book, "The Signal and the Noise: Why So Many Predictions Fail." His book should be required reading for students. So should "Why Most Published Research Findings Are False," a 2005 paper by Stanford University's John Ioannidis, who demonstrated that the majority of hypotheses "proved" to be true by common tests are actually false. Analysis similar to his was presented in the March 11 edition of Science magazine in the article "Sizing Up the Evidence," which explores efforts to apply statistics to forensics to judge the reliability of such evidence as shoe, tire and finger prints.

Most fundamentally, there is a difference between probability and likelihood. Probability is a deterministic concept with formulas such as a Gaussian Distribution Function that one can populate with numbers. Likelihood employs beliefs or hypotheses about the way things behave, and it exploits evolving data about those things. Likelihood involves joint probabilities. If this happened, what is the probability that something else happened? This is called Bayesian Analysis.

A thorough understanding of these and other principles of statistics is crucial for proper analysis of risk in two of today's fastest growing aerospace fields: drones and satellites.



An F-16 Fighting Falcon after striking a bird. Estimating the odds of such collisions must taken into account the fact that aircraft and birds might fly at different times and are not evenly distributed.

U.S. Air Force

Collision calculations

To accurately assess the risk that drones might pose to airliners, for example, one cannot make simplistic comparisons to bird strikes, as tempting as that might be. One reason is that birds are not uniformly distributed. Neither are drones for that matter. Birds also fly less often at night compared to airplanes. In addition, inaccuracies in the public reporting of incidents must also be considered. The drone that was reported to have struck a British Airways jet in April appears to have been an errant plastic bag. Simplistic or inaccurate analyses could prompt policy makers or Congress to make decisions based on convenient but wrong information.

There are also misunderstandings in examining potential collisions among objects in near Earth space. It is too often assumed that an object is moving through a sparse cloud with uniform local density of debris. In engineering and science, density is an equilibrium concept. In any volume, as many objects enter as leave. As in kinetic theory of gases, density is the expected number of particles in a locally meaningful volume even though there is a lot going on inside that volume. It has a lot to do with the assumption that a volumetric average at a given time is the same as the temporal average in a given volume. This is what allows us to treat an aircraft moving through the atmosphere as though the airplane were fixed, and the gas were moving past it. This is called the ergodic principle, and it applies only in equilibrium.

Some researchers estimate with multiple realizations the likelihood that a satellite might experience a collision, adjusting the initial location of a satellite in its orbit over numerous possibilities. They might propagate this over a year or more. However, it would take much longer than a year for the satellite to have been in any possible location within its orbit relative to a debris environment that also evolves. This is a nonequilibrium circumstance that could take centuries to equilibrate to a rigorous definable "density." It violates ergodicity, the principle that a sample should reflect the characteristics of the whole, on any time scale of interest. Worse yet, the outcomes are divided by the interval propagated or the number of realizations, stating a collision rate per year, month, or week when they are valid only over the integration interval or over many, many realizations, not per realization. It is akin to expecting flips of a fair coin never to show successive heads or tails. Only over an infinite number of flips is the probability 50-50.

Define the unknowns

It is very important to propagate uncertainty from all important causes, uncertainty that might neither be Gaussian nor able to be quantified with straightforward equations. Satellite orbits are uncertain, subject to errors in physical hypotheses and in observations (process and measurement noise). If hypotheses are not reconsidered based on expectations not meeting estimates or there is no additional data, uncertainty grows the further in the future one propagates until the satellite population can only be described statistically, not deterministically. We can estimate (not predict) that there might be a collision with some likelihood within a certain period of

time, but we cannot know when or what might collide with what. Analyses that propagate the orbit of a specific satellite over years or decades, stating the future location and state explicitly, are wrong.

Orbit estimation suffers acknowledged process and measurement noise, which are clearly separable only in a linear sense. The estimation process gauges the degree to which hypotheses of equations of motion actually fit observations. A dilemma is that orbit elements determined with quantified uncertainty for a set of hypotheses are very often used to propagate orbits under different hypotheses. This is not a sound process. Assume for a moment that an investigator achieves relative to others a better fit under his hypotheses about atmospheric resistance, the structure of the atmosphere, or gravitation. That does not mean that similar precision can be achieved by others using that investigator's orbit elements in their trusted techniques.

Not to diminish real risks, it should be noted that sometimes risks are stated incompletely, tendentiously or incorrectly. A popular scientific commentator once stated that an asteroid might hit Earth once every billion years. If there are six billion people on Earth, six people might be killed by an asteroid every year. That sounds ridiculous, but the these kinds of flawed analyses are sometimes aired. In reality, the probability is one in a billion every year even if there had just been an impact. That there had been no impact for a billion years does not mean that there might not be one tomorrow.

We can reasonably accept that astronauts have less than 1 percent probability of surviving if the International Space Station or their launch vehicle were to collide with something. But a more meaningful measure of the risk to astronauts must include the probability of there being a collision or a failure in the first place, and those events have an overall likelihood of one in 10,000.

A similar problem exists in stating the probability of injury or death due to common, but intrusive, medical procedures. Few occurrences of death or injury are included in the sample data. The risk for most patients is probably greatly overstated. It is a worst case hedge against something very unlikely going wrong. A similar flaw with a different result was implicated in both the Challenger and Columbia tragedies. Each success was included in the data, lowering the erroneously perceived probability of failure.

Preserving a low risk of collisions in the near Earth space environment is a matter of degree and effort. It is a statistical problem. The near Earth space environment is diverse. We could hardly perceive or track everything all of the time. Preserving the environment is a matter of degree and effort. It is now a statistical problem. We can build on the understanding of ecology, demographics, and epidemiology, but we need to do better at exercising the discipline necessary to identify and reject noise in order to discern the signals of phenomena we can address. Building more and more sensors is not the answer for either space or airspace. Sampling intelligently and teasing out the signals requires that we understand, teach, and employ sound statistics.

Poor understanding of probability and statistics has again penetrated our profession. Engineers and scientists have used probability and statistics improperly in estimates of the risk to aircraft of private multicopter drones, the risk of space debris, and the consequences of asteroid impacts. There are many serious and correct assessments, but they seem to be overwhelmed by poor analysis.

Our profession demands good understanding of statistics, probability, and likelihood. It also requires that we appreciate the interaction of our physical and mechanical analyses and experiments with these concepts. We must recognize how biases and subjective expectations affect our estimates. It is not that statistics lie. It is that some would intentionally or unintentionally misapply principles of statistics. Our successors must understand these distinctions.

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Dave Finkleman is a retired Air Force colonel and a former chief technical officer at the North American Aerospace Defense Command and the former U.S. Space Command. He has a Ph.D. in aerodynamics and gas dynamics from MIT and is an AIAA emeritus fellow.

Massive wildfires have become almost a summer ritual in the U.S. But airtankers, the air cavalry of forest fires, have been in short supply for years. Michael Peck explains how technology based on military smart bombs and drones could beef up the firefighting arsenal.

SMART WEAPONS

A C-130 drops boxes containing fire retardant gel during a test at the U.S. Army's Yuma Proving Ground in Arizona in 2011. More than a decade after a Boeing engineer conceived the idea, the system is still not in use anywhere to fight wildfires.

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

William Cleary was struck by an inspiration one day 13 years ago. "My son was on a third-floor balcony and nailed me with a water balloon," recalls the veteran Boeing aircraft engineer. "And I thought, why can't you do this with a fire?"

Like the apple landing on Isaac Newton's head, the prank spurred Cleary to come up with a new way to combat forest fires, one that would use military transport aircraft to douse flames with giant water balloons in the same way that planes drop cargo to troops or food and water to refugees.

More than a decade after Cleary's eureka moment, supporters believe they're at last close to securing the approval from the U.S. Forest Service, the final arbiter in most locales, to enlist the technology in the U.S. firefighting arsenal.

High stakes

Smoky the Bear can certainly use the help. A record 68,151 wildfires scorched the U.S. last year, burning almost 41,000 square kilometers. That's akin to obliterating all of Denmark or Switzerland. Forecasters say this year won't be quite as intense. But even so, the Forest Service will field only

for fighting fires

Flexible Attack Innovations

21 aerial tankers, some of them ex-Navy patrol planes dating back to the 1950s. The Pentagon will join the fight, but with eight U.S. military C-130 transports fitted with retardant-spraying systems, it's not much of a reinforcement.

However, what if firefighters had potential access to hundreds of U.S. military transports, similar to the C-130s that the Forest Service is already using to fight fires? That's the strikingly simple concept behind Cleary's Precision Container Aerial Delivery Systems, or PCADS: Extinguish or cordon off flames by mimicking how military transports drop boxes of cargo by parachute.

Each PCAD consists of a triple-walled corrugated cardboard container housing a 946-liter biodegradable polyurethane bladder that can be filled with water or fire retardant gel. The container has pyrotechnics timed to burst at least 300 feet above the ground.

"A one-ton water balloon," says Ty Bonnar, president of California-based Flexible Attack Innovations, which is marketing the product to the Pentagon, state Air National Guards and internationally. Last September, Bonnar and Boeing secured a patent for PCADS, though the aerospace giant is no longer actively involved with the project.

Firefighting drones

After demonstration tests in October in Boise National Forest, the U.S. Department of the Interior concluded that the K-MAX helicopter was capable of delivering firefighting cargo and water in an unmanned configuration "with the same or better precision" as a pilot on board.

Lockheed Martin

While the U.S. Forest Service has experimented with drones to monitor fires, the idea of deploying unmanned aircraft to extinguish real blazes has proven incendiary. A pilotless plane dropping water or chemicals inevitably raises worries about the consequences of a malfunction for people on the ground.

In October, the Interior Department tested the firefighting capability of an unmanned K-MAX helicopter from Kamen and Lockheed Martin during simulated fire suppression and resupply missions in Boise National Forest. The K-MAX is an "optionally piloted" helicopter that can be flown with a pilot, or quickly transformed into an unmanned aircraft controlled by a ground station. The Marines flew the unmanned version of K-MAX, which has a cargo capacity of 2,700 kilograms, for almost three years in Afghanistan, as an alternative to sending truck convoys down roads studded with bombs and other explosives.

But how would an unmanned aircraft fare as a firefighter? Operating in its unmanned mode in Boise, the helicopter flew autonomously, with the ground control operator ordering minor corrections as needed. The helicopter delivered simulated firefighting cargo to remote locations.

"We ran one mission where we delivered four different loads in one flight to different locations across a mountain ridgeline," says Terry Fogarty, director of K-MAX business development for Kamen. "We also delivered cargo into a grove of trees and subsequently backhauled the equipment from similar locations. "

On other flights, K-MAX carried a bucket on a tether 15 to 46 meters long, and dropped water at successive points. This created a "wet line" that would have kept fires from spreading, according to an Interior Department report. K-MAX received the drop coordinates from a fire fighter on the ground, and its flight control system flew to them with the aid of Google Earth.

The helicopter's infrared sensor measured the location and effectiveness of the water drops and detected active wildfires more than 20 kilometers away through dense smoke. The report concluded that the unmanned helicopter "performed well in mountainous terrain and was able to deliver cargo and water with the same or better precision, as it was capable of in the manned configuration."

What particularly impressed the agency's evaluators was the K-MAX's ability to quickly switch from unmanned to manned flight, which means a human pilot could ferry the helicopter from fire to fire without having to file a special unmanned aircraft flight plan with the FAA. It also means that a human pilot could fly during the day while the pilotless version flies more dangerous missions at night and during reduced visibility, a key advantage given that the Forest Service has only one helicopter capable of flying at night.

The downside of an unmanned firefighter, of course, is the same as every other drone: What happens if something goes wrong?

Fogarty says the K-MAX is no substitute for real humans.

"The unmanned K-MAX today, and for the next few years, will never be as efficient as manned aircraft at dumping water," he says. "But it can fly when those guys can't. Which means that instead of aircraft fighting fires eight hours a day, now you can do it 24 hours a day."

Michael Peck

PCADS can be dropped from any aircraft that has a rear ramp or cargo rollers, and that uses a cargo-dropping system like the Container Delivery System, or CDS, which the U.S. military has used as far back as the Korean War to parachute supplies. That qualifies many military transports, including C-130s, C-17s, C-27s, V-22 Ospreys, CH-53 helicopters and even Russian IL-76 and IL-78 transports.

As far as the transport pilots and loadmasters are concerned, PCADS is no different from the bullets and rations they've dropped over battlefields and disaster zones since the 1940s. Rather than conventional airtankers that are permanently fitted with tanks of fire retardant, "PCADS is an opportunity to separate the firefighting equipment from the delivery platform," Cleary says.

Firefighting arsenal

PCADS offers several advantages, according to its proponents. One, it vastly expands the number of potential airtankers. The Forest Service currently relies on a small number of retired airliners or military aircraft permanently converted into airtankers by fitting them with tanks of fire retardant. The agency this year will deploy a polyglot collection of privately contracted aircraft, including five converted BAE-146 and four RJ85 regional jets; two converted DC-10s and two MD-87s; a C-130Q and six 1950s-era P-2V maritime patrol aircraft. These will be joined by an HC-130H that will be flown by the Forest Service itself as the first of seven HC-130Hs transferred from the Coast Guard.

The Pentagon also will contribute eight Modular Airborne Fire Fighting Systems, or MAFFS, tanks of fire retardant temporarily fitted to C-130H and J aircraft, which spray the chemicals from nozzles. The MAFFS are carried, two per wing, on Air National Guard C-130s in California, Wyoming and North Carolina, and on those flown by the Air Force Reserve in Colorado.

Even backed by the MAFFS-equipped aircraft, the Forest Service can muster only a tiny airtanker squadron compared to the 222 C-17s and 346 C-130s available to the Air Force's Air Mobility Command. If even a fraction could be spared from military du-

ties to carry PCADS, that would be a considerable force. Military transports equipped with computerized and GPS-enabled navigation systems such as the Air Force's Precision Airdrop System can also accurately drop PCADS containers.

PCADS also offers a more direct way of putting out fires, proponents say. Conventional firefighting aircraft drop retardant around a wildfire to keep the flames from spreading. However, Bonnar believes that PCADS is accurate enough for "direct attack," in which water or fire-extinguishing gel is dropped directly on the fire to extinguish it or prevent its spread. Or, it can be used to create "wet lines" on unburned vegetation to keep fires from spreading.

PCADS may also be safer for flight crews than conventional airtankers that must spray retardant from low altitudes. Retired U.S. Air Force Brig. Gen. Harold Reed, a former Wyoming Air National Guard chief of staff and a former commander of a MAFFS-equipped C-130 unit, says that some runs are at 75- to 100-feet altitude in rough terrain.

"It is the closest thing to combat," says Reed, an independent expert who notes that weather or smoke often preclude low-altitude flights.

Because PCADS is dropping boxes that are timed to airburst above the fire, they can be dropped from much higher altitudes.

"No more dive bombing," Bonnar says. "Most of our missions will probably be at 1,000 feet during daytime."

Reed would like to see drops tested from 5,000 feet. Drops also can be made at night and in bad weather, conditions military airlift units are also trained to fly in.

Bonnar sees PCADS as complementing conventional airtankers, which don't usually fly at night. PCADS can be used for night firefighting, when lower temperatures and calmer winds make fires easier to manage. To Bonnar, PCADS is best for carpet-bombing young fires, dropping a deluge of tens of thousands of liters of water or gel to extinguish a blaze before it gets bigger.

"There's a place for PCADS, and a place for the airtankers," he says.

The Pentagon supplements the U.S. Forest Service's small fleet of airtankers with eight Modular Airborne Fire Fighting Systems, which are tanks of fire retardant temporarily fitted to C-130s.

Regulatory hurdles

Nonetheless, PCADS is currently not being used by any agency to fight fires. It has been approved by the U.S. Air Force, Air Mobility Command and the Air Transportability Test Loading Agency for use on Department of Defense aircraft. Later this year, PCADS will also undergo Opera-

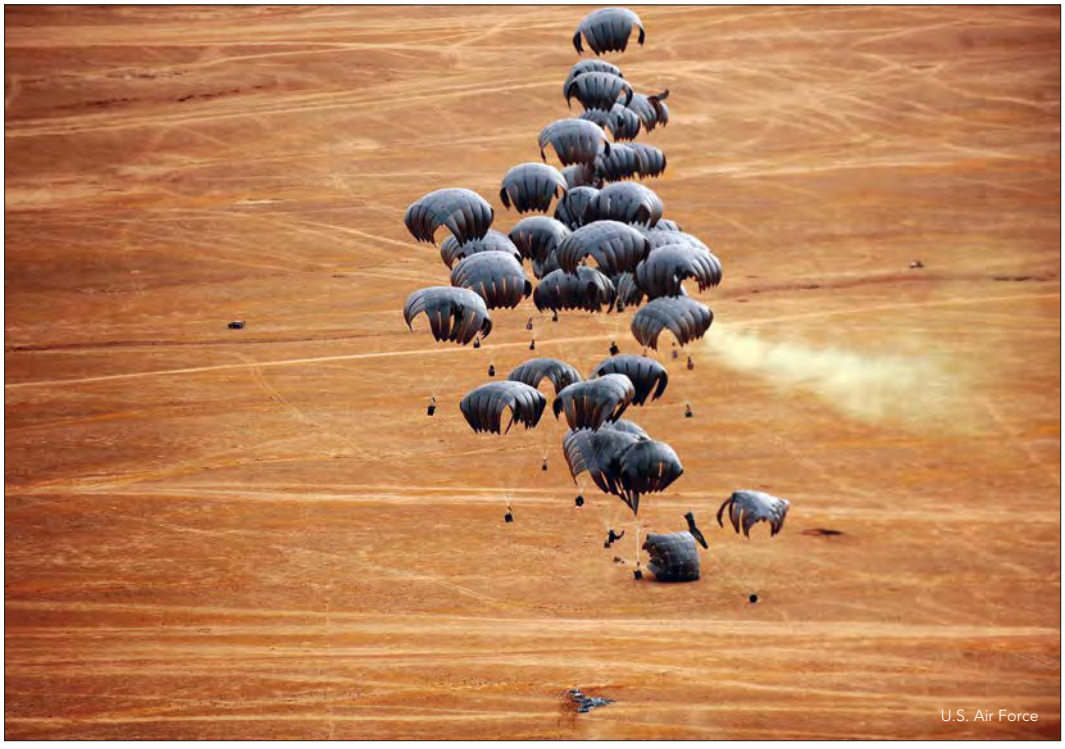
U.S. Air Force

A U.S. Air Force loadmaster loads cargo aboard a C-17. Any military aircraft that have a rear ramp or cargo rollers and that use the cargo-dropping Container Delivery System can be loaded with water or flame retardant.

tional Test & Evaluation to determine whether it can be loaded on Air National Guard C-130s. This solves the problem of what platforms can carry PCADS, but it doesn't amount to approving the technology to fight fires.

The Forest Service says it is aware of the technology, but is not saying much more than that.

"The agency has been tracking the development of the PCADS system for several years," says spokeswoman Jennifer Jones by email. "The last time that the U.S. Forest Service conducted tests of the


U.S. Air Force

A C-17 drops supplies in Afghanistan. The Pentagon's fleet of these and other transports could be enlisted to supplement the Forest Service's firefighting airtankers.

PCADS system was more than eight years ago – the agency understands that a number of changes have been made to the PCADS system since that time and consequently believes that it would not be relevant or appropriate to discuss the testing that the U.S. Forest Service was involved in at the present time."

PCADS supporters like Reed suggest that what's blocking the Forest Service from adopting PCADS is a turf battle between states and the federal government over who owns firefighting resources. States control the C-130s in their respective state Air National Guards, which in theory should allow governors to commit MAFFS-equipped aircraft to putting out wildfires.

However, the MAFFs gear itself is owned by the Forest Service, which must authorize states to use it. Reed says Wyoming once had to wait three days to get Forest Service approval to install MAFFS to quell a fire, which let the fire spread. The attraction of PCADS, as states-rights supporters see it, is that controlling both the C-130s and the PCADS equipment offers more flexibility and quicker response times, especially for fires on state- or privately-owned lands.

Still, the Forest Service may have reason for caution. While conventional air tankers and MAFFS gently spray retardant, PCADS involves dropping 900-kilogram boxes from the sky. Though the containers are now set to burst above the ground (the original design had the boxes hit the ground like a bomb), a malfunction could pose a danger to people and property below, which has occurred during regular military cargo drops.

Even so, Cleary expects PCADS to ultimately emerge as the cavalry riding to the rescue, as in the movies. Bonnar shares that sentiment.

"It's when you've thrown everything at the fire, and it still gets out of control, and we can't see any other way to stop this thing," he says.

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Out of the

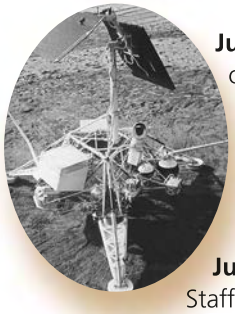
25 Years Ago, June 1991

June 26 The Sentinel 1000 airship flies for the first time. It is powered by two gimbled Porsche automobile engines, is 67 meters long and has a volume of 10,000 cubic meters filled with helium. It is built by Westinghouse Airships of Weeksville, North Carolina. The target market for the airship is law enforcement agencies for maritime and drug interdiction use. David Baker, Flight and Flying: A Chronology, p. 485.

50 Years Ago, June 1966

June 1 The unmanned Augmented Target Docking Adapter, or ATDA, for the Gemini 9-A mission is launched by an Atlas booster from the Kennedy Space Center in Florida into a 298-kilometer orbit. New York Times, June 2, p. 1.

June 1 A Saturn 5 third stage, weighing almost 150,000 kilograms, is flown by a Super Guppy aircraft from Douglas Aircraft's plant in Huntington Beach, California, to its Sacramento test site for static testing. Aviation Week, June 6, p. 25.



June 2 The Surveyor 1 becomes the first U.S. spacecraft to soft land on the moon when it touches down in the Ocean of Storms and starts to transmit more than 10,000 detailed TV photos of the lunar terrain to NASA's Jet Propulsion Laboratory receiving station in Goldstone, California. New York Times, June 3, p. 2; Washington Post, June 15, p. A10; Aviation Week, June 6, pp. 27-28.

June 3 The Gemini 9 spacecraft, flown by command pilot Thomas Stafford and pilot Eugene Cernan, is launched from the Kennedy Space Center by a Titan 2 booster. Its mission includes docking with the ATDA, launched on June 1, as well as to evaluate extravehicular life-support and maneuvering equipment and procedures. The docking is completed, and on June 5, Cernan makes a "space walk" to retrieve a micrometeoroid impact detector attached to the spacecraft and moves to the full length of his 7.6-meter tether to take photos. Later, he ventures out again to test the Astronaut Maneuvering Unit. Altogether, Cernan spends more than two hours, a new record, for extravehicular activities. A highly accurate reentry and splashdown is made on June 6. New York Times, June 4, pp. 1, 10, and June 7, pp. A1, A6.

June 3 Edgar Bush, a senior technician at NASA's Goddard Spaceflight Center since 1959, who designed the first microelectronic circuitry used for spaceflight computers, dies. Bush had designed the computers for the Vanguard 3 Explorer satellites and lunar orbiters. Washington Evening Star, June 7, p. B5.

June 6 The Orbiting Geophysical Observatory, OGO 3, is launched from the Kennedy Space Center in an Atlas-Agena B booster. It is the third in a series of seven in the OGO program that studies solar wind, solar flares, magnetic field disturbances, radiation belt particles, aurora events and other phenomena. New York Times, June 8, p. 15.

June 8 The XB-70 No. 2 experimental bomber and its F-104 chase plane collide near Barstow, California, killing its famed NASA test pilot Joseph Walker and co-pilot, Major Carl Cross. Walker held world records for flights in the X-15 rocket research aircraft. President Johnson praises the pilots who gave "their lives in advancing science and technology." Flight International, June 12, p. 1033.

June 12 Otto Ernst Meyer, the German-born aviation pioneer who had founded Brazil's first national airlines, Varig, in 1927, dies in Porto Alegre, Brazil. A World War I pilot, Meyer immigrated to Brazil in 1921. Flight International, July 7, p. 15.

June 20 British aviatrix Sheila Scott lands her Piper Comanche 260B at London's Heathrow Airport, completing the longest solo flight in a single-engine aircraft to date. Scott, who had begun her flight from Heathrow on May 18, flew some 46,116 kilometers at an average speed of over 58 kph, setting many new world flight records. Flight International, June 30, p. 1109.

June 22 PAGEOS 1, the Passive Geodetic Earth-Orbiting Satellite, is launched from Vandenburg Air Force Base, California. Similar to the earlier Echo balloon-type passive communications satellite, the PAGEOS consists of a balloon folded and packaged into a spherical canister ejected into space, then separated and automatically inflated to a 30-meter diameter sphere. It contains no instruments and is used to reflect sunlight as a source of light to be photographed over a five-year period to more accurately

Past

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

measure the size and shape of Earth than previously possible. The PAGEOS system includes multiple camera stations around the world. Washington Post, June 24, p. A5.

June 25 A new Concorde supersonic airliner flight simulator is unveiled at France's Sud-Aviation laboratories in Toulouse, France. Minister of Transport Andre Bettencourt hosts the ceremony that includes top French and British aviation officials and representatives from the aviation industries of both nations. Andre Turcat, Sud Aviation's flight-test director, conducts the supersonic flight simulation. Flight International, June 30, p. 1078.

75 Years Ago, June 1941

June 17 Famed American pilot Jacqueline Cochran becomes the first woman to fly a bomber across the Atlantic Ocean. Despite objections from male pilots, Cochran makes the flight after the intercession of Lord Beaverbrook who authorizes Cochran to fly after she performs 60 takeoffs and landings in Montreal. To appease male pilots who were threatening to strike, Cochran agrees to let her male co-pilot take off and land the aircraft, despite her obvious ability to do so. David Baker, Flight and Flying: A Chronology, p. 263.

June 20 The U.S. Army Air Forces is formed, with Major Gen. Henry H. Arnold as chief. It consists of the Office

of the Chief of Air Corps and the Air Force Combat Command. During this month, Arnold receives the Gen. William E. Mitchell Trophy for 1940 for his "outstanding contribution to the advancement of aviation." Eugene Emme, ed., Aeronautics and Astronautics 1915-60, p. 41; Aero Digest, July 1941, p. 100.

June 22 Germany invades the USSR in a massive surprise air attack known as Operation Barbarossa. This is the largest air operation conducted to date, stretching over a 3,200-kilometer front. Among the aircraft used are the Messerschmitt Bf 109 fighter, Junkers Ju-87 Stuka dive bomber and the Junkers Ju-52 transport. By nightfall, some 1,811 Soviet aircraft are destroyed, including 1,489 on the ground, while German losses amount to only 35 aircraft. Eugene Emme, ed., Aeronautics and Astronautics 1915-60, p. 41.

June 22 American Rocket Society member Alfred Africano's ceramic-lined rocket motor generates 1,112 newtons of thrust when fired on the society's static test stand No. 2 in Midvale, New Jersey. The experimental motor is powered by alcohol and liquid oxygen and attains peak thrust for about two seconds. Eugne Emme, ed., Aeronautics and Astronautics 1915-60, p. 41; "Astronautics," Oct. 1941, pp. 3-4.

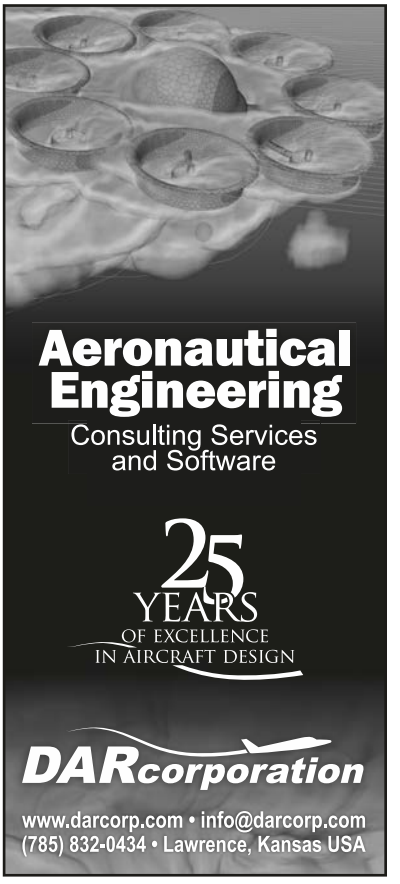
June 30 Northrop Aircraft is awarded a joint Army-Navy contract to design an aircraft gas turbine engine capable of developing 2,500 horsepower at a weight of less than 1,460 kilograms. Later known as the Northrop Turbodyne, this engine becomes the first turboprop power plant to operate in North America. Eugene Emme, ed., Aeronautics and Astronautics 1915-60, p. 41; R. Schlaifer, Development of Aircraft Engines, pp. 447-448.

100 Years Ago, June 1916

June 13 Robert Goddard experiments with firing a gun and a rocket in a vacuum. These tests are fundamental to proving that a reaction motion can work in either air or in a vacuum. This means that the rocket will work in the vacuum of space just as it works on Earth. This contradicts the centuries-old belief that the rocket needs air to push against. Goddard details the experiments in his Method of Reaching Extreme Altitudes (1919), but there are still many, including an editor of The New York Times, who do not understand the principle. Esther Goddard and G. Edward Pendray, eds., The Papers of Robert H. Goddard, Vol. I, pp. 167-169.

June 18 Clyde Balsley, member of the Lafayette Escadrille flying corps, is the first U.S. pilot shot down in World War I. Balsley survives the shooting, which occurred near Verdun, France. Francis K. Mason and Martin Windrow, Know Aviation, p. 18.

June 23 Victor Chapman becomes the first American aviator to be killed during World War I when he is shot down while flying his Nieuport in Verdun. He was flying for the famed Lafayette Escadrille before the U.S. enters the war. Edward Jablonski, The Knight Skies, p. 103, et. seq; Ezra Bowen, Knights of the Air, 102.



AIAA Bulletin

At 1935 hrs (EDT) on Monday, 16 May, NASA's super pressure balloon took off from Wanaka Airport, New Zealand, on a potentially record-breaking, around-the-world test flight. Video and pictures from the launch operation can be found at **https://blogs.nasa.gov/superpressureballoon/2016/05/17/super-balloon-takes-flight-from-new-zealand**. This image shows the balloon fully inflated and ready for liftoff. (*Photo credit: NASA/Bill Rodman*)

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Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2016			
11–12 Jun	Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-On Training Using CIFER®	Washington, DC	
11–12 Jun	Concept in the Modern Design of Experiments	Washington, DC	
11–12 Jun	Optimal Design in Multidisciplinary Systems	Washington, DC	
13–17 Jun	AIAA AVIATION 2016 (AIAA Aviation and Aeronautics Forum and Exposition) **Featuring:** 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference 34th AIAA Applied Aerodynamics Conference AIAA Atmospheric Flight Mechanics Conference 8th AIAA Atmospheric and Space Environments Conference 16th AIAA Aviation Technology, Integration, and Operations Conference AIAA Flight Testing Conference 8th AIAA Flow Control Conference 46th AIAA Fluid Dynamics Conference 17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference AIAA Modeling and Simulation Technologies Conference 47th AIAA Plasmadynamics and Lasers Conference 46th AIAA Thermophysics Conference	Washington, DC	**5 Nov 15**
15 Jun	Aerospace Spotlight Awards Gala	Washington, DC	
15–16 Jun	DEMAND for UNMANNED	Washington, DC	
16–17 Jun	6th AIAA CFD Drag Prediction Workshop	Washington, DC	
5–8 Jul†	ICNPAA 2016 Mathematical Problems in Engineering, Aerospace and Sciences	University of La Rochelle, France (Contact: Prof. Seenith Sivasundaram, 386.761.9829, seenithi@gmail.com, www.icnpaa.com)	
23–24 Jul	3rd Propulsion Aerodynamics Workshop	Salt Lake City, UT	
23–24 Jul	Advanced High-Speed Air-Breathing Propulsion Technology	Salt Lake City, UT	
23–24 Jul	Electric Propulsion for Space Systems	Salt Lake City, UT	
23–24 Jul	Fundamentals of Liquid Chemical Propellants and Applications for Less-Toxic Alternatives	Salt Lake City, UT	
23–24 Jul	Hybrid Rocket Propulsion	Salt Lake City, UT	
24 Jul	Detonation-Based Combustors Tutorial	Salt Lake City, UT	
25–27 Jul	AIAA Propulsion and Energy 2016 (AIAA Propulsion and Energy Forum and Exposition) **Featuring:** 52nd AIAA/SAE/ASEE Joint Propulsion Conference 14th International Energy Conversion Engineering Conference	Salt Lake City, UT	**12 Jan 16**
5–7 Sep†	Advanced Satellite Multimedia Systems Conference	Palma de Mallorca, Spain (Contact: www.asmsconference.org)	
7–8 Sep†	20th Workshop of the Aeroacoustics Specialists Committee of the Council of European Aerospace Societies (CEAS): Measurement Techniques and Analysis Methods for Aircraft Noise	University of Southampton, United Kingdom (Contact: www.southampton.ac.uk/engineering/research/groups/acoustics-group/ceas-asc-workshop-2016)	
11 Sep	Space Standards and Architecture Workshop	Long Beach, CA	
11–12 Sep	Introduction to Space Systems	Long Beach, CA	
11–12 Sep	Systems Engineering Fundamentals	Long Beach, CA	
13–16 Sep	AIAA SPACE 2016 (AIAA Space and Astronautics Forum and Exposition) **Featuring:** AIAA SPACE Conference AIAA/AAS Astrodynamics Specialist Conference AIAA Complex Aerospace Systems Exchange	Long Beach, CA	**25 Feb 16**
25–30 Sep†	30th Congress of the International Council of the Aeronautical Sciences (ICAS 2016)	Daejeon, South Korea (Contact: www.icas.org)	**15 Jul 15**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
25–30 Sep†	**35th Digital Avionics Systems Conference**	Sacramento, CA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)	
26–30 Sep†	**67th International Astronautical Congress**	Guadalajara, Mexico (Contact: www.iac2016.org)	
27–29 Sep†	**SAE/AIAA/RAeS/AHS International Powered Lift Conference**	Hartford, CT	**26 Feb 16**
12–13 Oct†	**12th Annual International Symposium for Personal and Commercial Spaceflight (ISPCS 2016)**	Las Cruces, NM (Contact: http://www.ispcs.com/)	**3 May 16**
17–20 Oct†	**22nd KA and Broadband Communications Conference and the 34th AIAA International Communications Satellite Systems Conference**	Cleveland, OH (Contact: Chuck Cynamon, 301.820.0002, chuck.cynamon@gmail.com)	
7–10 Nov†	**International Telemetering Conference**	Glendale, AZ www.telemetry.org	
2017			
7–8 Jan	**2nd Sonic Boom Prediction Workshop**		
9–13 Jan	**AIAA SciTech 2017 (AIAA Science and Technology Forum and Exposition)** **Featuring:** **25th AIAA/AHS Adaptive Structures Conference** **55th AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Information Systems — Infotech@Aerospace Conference** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **19th AIAA Non-Deterministic Approaches Conference** **58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **10th Symposium on Space Resource Utilization** **4th AIAA Spacecraft Structures Conference** **35th Wind Energy Symposium**	Grapevine, TX	**6 Jun 16**
4–11 Mar†	**IEEE Aerospace Conference**	Big Sky, MT (Contact: www.aeroconf.org)	
6–9 Mar†	**21st AIAA International Space Planes and Hypersonic Systems and Technology Conference (Hypersonics 2017)**	Xiamen, China	**22 Sep 16**
18–20 Apr†	**17th Integrated Communications and Surveillance (ICNS) Conference**	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, http://i-cns.org)	
25–27 Apr	**AIAA DEFENSE Forum (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	
25–27 Apr†	**EuroGNC 2017, 4th CEAS Specialist Conference on Guidance, Navigation, and Control**	Warsaw, Poland (Contact: robert.glebocki@mel.pw.edu.pl; http://www.ceas-gnc.eu/)	
3 May	**Aerospace Spotlight Awards Gala**	Washington, DC	
29–31 May†	**24th Saint Petersburg International Conference on Integrated Navigation Systems**	Saint Petersburg, Russia (Contact: Ms. M. V. Grishina, icins@eprib.ru, www.elektropribor.spb.ru)	
3–4 Jun	**3rd AIAA CFD High Lift Prediction Workshop**		
3–4 Jun	**1st AIAA Geometry and Mesh Generation Workshop**		
5–9 Jun	**AIAA AVIATION Forum (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **24th AIAA Aerodynamic Decelerator Systems Technology Conference** **33rd AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **35th AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **9th AIAA Atmospheric and Space Environments Conference** **17th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Flight Testing Conference**	Denver, CO	

continued on page **B4**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
	47th AIAA Fluid Dynamics Conference **18th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **48th Plasmadynamics and Lasers Conference** **AIAA Balloon Systems Conference** **23rd AIAA Lighter-Than-Air Systems Technology Conference** **23rd AIAA/CEAS Aeroacoustics Conference** **8th AIAA Theoretical Fluid Mechanics Conference** **AIAA Complex Aerospace Systems Exchange** **23rd AIAA Computational Fluid Dynamics Conference** **47th Thermophysics Conference**		
10–12 Jul	**AIAA Propulsion and Energy Forum** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **53rd AIAA/SAE/ASEE Joint Propulsion Conference** **15th International Energy Conversion Engineering Conference**	Atlanta, GA	
12–14 Sep	**AIAA SPACE Forum** **(AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA SPACE Conference**	Orlando, FL	
25–29 Sep†	**68th International Astronautical Congress**	Adelaide, Australia	

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

A BRIGHTER FUTURE FOR AIAA

Jim Albaugh, AIAA President

Two years have gone by quickly and I am now writing my last "From the Corner Office" column as President of AIAA. The past two years have been very busy ones for the Institute, as we've laid out a new vision for our governance, advocated for the importance of aerospace to our nation and world, instituted our new forum format, increased AIAA's value to the community, and strengthened the Institute's financial health.

As you know, almost two years ago the Board of Directors created a Governance Working Group to propose recommendations for a new system of governance of the Institute. You began voting on that new system in March of this year. The election is now finished and I am very happy to report that the membership has voted to approve the new Constitution change. During the eight weeks of the election more than 4,400 votes were cast—which is an impressive 20.65%, more than the 15% constitutionally required. The membership voted to accept the proposed Constitution change by a margin of 91.8% in favor and 8.2% against. That is obviously more than the 2/3 of votes cast needed to approve the proposed changes.

This ushers in a new era for AIAA, allowing us to be more nimble and responsive to changes in our industry and community—thereby serving you better. But the vote was just the beginning and change will not come overnight. We still have much work to do to implement change. The transition will begin at the June Board of Directors' meeting when the Board votes to formally adopt the Bylaws and a transition plan. The transition will take place over the next two to three years. The new governance system strives to encourage and promote engagement from the membership. Consequently, as we work through the transition, we will be looking for help and input from the membership as policies, procedures, and processes are created and documented.

No matter how you voted, thank you for taking the time to vote. Voting in elections is the most important right you have as a member. We are the sum of your decisions; we rely on your guidance and thoughts to continue to mold a strong Institute that is responsive to the needs of its members. So, if you voted, thank you.

There are three thoughts I would like to leave you with as I depart as President: First, we must all become "every day" champions for aerospace, never missing an opportunity to remind congressional decision makers and other government leaders about the importance of aerospace to our nation. Second, the AIAA forum program is continuing to grow and evolve, offering even greater opportunities for collaboration as a community. We saw a great example of this success at our SciTech Forum in January, which attracted over 4,000 attendees from around the world, with nearly 1,000 of them being students—an AIAA attendance record! Finally, to remain strong, AIAA must remain relevant. To that end, we are incorporating emerging trends and growth areas such as autonomy, additive manufacturing, commercial space, cybersecurity, and hybrid aircraft into our forum offerings and advocacy programs. The Board is committed to building an AIAA that will continuously evolve and that will address the key issues of the day affecting our profession.

If our greatest strength is our ability to inspire collaboration and conversation, then the pillar of that strength is its membership. I am honored and privileged that you allowed me to lead the Institute. As my term ends, I believe that AIAA is a much different organization than it was when I arrived and that is due to a lot of hard work on everyone's part. I am mindful of, and thankful for, all of the contributions each of you make for the success of AIAA. Your dedication to the Institute, your time spent contributing to our forums and other programming, and your insight into the changing trends in the industry are what drive AIAA. I have enjoyed meeting you over the past two years at our forums, and hearing your ideas on how to continue to grow AIAA. Your input has been important to me. I hope that you will continue to support AIAA and that your enthusiasm for our mission and purpose will help keep AIAA strong and relevant for many years to come. Thank you.

2016 BOD and Constitution Change Election
Voter Participation by Region

Region	Total Members	Total Ballots	% Received
Region I - North East	5,060	1,045	20.70%
Region II - South East	2,458	522	21.24%
Region III - Central	1,720	403	23.43%
Region IV - South Central	1,665	384	23.06%
Region V - Mid West	1,571	407	25.91%
Region VI - West	5,252	1,105	21.04%
Region VII - International	3,906	602	15.41%
Institute Total	21,632	4,468	20.65%

JOSHUA L. ROVEY WINS LAWRENCE SPERRY AWARD

Duane Hyland

Each year, AIAA presents the Lawrence Sperry Award for a notable contribution made by a young person, age 35 or under, to the advancement of aeronautics or astronautics. The award honors Lawrence B. Sperry, pioneer aviator and inventor, who died in 1923, in a forced landing while attempting a flight across the English Channel.

The winner of the 2016 award is **Joshua Rovey**, an AIAA Associate Fellow and associate professor of aerospace engineering at the Missouri University of Science and Technology (Missouri S&T), Rolla, MO. Rovey received the award in January, at the AIAA SciTech 2016 in San Diego, CA.

Rovey founded Missouri S&T's Aerospace Plasma Laboratory, and makes substantial contributions to the fields of plasmadynamics and space propulsion systems. Among his critical contributions to those fields are his findings on why inductive plasma will not form in strong magnetic fields, which has answered questions about the formation of plasma that have baffled investigators since the 1960s. Additionally, his work has caused the Air Force Research Laboratory and NASA to begin to explore alternate methods of plasma formation. Rovey has also formulated the idea of plasmonic space propulsion, a technology that promises to transform propulsion systems for small spacecraft, including nano, pico, and cube satellites. Rovey's systems would eliminate the need for those types of craft to have onboard power systems, reducing their mass while increasing their speed. In addition to Rovey's technical accomplishments, he has revitalized the AIAA student branch at Missouri S&T, increasing the size of the branch and increasing the number of lectures and programs available to members.

I was able to catch up with Dr. Rovey and talk with him about his achievements and thoughts on winning the Sperry award. We began the interview talking about what sparked his interest in plasma-based propulsion and plasmadynamics. Rovey noted "I've been interested in space propulsion, rockets, since an early age and so therefore I pursued aerospace engineering in college. I was introduced to advanced space propulsion in freshman engineering class. The topic had the word 'advanced' in front of it so it sounded challenging and cutting edge, i.e., cool! The thought of working on advanced rockets for deep-space exploration appealed to me and I was fortunate to receive a summer research fellowship working on that topic, through that experience I realized I wanted to make a career out of research on space propulsion."

When asked why plasma-based propulsion is so important to the future of space transportation, Rovey replied: "It's important because of fuel efficiency. Electric rockets require less propellant than their chemical counterparts, enabling deep-space travel or increased payload. But, additionally, it provides low thrust levels for precision pointing for long-distance communications and imaging, and continuous low thrust trajectories beneficial for certain missions." Rovey also discussed what he sees on the horizon for advances in the field, explaining, "In general the community is focused on high-power electric propulsion for 10–100 kilowatt spacecraft and also micropropulsion for small/CubeSats. And I think advances in manufacturing and materials will aid these efforts, enabling lower cost, lower mass, higher performance, and even entirely new methods of propulsion. In the future I see the additive manufacturing of complex electromagnetic systems, like electric propulsion thrusters. The cost will just be cheaper, especially for one-off experimental/lab thrusters." Rovey continued, "It also becomes possible to functionally grade components to their specific applications and achieve previously impossible geometry. Additionally for certain types of systems it may be possible to embed and/or integrate the power processing unit within the thruster with new manufacturing techniques. Advances in materials such as metamaterials and metasurfaces are already showing promise through controlled and tailored interactions with the propulsion system plasma. This has benefits for efficiency and lifetime of existing systems, but with the anticipated level of control new methods of propulsion may also be possible. Finally, advances in photonics and plasmonics promise new methods for manipulating light at the nanometer scale and may enable new methods for manipulating and accelerating charged particles for propulsion application."

Continuing our discussion, I asked Rovey how the technology benefits small spacecraft, particularly nano, pico, and cube satellites. Rovey explained, "Right now the maneuverability of these small satellites and CubeSats is a big challenge. Most do not yet have propulsion systems. However, that will change in the next few years, as there are numerous groups developing small satellite/CubeSat propulsion systems. So future small satellites and CubeSat developers will be able to choose whether they want cold gas, micro-chemical, or micro-electric propulsion for their small satellites and CubeSats. My group feels they shouldn't have to choose, but should have the best of both worlds. We've developed a combined micro-chemical-electric propulsion system that has one propellant, one propellant tank, one thruster, but can be operated as either high-thrust chemical or high-specific impulse propulsion. It fits within the same mass, volume, and power requirements as a single-mode system, with no performance penalty in either mode." Rovey concluded, "Having both chemical and electric propulsion is advantageous because it makes certain missions more efficient and can reduce propellant mass for deep-space missions. Perhaps most importantly it provides flexibility, allowing for drastic changes in the mission plan while on-orbit or with a relatively short turnaround from concept to launch."

When asked his thoughts on winning the Lawrence Sperry Award, Rovey replied, "Thank you to my colleagues who took the time to nominate me. And to my graduate students and AIAA officers, this award is as much theirs as it is mine. The accomplishments of the previous Sperry winners are mind blowing, so I feel honored and terrified. A colleague of mine put it succinctly when he entered my office and said, 'Congratulations on the Sperry Award! No pressure!'"

Toward the end of the interview, we discussed Rovey's thoughts on the value of AIAA student branches and the opportunities they give professional members to interact with students. I asked if the branches are important for preparing the future workforce. Rovey noted, "They certainly can be. In my experience an AIAA student branch is vibrant when it's led by the students and is integrated with an active local section. Over the past few years we've seen a resurgence in our student branch activities, and subsequently our membership, because of key student leaders and renewed interest and partnership with the active St. Louis section. This interaction has led to numerous professional development and networking activities for students including visits to Boeing and GKN Aerospace, and hosting AIAA Executive Director Sandra Magnus."

In closing, Rovey assured me that he really does get out of the lab from time to time, and that "he, his wife, and their four children can be found camping and hiking around the Ozarks."

AIAA K–12 STEM ACTIVITIES

The K–12 STEM Outreach Committee would like to recognize outstanding STEM events in each section. Each month we will highlight an outstanding K–12 STEM activity; if your section would like to be featured, please contact Supriya Banerjee (1Supriya.Banerjee@gmail.com) and Angela Diggs (Angela.Spence@gmail.com).

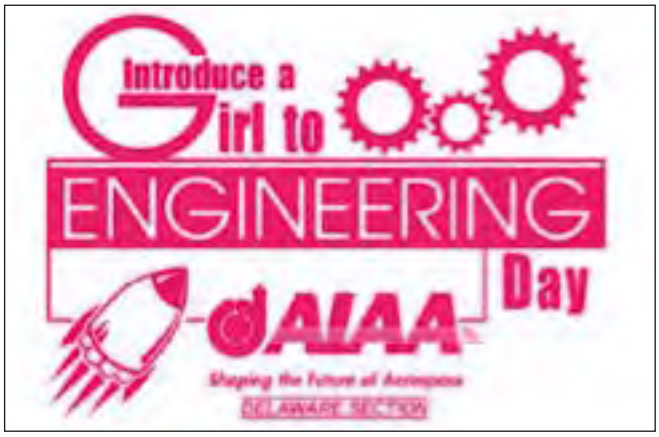
AIAA Delaware Section Introduce a Girl to Engineering Day Expansion

Breanne Sutton, AIAA Delaware Section Chair, AIAA K–12 STEM Section Engagement Committee

The AIAA Delaware Section has been hosting Introduce a Girl to Engineering Day (IGED) at Orbital ATK's Elkton, MD, facility since 2005, always paired up with the same middle school. Eighty-six students have participated in the program over the years. Recently, the section has found a way to collect metrics on graduating seniors who participated in the program. Of the 15 IGED alumni participating in the survey, six are pursuing STEM degrees after graduating from high school, three of them are pursuing engineering degrees. This year, Section Chair Breanne Sutton and STEM Chair Elishabet Lato decided to expand the program to other schools and engineering companies. The goal is to have six different IGED programs running over the next few years, each paired up with one of the county's six middle schools, which will increase the number of girls participating each February from eight students at one school to 48 students across six schools.

The first stage of the plan was to pilot the program with one new company in 2016. The Delaware Section joined forces with an engineer at Terumo Cardiovascular group, also in Elkton, MD. In addition to providing guidance with face-to-face meetings and advising over emails, the section had developed a handbook for hosting Introduce a Girl to Engineering Day based on the experiences and lessons learned from executing the event for 11 years. The handbook includes information such as a planning schedule, day of schedule, supplies, budget and metrics to collect. It also includes examples of the forms used, presentations given, certificates, surveys, and activities.

Terumo hosted their first IGED on 25 February 2016. The students spoke with each of the female engineers at the company about their job function, had a tour of the lab, and participated in a hands-on activity simulating the removal of a blockage in a vein with Play-Doh. The students and volunteers had an absolutely wonderful time and Terumo is already excited to host Introduce a Girl to Engineering day next year! Phase one is complete and the Delaware Section is now targeting other engineering companies in Cecil County to continue the expansion in 2017.



AIAA Delaware Section Introduce a Girl to Engineering Day volunteers and participants.

Terumo Cardiovascular Group's inaugural Introduce a Girl to Engineering Day volunteers and participants.

Courtesy of Textron Aviation.


Courtesy of Textron Aviation.

20TH DESIGN/BUILD/FLY COMPETITION

The 20th annual Textron Aviation/Raytheon Missile Systems/AIAA Foundation Design/Build/Fly Competition (DBF) was held 15–17 April 2016, in Wichita, KS. This year drew interest from 137 teams. There were 93 teams that qualified for the Design Report Phase, and 66 teams were onsite at the flyoff.

The contest simulated distributed manufacturing, and therefore teams had to actually design two airplanes for the competition. One of those airplanes had to be able to transport the other, as a whole or in subassemblies.

After a windy and rainy weekend, San Jose State University ended up in the top slot followed by Georgia Institute of Technology and the University of California, Irvine. For full details about the rules, overall placement of teams, and other information, you can visit the DBF website (**www.aiaadbf.org**), and read the article on page **30**. The organizing committee looks forward to next year's competition and continuing to provide engineering education opportunities to university students.


Courtesy of Textron Aviation.

Courtesy of Textron Aviation.

Courtesy of Textron Aviation.

Courtesy of Textron Aviation.

Courtesy of Textron Aviation.

Courtesy of Textron Aviation.

OBITUARIES

AIAA Senior Member Died in February

John E. Draim, USN (Ret.), died on 17 February 2016. He was 88 years old.

Captain Draim graduated from the U.S. Naval Academy with distinction in 1949. Following a year aboard the destroyer USS Damato, he entered flight school at Pensacola, earning his pilot wings in 1951, while flying the Grumman F8F Bearcat fighter. He then received a degree in Aeronautical Engineering from the Naval Postgraduate School in Monterey, CA. During the course of his naval career, he also received two more graduate degrees in Aerospace Engineering from MIT. Captain Draim served as a pilot and aircraft maintenance officer in several jet fighter and heavy attack squadrons, piloting the F9F-6 Cougar fighter, the supersonic FJ-3M Fury, the A3-D Skywarrior bomber, and the supersonic RA5-C Vigilante bomber. During the Cuban Missile Crisis, he was aboard the USS Forrestal in the Mediterranean.

In addition to his flight assignments, Captain Draim served in a number of prominent posts in Navy research and development. From 1958 through 1961, at the Naval Missile Center, Point Mugu, CA, he was the director of the Space Research Division, where he originated and managed the Navy''s Project Hydra, developing new technology and receiving a number of patents for water-based vertical floating launch of rocket vehicles. From 1965 to 1967, he was director of the Naval Armaments Division, U.S. NATO in Paris, and helped oversee several NATO weapons programs, including the NATO Sidewinder, NATO Bullpup, and NATO Maritime Patrol Aircraft. He also piloted the French Navy's Brequet ATLANTIC prototype aircraft during its test phase. In 1969, Captain Draim reported to the Office of the Chief of Naval Operations and served as deputy director of the Navy Space Program. In 1970 he reported to the Undersecretary of the Air Force as director of Programs in the National Reconnaissance Office, for which he was awarded the Air Force Meritorious Service Medal.

After retiring from the Navy in 1972, he was an aerospace engineer for various government contractors, primarily working on missile and space systems. He continued to invent, and held more than 30 U.S. and foreign patents. Captain Draim became known internationally for his contributions in the field of satellite constellation design, presenting numerous technical papers at conferences throughout the world. In recognition of this work on orbits and satellite constellation design, he received the 2003 Randolph Lovelace II Award from the American Astronautical Society, and the 2004 John V. Breakwell Memorial Award from the International Astronautical Federation.

AIAA Honorary Fellow Miele Died in March

Angelo Miele, a pioneer in the development and application of methods for the optimization of aerospace vehicle trajectories and of aerodynamic shapes, passed away on 19 March 2016, at the age of 93.

Born in Formia, Italy, Miele finished his formal education at the University of Rome "La Sapienza," receiving doctoral degrees in Civil Engineering (1944) and Aeronautical Engineering (1946). He spent most of his career in academia, going from the University of Cordoba (1947) to Brooklyn Polytechnic (1952) to Purdue University (1955), and finally to Rice University (1964). He advanced in rank from Lecturer in Argentina to A.J. Foyt Professor of Engineering, Aerospace Sciences, and Mathematical Sciences at Rice. He was an excellent teacher and researcher.

While serving as the Director of Astrodynamics and Flight Mechanics at the Boeing Scientific Research Laboratories (1959–1964), he published the textbook, *Flight Mechanics*. In 2016, Dover Publications selected *Flight Mechanics* to be part of its well-known reprint series. Miele's contributions were mainly in the areas of flight mechanics, astrodynamics, optimization theory, aerospace vehicle trajectory optimization, and optimal aerodynamic shapes. He was a prolific writer, publishing over a hundred journal articles, and two books.

While his contributions are many, his development of Green's theorem approach to solving variational problems of a linear type should be noted. The method was applied to the minimum time-to-climb problem for jet-powered aircraft (1949), which at the time was a very difficult problem. He also worked on the exposition of the application of variational methods to the optimization of aerospace vehicle trajectories (1958), and the Theorem of Image Trajectories (1960) in the restricted three-body problem. The theorem enabled a user to calculate one Earth-moon trajectory and get three more at no expense. It also motivated free-return trajectories. From 1967 to 1983, Miele concentrated on the development of numerical methods for solving optimal control problems, developing several well-known algorithms including the Sequential Gradient-Restoration Algorithm. From 1983 to 1993, his emphasis was on the engineering applications of numerical optimization, and he studied wave identification, aero-assisted orbital plane change, national aerospace plane, flight in windshear, and wind identification and detection.

In 1993, Miele retired as Professor Emeritus from Rice University, while continuing to teach and do research with his students at Rice over the next fifteen years.

Miele was recognized for his exceptional work with awards from several organizations including the 1982 AIAA Mechanics & Control of Flight Award and the 1982 AIAA Pendray Aerospace Literature Award, as well as the Shuck Award from the American Control Council and the Dirk Brower Award from the American Astronautical Society. He was elected to the National Academy of Engineering, the International Academy of Astronautics, the Russian Academy of Sciences, and the National Academy of Engineering of Argentina.

Although Miele spent most of his life in the United States, becoming a citizen in 1985, his heart never really left Italy; his ashes were returned to Formia, his birthplace, for burial.

AIAA Fellow Ryan Died in April

Robert S. Ryan, age 90, passed away on 15 April 2016.

Mr. Ryan was a former World War II veteran. After his brief service, he became a teacher and basketball coach at Priceville High School, Morgan County, AL (1948–1955).

From 1956 until 1960, Mr. Ryan worked as an aerospace engineer for the Army Ballistic Agency. He worked on Redstone, Jupiter, and Pershing missiles and then the Explorer, JUNO satellites and the Saturn I Launch system. In 1960, the Von Braun team was transferred to NASA, and he started working on the Apollo program where he served as chief of the Dynamic Analysis Branch for Marshall Space Flight Center (MSFC). He has served in various management and leadership positions for MSFC as branch chief, division chief of Structural Dynamics, and retired as deputy director of the System Dynamics Laboratory. He worked on Saturn V Apollo, Skylab, Hubble Space Telescope, HEAO, Space Shuttle, AXAF, X-33, Spacelab, and numerous scientific payloads.

After retiring from NASA in 1996, Mr. Ryan worked as a consultant for Boeing on the International Space Station and for Lockheed on the single stage to orbit X-33 launch vehicle. During this time, he consulted with NASA on the Constellation Program and Space Launch System Program and taught short courses in launch vehicle design and lessons learned in engineering. He has over 100 publications and special presentations to his credit. He also received the 1994 Structures, Structural Dynamics, & Materials Award, the first AIAA Crichlow Trust Prize in 1995 and was inducted into the Alabama Engineering Hall of Fame in 2007.

CALL FOR NOMINATIONS

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

Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines carefully. AIAA members may submit nominations online after logging into **www.aiaa.org** with their user name and password. You will be guided through the nomination entry. If preferred, a nominator may submit a nomination by completing the AIAA nomination form, which can be downloaded from **http://www.aiaa.org/OpenNominations/**.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Pendray Aerospace Literature Award presented for an outstanding contribution or contributions to aeronautical and astronautical literature in the relatively recent past. The emphasis should be on the high quality or major influence of the piece rather than, for example, the importance of the underlying technological contribution. The award is an incentive for aerospace professionals to write eloquently and persuasively about their field and should encompass editorials as well as papers or books.

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

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

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

Sustained Service Award recognizes sustained, significant service and contributions to AIAA by members of the Institute. A maximum of 20 awards are presented each year. A special nomination form and scoresheet is required; contact AIAA for details.

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

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

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

AIAA Propulsion and Energy Forum and Exposition

25–27 July 2016
Salt Palace Convention Center
Salt Lake City, Utah
#aiaaPropEnergy

Propulsion and energy systems are at the very heart of aerospace, whether you are flying passengers to London or satellites to LEO. Every move forward in our exploration of the world, and the universe, is enabled by new technologies coming from the researchers and engineers who will assemble at the AIAA Propulsion and Energy Forum and Exposition 2016 (AIAA Propulsion and Energy 2016).

Featuring

52nd AIAA/SAE/ASEE Joint Propulsion Conference
14th International Energy Conversion Engineering Conference

Executive Steering Committee

Our thanks to these tireless volunteers:
Al Romig, National Academy of Engineering
Michael Heil, Ohio Aerospace Institute
Julie Van Kleeck, Aerojet Rocketdyne
Bob Hwang, Sandia National Labs
Daniel "Dan" Dumbacher, Purdue University

For a complete list of organizing members, please see aiaa-propulsionenergy.org/Organizers.

Sponsors

GE
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Technical Program

The 52nd AIAA/SAE/ASEE Joint Propulsion Conference and the 14th International Energy Conversion Engineering Conference will meet at AIAA Propulsion and Energy 2016. They will feature almost 800 technical papers on 24 subject areas including:

- Additive Manufacturing for Propulsion Systems
- Energy-Efficient and Renewable Energy Technologies
- Electric Propulsion
- Thermal Management Technology
- Gas Turbine Engines
- Spacecraft and Aircraft Power System Technologies

See who is scheduled to present papers at **aiaa-propulsionenergy.org/techprogram**.

Plenary Program

These are big-picture conversations with thought leaders in propulsion and energy:

- Air and Space Propulsion System Needs
- Game-Changing Developments in Propulsion and Energy
- High-Powered Systems for Aerospace Applications

AIAA Programs

Forum 360

We dialogue with experts to cover a spectrum of topics relevant to propulsion and energy.

- NRC Low-Carbon Aviation Report and Recommendations
- Launch Vehicle Reusability: Holy Grail, Chasing our Tail, or Somewhere in Between?
- Nuclear Power for Distant Solar Systems Destinations

Continuing Education

Register for one of our continuing education courses and gain access to all forum activities. Courses offered during this forum:

- Advanced High-Speed Air-Breathing Propulsion Technology
- Electric Propulsion for Space Systems
- Hybrid Rocket Propulsion
- 3rd Annual Propulsion Aerodynamics Workshop (PAW03)
- Fundamentals of Liquid Chemical Propellants and Applications for Less-Toxic Alternatives

Recognition

Join colleagues and friends in celebrating innovations and achievements in propulsion and energy at the AIAA Awards Luncheon. The following awards will be presented:

- Air Breathing Propulsion Award — Wesley Lord, Pratt & Whitney
- Engineer of the Year Award — Robin J. Osborne, NASA Marshall Space Flight Center
- Sustained Service Award — Sanjay Garg, NASA Glenn Research Center
- Certificates of Merit for Best Papers — Gas Turbine Engines, Propellants and Combustion, Solid Rockets, and Terrestrial Energy

Rising Leaders in Aerospace

We are pleased to offer a program for young aerospace leaders that features speed networking, leadership mentoring, Q&A sessions with top industry leaders, and multiple opportunities to network with peers.

Additional Events

During the three days of AIAA Propulsion and Energy 2016, there will be networking receptions, book signings, vendor exhibits, youth-focused STEM activities, and a fundraising silent auction to support programming of the AIAA Foundation.

2016 Exhibitors

- Aerojet Rocketdyne
- Barber-Nichols, Inc.
- Beta CAE Systems USA, Inc.
- Cambridge University Press
- CF Turbo Software & Engineering GmbH
- Cobham
- Aerion, Technologies, Inc.
- ESTECO
- General Dynamics – OTS
- Intelligent Light
- Jansens Aircraft Systems Controls
- Marotta Controls, Inc.
- Moog Inc.
- MTU Aero Engines North America, Inc.
- MTU Aero Engines AG
- Notre Dame Turbomachinery Laboratory
- PCB Piezotronics, Inc.
- Poco Graphite
- Pointwise, Inc.
- Rolls-Royce
- Tecplot Inc
- University of El Paso, Department of Mechanical Engineering
- University of Cincinnati Research Institute
- Vacco Industries
- Valcor Engineering Corporation
- Worthington Industries

Exhibit and sponsorship opportunities are available. Please see **aiaa-propulsionenergy.org/whyexhibitandsponsor**.

Book Your Hotel

Hilton Salt Lake City Center (1.5 blocks to front side entrance of convention center)
255 South West Temple
Salt Lake City, UT 84101
801.328.2000
Cut-off date: 1 July 2016
Rate $169 single or double

Radisson Hotel Salt Lake City Downtown (.5 blocks to back entrance of convention center)
215 W South Temple
Salt Lake City, UT 84101
801.531.7500
Cut-off Date: 1 July 2016
Rate: $149 single or double

Register Today!

AIAA members save $350 if they register by the early-bird deadline of 6 July 2016!

aiaa-propulsionenergy.org/register

MEMBERSHIP MATTERS






Your Membership Benefits

1. **Get Ahead of the Curve –** Stay abreast of in-depth reporting on the innovations shaping the aerospace industry with ***Aerospace America***, and a daily dose of vetted industry news in the ***AIAA Daily Launch*** – both delivered free with AIAA membership.

2. **Connect with Your Peers –** Whether you are ready to travel to one of AIAA's five forums, or you want to stay close to home, AIAA offers the best opportunities to **meet the people working in your industry and interest.**

3. **Explore More Opportunities –** AIAA has deep relationships with the most respected and innovative aerospace companies in the world. They look to our membership for the most qualified candidates. As an AIAA member, you get access to our **Career Center** to view job listings and post your resume to be seen by the best companies in the industry.

4. **Publish Your Work –** If you are searching for the best place to publish or present your research, look no further! AIAA has five targeted **forums**, eight specifically focused **journals**, and a number of co-sponsored conferences to choose from. Find your peers, publish your work and progress in your career!

5. **Save Money –** Get free access to all our **standards documents** and get discounts on forum registrations, journal subscriptions and book purchases. These savings can quickly pay for your membership!

www.aiaa.org

AIAA
Shaping the Future of Aerospace

16-1030

Upcoming AIAA Continuing Education Courses

Courses at AIAA Aviation and Aeronautics Forum 2016 (AIAA AVIATION 2016)
www.aiaa-aviation.org/CoursesWorkshops
11–12 June 2016

Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-on Training Using CIFER® **(Instructor: Dr. Mark B. Tischler)**
The objectives of this two-day short course is to 1) review the fundamental methods of aircraft and rotorcraft system identification and illustrate the benefits of their broad application throughout the flight vehicle development process and 2) provide the attendees with an intensive hands-on training of the CIFER® system identification, using flight test data and 10 extensive lab exercises. Students work on comprehensive laboratory assignments using a student version of software provided to course participants (requires student to bring a PC laptop running Windows 7 (preferred) or above, or a Mac laptop capable of dual-booting to Windows OS or running Windows virtual machine using VMware Fusion or Parallels Desktop). The many examples from recent aircraft programs illustrate the effectiveness of this technology for rapidly solving difficult integration problems. The course will review key methods and computational tools, but will not be overly mathematical in content. The course is highly recommended for graduate students, practicing engineers and managers. Course includes the AIAA book, *Aircraft and Rotorcraft System Identification*.

Concepts in the Modern Design of Experiments **(Instructor: Dick DeLoach)**
Aerospace researchers with considerable subject-matter expertise who have had relatively little formal training in the design of experiments are often unaware that research quality and productivity can be substantially improved through the specific design of an experiment. Reductions in cycle time by factors of two or more, with quality improvements of that same order, have occurred when the fundamental precepts of experiment design covered in this course have been applied in real-world aerospace research. Examples drawn from specific studies will quantitatively illustrate resource savings, quality improvements, and enhanced insights that well-designed experiments have delivered in various aerospace applications. As a bonus, each student will be able to download an evaluation copy of experiment design software that simplifies many aspects of experiment design.

Optimal Design in Multidisciplinary Systems **(Instructors: Joaquim R. R. A. Martins and Jaroslaw Sobieski)**
When you are designing or evaluating a complicated engineering system such as an aircraft or a launch vehicle, can you effectively reconcile the multitude of conflicting requirements, interactions, and objectives? This course discusses the underlying challenges in such an environment, and introduces you to methods and tools that have been developed over the years. The course includes a review of the state-of-the-art methods for disciplinary optimization that exploit the modern computer technology for applications with large numbers of variables, design limitations, and many objectives. Students will learn how to evaluate sensitivity of the design to variables, initial requirements, and constraints, and how to select the best approach from many currently available.

Courses and Workshop at AIAA Propulsion and Energy Forum 2016 (AIAA Propulsion and Energy 2016)
www.aiaa-propulsionenergy.org/CoursesWorkshops
23–24 July 2016

3rd AIAA Propulsion Aerodynamics Workshop **(Organized by the AIAA Air Breathing Propulsion System Integration Technical Committee)**
The focus of the workshop will be on assessing the accuracy of CFD in obtaining multi-stream air breathing system performance and flow structure to include nozzle force, vector and moment; nozzle thrust (Cv) and discharge (Cd) coefficients; and surface pressure prediction accuracy. Experimental data are available for the test cases; however, the CFD studies will be performed as a blind trial and compared with the experimental data during the PAW02 workshop. Models will be provided for multiple cases featuring isolated inlets, isolated nozzles, and nozzles with or without a ground plane. A statistical framework will be used to assess the CFD results. Baseline computational grids will be provided for structured solvers. Geometry will also be available to those interested in developing their own meshes or employing an unstructured grid. Participants may run one or more cases if the required example grid solution is completed. The workshop provides an impartial forum to present findings, discuss results, exchange ideas, and evaluate the effectiveness of existing computer codes and modeling techniques.

Topics include:

- Analysis of flow in a diffusing S-duct with and without AIP instrumentation, and with and without flow control
  – Comparisons of AIP total pressure recovery and distortion both steady-state and dynamic
  – Comparisons of steady-state surface static pressure distributions
- Analysis of flow in a Dual Separate Flow Reference Nozzle (DSRN) and Dual Mixed Flow Reference Nozzle (DMFR)
  – Comparisons of thrust coefficient

Advanced High-Speed Air-Breathing Propulsion **(Instructors: Dr. Dora E. Musielak, Dr. Tomasz Drozda, Mr. Robert Moehlenkamp, Dr. Steven Russell, Dr. Venkat Tangirala)**
Revolutionary methods of high-speed air-breathing propulsion are needed to extend the flight regime of aircraft, missiles, and improve Earth-to-orbit spacecraft. Advanced High-Speed Air-Breathing Propulsion will introduce students to the design and development processes of high-speed propulsion, including ramjet/scramjets and TBCC concepts. The course will present a comprehensive overview of the state of the art, including highlights of current high speed propulsion programs in the world. An introduction to multidisciplinary design optimization (MDO) will help students appreciate the challenges of developing this breakthrough propulsion technology. Instructors actively engaged in high-speed propulsion R&D will discuss the challenges, and development trends of this advanced propulsion technology. This course is sponsored by the AIAA High-Speed Air-Breathing Propulsion Technical Committee (HSABPTC).

Electric Propulsion for Space Systems **(Instructor: Dan M. Goebel, Ph.D.)**
Over 120 spacecraft presently use electric thruster systems for primary or auxiliary propulsion. Electric thrusters are now being used to provide most of the post-LEO propulsion demands for both geosynchronous and deep space missions. The availability of practical, high-specific-impulse electric thrusters with long life, and the development of electrical power-systems required to sustain them, has resulted in extremely rapid growth in the applications of this technology. This course describes the fundamental operating principles, performance characteristics and design features of state-of-the-art systems in each of the three classes of electric thrusters (electrothermal, electromagnetic and electrostatic). The impacts of the thruster performance and life on mission planning; mission analysis techniques; and on-board spacecraft systems will be addressed. The extension of spacecraft capabilities afforded by electric propulsion and issues associated with its integration into spacecraft will also be discussed.

Fundamentals of Liquid Chemical Propellants and Applications for Less-Toxic Alternatives **(Instructor: Dr. Timothée Pourpoint)**
Liquid propulsion systems are critical to launch vehicle and spacecraft performance, and mission success. This two-day course, taught by a team of government, industry and international experts, will cover propulsion fundamentals and topics of interest in launch vehicle and spacecraft propulsion; non-toxic propulsion; microsat and cubesat propulsion; propulsion system design and performance; and human rating of liquid engines.

Hybrid Rocket Propulsion **(Instructors: Dr. Joe Majdalani and Dr. Arif Karabeyoglu)**
This short course is quintessential for all professionals specializing in chemical propulsion. The mechanisms associated with hybrid combustion and propulsion are diverse and affect our abilities to successfully advance and sustain the development of hybrid technology. It is our penultimate goal to promote the science of hybrid rocketry, which is safe enough to be used in both academia and the private sector. A historical demonstration of hybrid rocket capability is the 2004 X-prize winner SpaceShipOne. This technology can also be used in outreach activities when used in conjunction with hands-on design projects and payload launches that involve student teams. Interest in hybrid rocketry can thus be translated into increased awareness in science and technology, helping to alleviate the persistent attrition in our technical workforce. This course reviews the fundamentals of hybrid rocket propulsion with special emphasis on application-based design and system integration, propellant selection, flow field and regression rate modeling, solid fuel pyrolysis, scaling effects, transient behavior, and combustion instability. Advantages and disadvantages of both conventional and unconventional vortex hybrid configurations are examined and discussed.

Courses at AIAA Space and Astronautics Forum 2016 (AIAA SPACE 2016)
www.aiaa-space.org/CoursesWorkshops

11 September 2016

Space Standards and Architecture Workshop **(Instructors: Frederick A. Slane, Mike Kearney, Ramon Krosley)**
This workshop is geared toward mission users, not standards developers and is intended for individuals and organizations that desire to increase their teams' understanding of the benefits of and the usability of 1) space standards and 2) architecture framework. Spaceflight mission planners, designers, and engineers who seek guidance on the broad standards environment and techniques to "harvest" the most beneficial standards to be applied to their missions would benefit from participating in the workshop. This applies to all engineering domains, but is especially valuable where systems interface across organizational boundaries.

11–12 September 2016

Introduction to Space Systems **(Instructor: Prof. Mike Gruntman, Ph.D.)**
This course provides an introduction to the concepts and technologies of modern space systems. Space systems combine engineering, science, and external phenomena. We concentrate on scientific and engineering foundations of spacecraft systems and interactions among various subsystems. These fundamentals of subsystem technologies provide an indispensable basis for system engineering. The basic nomenclature, vocabulary, and concepts will make it possible to converse with understanding with subsystem specialists. This introductory course is designed for engineers and managers – of diverse background and varying levels of experience – who are involved in planning, designing, building, launching, and operating space systems and spacecraft subsystems and components. The course will facilitate integration of engineers and managers new to the space field into space-related projects.

Systems Engineering Fundamentals **(Instructor: John C. Hsu, Ph.D., P.E., AIAA Fellow, INCOSE ESEP)**
In today's globalized environment, manufacturing and designing companies compete for business. To be successful, companies need to practice strategies that minimize the possibility of degradation of product quality, cost overrun, schedule slippage, customer dissatisfaction and system development failures. In this course you will learn why do we need systems engineering, the systems engineering fundamentals including Requirements Analysis and Development, Functional Analysis and Allocation, Design Decision Analysis based on requirements; Risk Management throughout the development and design cycle; Integrated Master Plan/Integrated Master Schedule and Work Breakdown Structure for development and design management; Technical Performance Measurement for measuring, tracking and validating design; Interface Management across in-house disciplines, supplier, and customer; and Verification and Validation to prove the right system was built and the system was built right.

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