April 2014

AEROSPACE AMERICA

FUNDING THE TRIAD

Wanting nuclear upgrades is easy — paying the bill is harder *page 28*

NASA's asteroid hunter page 20

Tanker drama page 40

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AEROSPACE
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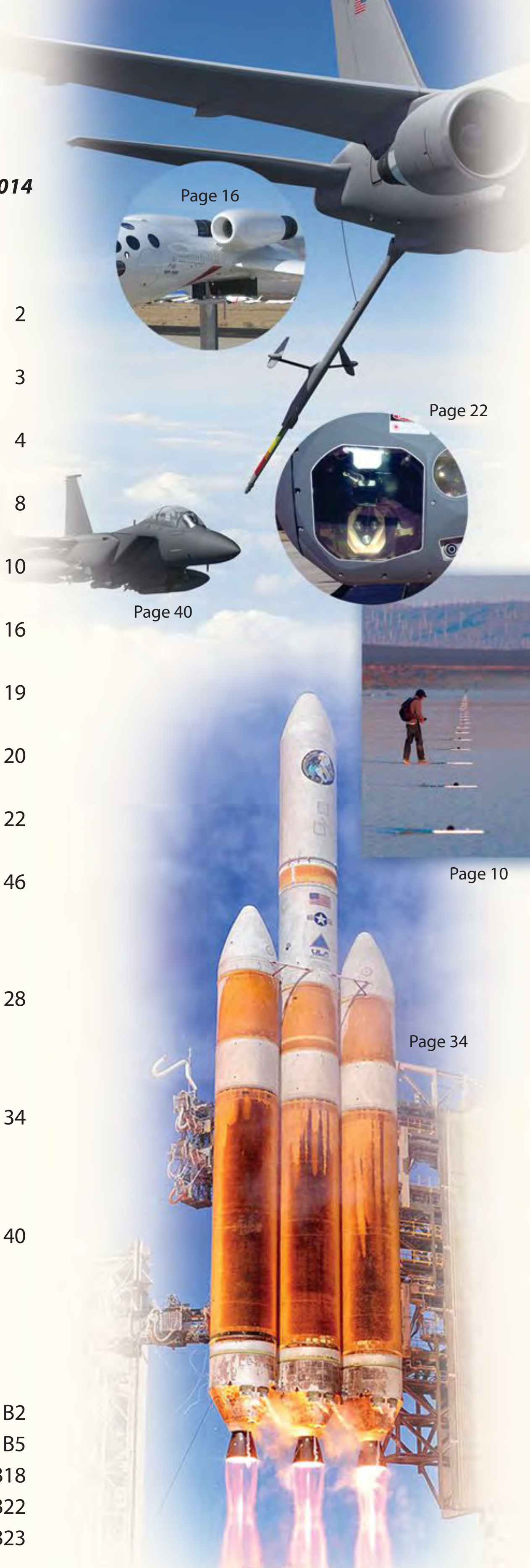

DEPARTMENTS

FEATURES

BULLETIN

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The World's Forum for Aerospace Leadership

Two problems worth solving

Considering all the engineers, entrepreneurs and inventors out there, it's not naïve to assume there's a technical solution to nearly every problem. In our wireless world, how can a 74-meter-long airliner carrying 239 people simply disappear with almost no digital traces? How can a nation that has a rover crawling across Mars still be sucking ancient swamp goo from Earth and burning it?

These two problems — airliner monitoring and fossil fuels — are totally unrelated, except in one fundamental sense. We haven't solved them for reasons of economics. From what I've read, economics is driven by human psychology: A problem won't be solved — a market won't shift — until consumers perceive a problem and someone offers a solution at a price that will motivate them to act.

The battle over climate science is actually a battle for the hearts and minds of energy consumers who must decide whether the risks of fossil fuels are so high that they should be motivated to act. A skirmish can be found in this month's letters section, Page 3, in the form of strong reactions to our February cover story, "Target: Climate change."

On airliner monitoring, the battle for hearts and minds hasn't reached the mainstream flying public yet — but it might, given the Malaysian Airlines incident and realization that we could readily stream cockpit audio, flight data and maybe even video off airliners. A concept for doing so is described in the article, "Malaysian Airlines case stirs call for streaming data," Page 8.

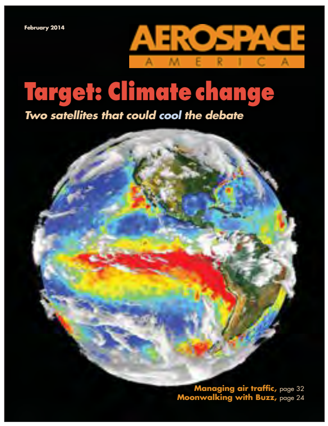
If the airliner monitoring issue isn't solved soon, the flying public will find itself in an ironic position: Passengers will be paying directly or indirectly for satellite Internet to stream movies, check email and play video games. I'm told this kind of connectivity will be expected by the millennial generation. Meanwhile, cockpit data that could be the key to an emergency rescue will be locked away in old-fashioned black boxes, because supposedly no one can afford to stream it.

On fossil fuels, Aerospace America will continue to look at the roles of space and airborne sensors in helping scientists assess the impacts of these fuels on Earth's environment and climate. Putting on my opinion hat, I don't know that scientists will ever deliver the level of predictability demanded by engineers accustomed to taking the plane out of the hanger to test it. Climate change is a question of how much risk to assume. By continuing to burn fossil fuels, consumers are assuming a lot of risk, whether that's human-induced global warming, rising sea levels, eye-burning smog or cancer.

Once a tipping point is reached among consumers on these issues, change could come quickly. The question is how many planes will be lost and how much environmental damage will be done until then.

Ben Iannotta
Editor-in-Chief

Santa Claus and climate science



Several readers were disturbed by the depiction of global warming skeptics as "wacky" and "Santa Claus" believers, in the words of two scientists quoted in the article, "Target: Climate Change" (February, page 26). **David C. Howe of Vernon, Conn.**, fired back: "Data and studies in the scientific/geological community have highlighted this [global warming] 'hoax' for what it is." As long as scientists "are dependent on government funding for their projects, they will continue to 'toe the government line' in order to obtain that funding," Howe wrote.

Peter Badzey of Huntington Beach, Calif., found irony in the article's subtitle "Two satellites that could cool the debate." Badzey wrote: "Apparently, Josh Willis doesn't agree that there is a debate to be 'cooled.' There is only name-calling and denigrating people who disagree with his opinion."

Wilbur Wells of Tehachapi, Calif., pointed to data showing cooling in recent years: "These data raise an obvious question: Why are we spending so much money to characterize global warming when none is occurring? Also, the amount of fossil fuel (oil, coal, and gas) on the earth is finite and will eventually be exhausted, perhaps in as little as 100 years. If this is true, won't human-caused global warming simply go away in the next few generations when no fossil fuels are left?"

Retired astronaut and Air Force **Col. Donald H. Peterson of El Lago, Texas**, noted that reputable scientific sources are reaching entirely incompatible conclusions about the future of the planet he viewed during a four-hour spacewalk from the shuttle Challenger: "How can their absolutely contradictory statements be reconciled? Perhaps it would be informative if each of them would turn over their data to some neutral scientific group for analysis. Failing that, I would love to read their rationale and explanations of such total disagreement."

Space Launch System: Reacting to the Editor's Notebook column, "Unsettled Business," (February, page 2), **John W. Robinson of Seal Beach, Calif.**, wrote to say that an advocacy group he chairs, the Space Propulsion Synergy Team, believes "it is prudent to have a backup plan" to the Space Launch System rocket "with alternative approaches for future more sustainable transportation capabilities allowing further development of needed space infrastructure." He said his group does not advocate canceling SLS but encourages NASA "to consider in their long range planning a focus on reduced life cycle cost including affordable elements like partly reusable launch vehicles, space depots, and high performance environmentally clean propulsion systems."

Going green: **David J. Paisley of North Bend, Wash.**, felt we were one sided in the technology discussion in the article, "Runway taxiing goes green" (February, page 16). "The article allows the Wheeltug spokesperson to arm-wave away some really difficult issues concerning certification of systems that are really quite complex additions to airplanes that they do not necessarily understand fully," he wrote.

Impact of "Gravity": Lyle Kelly of Mason, Ohio, enjoyed "Grading 'Gravity,'" former astronaut Tom Jones' close look at the award-winning film (February, page 20). "I am hopeful that increased exposure to endeavors in space will encourage more young people to think about a future there, and more potential investors to support space industry and other ventures," he wrote.

Corrections

The manufacturer of the Orion crew vehicle was misidentified in, "Choose your launcher" (March, Page 34). Orion is made by Lockheed Martin.

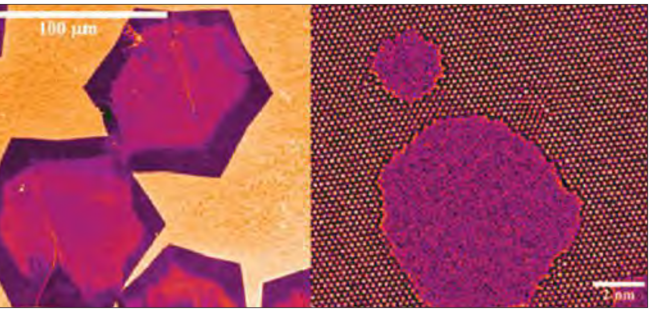
This photo of a South African park ranger with an Aurora Skate plane ran with an incorrect credit in our January issue. The photo was taken by **Justin Leto** on assignment for Make magazine.

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

Graphene on the fast track

The European Union is concerned that its industry is falling behind in the global race to develop graphene-based components that could radically transform the performance of aerospace, information technology and energy storage equipment. So, in June 2014 the European Union's Graphene Flagship research program will host a "Graphene Week" in Gothenburg, Sweden, to explore "the wonder material of the twenty-first century," as the program's website describes graphene.

Oxford University



"Wonder" material: Hexagonal shape of graphene flakes seen in a spectroscopic image. Europe is racing to catch up on turning the material into useful products.

Graphene consists of a sheet of carbon atoms just one atom thick. The European Union last year decided to spend €1 billion in the coming years researching graphene and its applications through a new Graphene Flagship program, which consists of 75 academic and industrial partners in 17 European countries including Sweden. There are two strands of work: a 30-month ramp-up phase that began in October and runs to March 2016, followed by a more detailed research program to 2020, focusing on developing applications in information technology, transport, energy technology and sensor sectors.

In 2004, professors Andre Geim and Kostya Novoselov of Manchester University in the U.K. revealed graphene's unusual properties and hinted at applications in a wide range of products, from aircraft to electronics to flexible cellphones. The two scientists won the Nobel Prize for physics in 2010.

Graphene's carbon atoms are arranged in a hexagonal lattice that is chemically and thermally stable. It conducts electricity better than copper, is up to 300 times stronger than steel and has unique optical properties, scientists report. According to the Graphene Flagship website: "This material is the first 2D atomic crystal ever known to us; the thinnest object ever obtained; the world's strong-est material… it is extremely electrically and thermally conductive; very elastic; and impermeable to any molecules."

Graphene composites could be a "valid, lightweight alternative to metals," says Italian chemist Vincenzo Palermo, who along with other scientists proposed creating the Graphene Flagship program. Graphene could also be used as a coating that would serve numerous roles, some of them basic — providing resistance to solvents, protection from ultraviolet radiation and flammability reduction, Palermo says. Others could be more complex, "such as strain measurements in materials or devices subject to high mechanical or thermal stress," he adds.

Specifically, Graphene could be used to replace composites and aluminium alloys in aircraft structures and batteries, and as a coating to prevent damage from lightning strikes.

"Advanced composites, lightweight cables, improved batteries and thermal management are the most promising applications for aerospace industry," says Jesus de la Fuente, chief executive officer of Graphenea, a technology company based in Spain. "But typically 10 to 15 years development cycles are needed for full spread utilization in an industry like aerospace."

One of the objectives of Graphene Flagship is to cut the timescale from experimentation to industrial use — after all, there is a global race underway to produce industrial graphene products with a clear competitive edge over legacy items.

"Graphene is elastic and can stretch up to 20% of its length, making it ideal for flexible [computer] displays," according to the report, "Graphene: The worldwide patent landscape in 2013," from the U.K.'s Intellectual Property Office.

The U.K. study into graphene patents shows that China is the world-leader in patenting graphene-based designs, followed by the U.S., Korea and Japan, with European countries well down the list. China's lead has been growing since 2008 and is now well over 50 percent, according to the study.

But the challenges to building aerospace components from graphene will mean overcoming industrial and technical hurdles.

"Graphene-based materials showing performance suitable for aerospace applications could be developed at research level in the next years, but the real application of these materials in aerospace will require the establishment of an industrial value chain, with some company producing graphene with the right specifications, other companies processing it in real devices, and end-users validating the new technology and applying it in their applications," says Palermo. "After all, graphene technology is very young — it has been going less than 10 years — and thus still needs time to develop."

Trending in Europe: Unmanned craft collaboration

France and the U.K. are working to develop a common set of mission requirements for unmanned combat planes, now that the two countries have decided to explore the possibility of merging their competing industry teams.

The work is part of a £120-million, two-year feasibility study announced in January by French President François Hollande and U.K. Prime Minister David Cameron at their summit at the Royal Air Force's Brize Norton station.

European officials want to shift to unmanned planes after 2030, when they expect to begin retiring today's traditionally piloted strike aircraft: The multi-prime contractor Eurofighter Typhoon, the Saab Gripen and the Dassault Rafele.

Some experts view the combat plane requirements of European nations as simply too small to justify two separate development efforts. France and the U.K. have aired the idea of the European industry collaborating to provide a single unmanned combat air vehicle, or UCAV, that would compete for global sales to allies.

There are currently two UCAV development programs underway in Europe:

• nEUROn (pronounced like neuron) flew for the first time in December 2012. It was developed by a French-led multinational team headed by Dassault of France with partners: Alenia of Italy, Airbus Defence and Space of Spain, the Hellenic Aerospace Industry of Greece, RUAG Aerospace of Switzerland, and Saab of Sweden.

• Taranis (named for the Celtic god of thunder) flew for the first time in August 2013. It was designed and built by an all-U.K. consortium of BAE Systems, GE Aviation, QinetiQ, and Rolls-Royce.

France and the U.K. hope to settle on a single set of UCAV requirements by 2016 so that Europe's major air combat integrator companies can work on a single program.

There might be little choice other than to pool resources. "It is very unlikely that a UCAV program of this scale will be developed on a national basis in Europe, partly because of military budget severity and partly because of the numbers required versus the research and development investment," says Douglas Barrie, senior fellow for military aerospace at the London-based International Institute for Strategic Studies.

Barrie figures the U.K. and France might each need up to 100 unmanned combat aircraft, a number he says would be "quite small" to justify developing two separate airframes. Collaborating would be a cultural shift, especially for the British, he says. "The U.K. has tended much more towards bilateral projects rather than multinational projects because of its experience in the 1990s of programs which did not perform as expected in terms of cost and timeline," he explains.

Competing with Herons, Reapers

Some in Europe also want collaboration on development of a medium altitude long endurance, or MALE, unmanned plane that would compete with the Reapers produced by General Atomics Aeronautical Systems of San Diego and the Herons produced by Israel Aerospace Industries.

In November, the European Defence Agency's Steering Board of European States agreed to establish a "common staff target"—meaning a formal needs statement—for medium altitude planes. Not everyone has signed on, but France, Germany, Greece, Italy, Netherlands, Poland and Spain are now talking about potentially harmonizing future requirements. The impetus for the accord came during the runup to the 2013 Paris Air Show, when Dassault of France, Alenia Aermacchi of Italy and the multinational EADS Cassidian company (now Airbus Defence and Space) wrote an open letter calling for a single European MALE requirement and said they would pool their industrial capabilities to meet it.

Dassault

BAE

The U.K. and France are discussing merging their work on unmanned combat planes: the French-led nEUROn, left, and the U.K.'s Taranis.

Remote towers to go live

Project managers for r-TWR, a remote tower air traffic control program in Sweden, expect the Swedish Transport Agency to grant a license in the first half of 2014 for air traffic controllers at Sundsvall airport to manage aircraft operations at Örnsköldsvik Airport, 125 kilometers away. Although trials of the r-TWR concept have taken place in several airports around the world, this would mark the first time that the full range of airfield operations have been remotely controlled on a day-to-day basis.


Saab Group

A panoramic screen shows traffic at an airfield far away from Norway's Bodø Airport, where remote towers have been tested.

Controllers in Sundsvall would have complete control over all sensors, lighting, alarms and other tower systems at Örnsköldsvik. A digital video real-time image of the airfield at Örnsköldsvik, taken from a series of high-definition cameras mounted at strategic points around the airfield, can be projected onto panoramic screens at Sundsvall, giving controllers a complete 360-degree view of the distant airport. A fiber optic link would carry the data between the two sites. At Sundsvall, data from camera views, radar data and wind and weather information can be projected onto the screen. Features such as digital map overlays, object tracking and alerting have been designed to make situational awareness better than at standard tower operations, according to Saab Air Traffic Management and LFV, Sweden's air navigation service provider. They are the two main organizations behind the program and have been working on the r-TWR concept since 2005.


Saab Group

A camera mast at Sweden's Sundsvall airport. Controllers expect to be licensed to manage air traffic at a distant airport.

The aim is to deliver air traffic control tower services at remote airfields where there is not enough traffic to justify the investment in manpower and equipment for a conventional ATC tower system.

The program has been accelerated by the adoption of the concept by SESAR, the Single European Sky ATM Research program, which is the European Union's version of the Federal Aviation Administration's NextGen. The Swedish system passed SESAR site acceptance testing in February of 2013.

Trials of the concept are underway elsewhere in the world. Avinor, Norway's Air Navigation Service Provider. is testing an r-TWR operation at Bodø, remotely managing operations at a heliport at Værøy airport and fixed-wing aircraft operations at Roest Airport. In October 2013 Airservices Australia began a four-month trial of the concept by evaluating the provision of aerodrome and approach control services at Alice Springs Airport from Adelaide Airport, 950 miles (1,529 kilometers) away.

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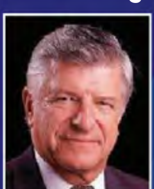

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This event is organized according to government directives. Government guest selection, invitation, and seating will be administered solely by AIAA in accordance with government policy.

14-247

A drone's day in court

The FAA says it will appeal a National Transportation Safety Board ruling in a case that appears to clear the way for small unmanned aircraft to perform jobs the FAA previously insisted were strictly off-limits, from bringing beer to ice fishermen in Minnesota to delivering Valentine's Day flowers to a Detroit suburb.

On March 6, an NTSB administrative law judge dismissed the FAA's case against Raphael Pirker, who used a Ritewing Zephyr to obtain promotional videos of the University of Virginia in Charlottesville in 2011. NTSB ruled the FAA could not fine Pirker $10,000 for failing to follow rules for unmanned aircraft operations when the agency never established those rules in the first place. The judge was unswayed by the FAA's contention that existing regulations apply to all aircraft intended for flight, including model aircraft, by asking whether the agency also intended to regulate paper airplanes and balsa wood gliders.

As a result of the ruling, "people could in theory go out and conduct commercial operations with drones as long as they stay below 400 feet and out of controlled airspace," said Missy Cummings, a former Navy fighter pilot and now director of the Massachusetts Institute of Technology's Humans and Autonomy Laboratory.

The FAA promises to fight the ruling. Even if the agency wins, unmanned aircraft enthusiasts said the judge's decision shows the FAA can't halt commercial enterprise indefinitely.

Unmanned aircraft appear poised to play a role in agriculture, cinematography, infrastructure inspection and pizza delivery. "We might finally be making some progress after being told repeatedly that entrepreneurs and developers can't engage in commercial activity until all the rules for unmanned aircraft operations are in place," said Brendan Schulman, an attorney who leads the unmanned aircraft systems practice group at the New York law firm Kramer Levin Naftalis and Frankel and represented Pirker in the federal case.

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TeamBlackSheep.com

At the center of the controversy: The Zephyr, a remotely controlled plane built by the Arizona company Ritewing.

Malaysian Airlines case stirs call for streaming data

Transmitting real-time data off airliners is a technology that might have kept Malaysian Airlines Flight 370 from turning into one of aviation's greatest mysteries, but the technology hasn't been adopted because of questions over costs and satellite bandwidth, aviation experts say.

The idea of streaming flight data, cockpit audio and possibly even video from airliners has percolated since the 1990s. When a plane goes missing or crashes in a remote region, the thinking goes, authorities wouldn't be relegated to frantic searches for voice and flight data recorders. They wouldn't need to coax foreign governments to release clues in their radar troves. They wouldn't need to tell an F-16 test pilot to go peer into the cabin of the jet, as in the case of the golfer Payne Stewart's doomed Learjet flight in 1999. Authorities would immediately have at their fingertips the information stored in the plane's black boxes — the flight data and voice recorders.

The question is whether the Malaysian incident will be enough to shift the industry's cost-benefit calculus about streaming flight data. History suggests it might not be enough.

The Air France crash off Brazil in 2009 also revived discussions about the technology. Investigators needed 11 months to find the flight's voice and data recorders at the bottom of the Atlantic Ocean, notes Hans Weber, president of the aviation consulting firm Tecop International of San Diego. Airlines and air navigation service providers reportedly objected to being required to adopt streaming: "Nobody was willing to pay for that," Weber says.

The most vocal advocate for real-time streaming is Seymour Levine, a retired Northrop executive who was chief engineer at Northrop Grumman Electronic Systems Division. In 1999, he patented a proposed system of aircraft electronics and satellite links called RAFT for Remote Aircraft Flight Recorder and Advisory Telemetry system.

RAFT would stream flight data and possibly audio and video to the ground to "eliminate or minimize the need for the costly and time-intensive recovery of the aircraft's recorder," Levine wrote in a 1998 paper.

Reached at his home in California, Levine expressed frustration that his technology has not been adopted, despite decades of technical articles, speeches and coverage in the media, including Aerospace America, Wired, and the BBC. "It could have saved lives," he said.

In the years since Levine first proposed his technology, efforts to keep connected with airliners have largely been boiled down to the Aircraft Communications Addressing and Reporting System, which transmits short text messages to airline operations centers, and systems for transmitting GPS locations, such as the Automatic Dependent Surveillance-Broadcast service. One version of ADS-B would have required an aircraft like Malaysian Flight 370 to be within range of a ground station. A version coming in 2015 from Iridium and Aireon would not require a ground station, because the Iridium satellites pass information from satellite to satellite over cross-link antennas.

Advocates of ADS-B say the technology probably would not have helped in the Malaysian case, if reports prove accurate that communications equipment was intentionally dismantled on the plane. "Then the controllers on the ground would be blind to where the plane is," says Don Thoma, chief executive officer of Aireon, the company that plans to use Iridium for ADS-B services.

Levine's technology or something like it would have told authorities what was happening in the cockpit before contact was lost. Levine said it's been emotional for him to watch authorities grapple with a lack of data in the Malaysian case: "You know why I feel bad? I feel bad because I'm sure it's going to be fixed. The only question is whether it will be in my lifetime."

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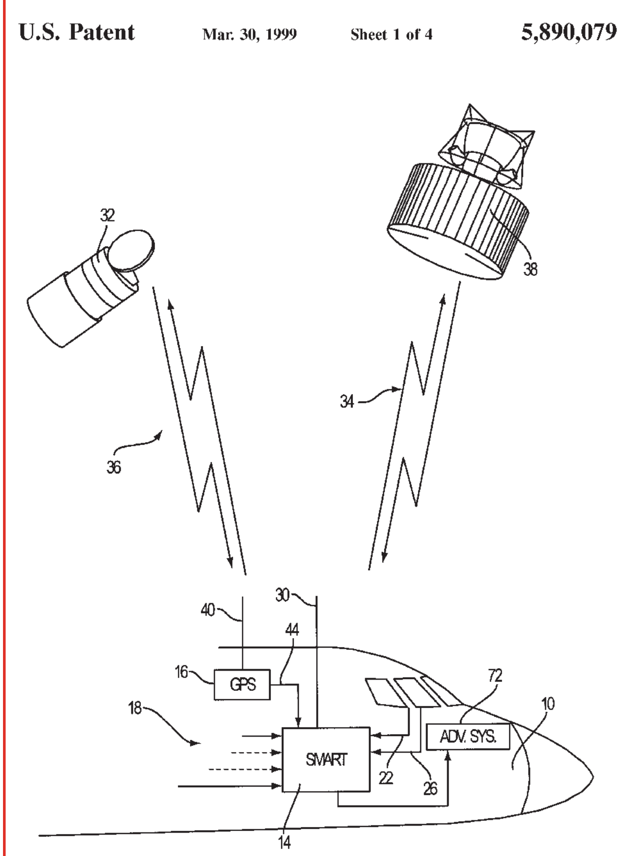


Long overdue? A 1999 drawing of the Remote Aircraft Flight Recorder and Advisory Telemetry, or RAFT System, installed on an airliner. SMART stands for Sensor Multiplexer Receiver and Transmitter.

Google Patents

NASA

Discovery's swan song: Delivering the Leonardo module to the space station in 2011.

Life after the shuttle program

Three veterans of the space shuttle program gathered last month to share memories, and venture a bit of Monday morning quarterbacking about the decision to end the program.

"I wish we had kept flying," said Wayne Hale, a flight director on 40 shuttle missions and the shuttle pro-

continued on page 13

Beating noise pollution

NASA researchers want to figure out how to build jets that can fly supersonically over populated areas without leaving a trail of annoyed residents. Chris Kjelgaard examines the sonic-boom work performed in NASA's High Speed Project.

To the casual observer, the sonic-boom research under NASA's High Speed Project and its precursor the Supersonics Project might seem like a hodgepodge.

Since 2011, microphones installed on the ground beneath a sonic boom test corridor in California have recorded booms made by an F/A-18. Other microphones at Rogers Dry Lake recorded the rapidly decaying or "evanescent" waves typically perceived on the ground as a rumbling noise. Meanwhile, volunteers in the housing at Edwards Air Force Base, Calif., wrote down details every time they heard a sonic boom from the nearby test range. NASA has also been using the German-pioneered schlieren photographic filtering technique to image booms — schlieren is German for streak, which is what a wave of compressed air looks like in schlieren images.

"The programs do all fit together," says Tom Jones, deputy project manager for the High Speed Project based at the Armstrong Flight Research Center adjacent to the Edwards range. "The end goal is to facilitate the ability for a new speed regime to be opened for civil transportation."

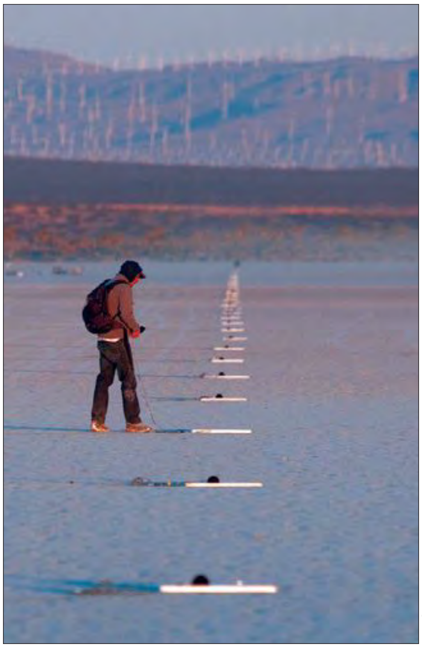
Researchers are now working to tie together findings from these projects into a fuller understanding of sonic booms and shockwaves. The goal is to give engineers the knowledge needed to build supersonic passenger jets that would give off weaker shockwaves when operated within certain parameters, or shockwaves that might be directed away from the ground.

Under the High Speed Project, researchers want to develop sub-scale concept models that would be tested in wind tunnels. The big excitement would come after that.

"The Supersonics Project and now the High Speed Project are trying to get the tools ready to prepare for a flight demonstration — and we feel we have come a long way in preparation for that," says Jones.

Starting point

Focused sonic booms are the harshest and loudest to the human ear, so they've been one of the main targets for the work. These booms occur when an aircraft accelerates during supersonic flight or when a military jet turns rapidly while traveling supersonically.



NASA

Rumble in the desert: *A researcher adjusts a microphone to record the short-lived "evanescent" shock waves that sometimes reach the ground when planes fly supersonically.*

At the front of a focused wave is a mass of compressed air, called the caustic surface, that can be several miles wide and a few hundred feet thick when it intersects with the ground. This compressed air is the product of waves emitted tangentially as the wave front races through the atmosphere. Researchers say the overpressure can be 10-11 pounds per square foot when the wave from an F/A-18 is at its most focused, or about 10 times greater than the overpressure from an F/A-18 during supersonic cruise.

"A focused boom might be a potential gotcha for a commercial aircraft," says Ed Haering, an engineer in NASA's Research Aerodynamics and Propulsion Branch, which leads Armstrong's sonic boom work. "NASA wants to understand it and pass that understanding on to the commercial sector."

NASA gathered acoustic data about these booms under an initiative called the Superboom Caustic Analysis and Measurement Program, or SCAMP. Eighty-one microphones were set up in 2011 along a dirt road in the Black Mountain Supersonic Corridor in California, a test range where supersonic flight is allowed. Microphones also were flown on an aerostat floating at 3,500 feet and on a TG-14 motor glider. A NASA F/A-18 jet then flew various supersonic flight profiles.

Caustic surfaces are of special interest, because if they can be kept high enough above the ground, people might not hear any sonic boom at all. On top of that, a wave's strength is "very sensitive to [aircraft] speed," says

Photographing shockwaves: *A NASA F/A-18B, left, carries a camera pod on its way to photograph an F-15B, right, that will soon be flying supersonically.*

aerospace engineer Larry Cliatt of the Research Aerodynamics and Propulsion Branch. A few knots of additional airspeed can mean the difference between a shockwave that can't be heard on the ground and one that produces a very loud boom. Perhaps aircraft could be designed to fly supersonically, but at a speed that would avoid producing the harshest, loudest focused waves.

One challenge under SCAMP was that the F/A-18 had to produce focused sonic booms at precise moments and locations so that researchers could study them. NASA used computational fluid dynamics and wind tunnel tests to produce algorithms to calculate the speed and navigation required to produce those booms. Armstrong researchers say the algorithms proved accurate enough to achieve a high rate of success in measuring the focused sonic booms.

Researchers might now be able to tune those algorithms in another direction, so that aircraft can accelerate and cruise at speeds and altitudes that would minimize shockwave exposure on the ground, says Armstrong's Jones.

Researchers also must understand in detail the different local shocks produced by an aircraft's nose, canopy, wing, tail and inlets, to prevent them from coalescing to form large shockwaves. Researchers graph the strength of sonic-boom waves against time, and when they do that for coalesced waves they see an N shape depicting two distinct spikes in intensity. This is why people often hear sonic booms as two bangs: they hear one spike of the N quickly followed by the second.

Researchers want to make waves less noticeable on the ground by designing planes so the shocks produced by different aircraft surfaces don't coalesce into a large wave with an N shape on the graph. Ideally, the local shocks should coalesce into a sine wave.

Hearing is believing

To understand how people perceive different strength waves, NASA enlisted help from 100 volunteers in the housing area at Edwards. The project was called WSPR, for Waveforms and Sonic boom Perception and Response. In November 2011, NASA flew an F/A-18 jet supersonically in different flight profiles while volunteers at home at Edwards noted on questionnaires and smartphone apps whenever they heard booms. Researchers recorded the exact times and strengths of the resulting booms with microphones installed at Edwards, according to NASA.

Ground truth: *Sonic boom recorders gathered data while residents at Edwards Air Force Base, Calif., noted reactions to the booms. The doghouse contains SNOOPI, short for Supersonic Notification of OverPressure Instrumentation.*

To gather data about the evanescent waves that form beyond the caustic surface and also at the sides of booms, NASA undertook a project called FaINT, for Farfield Investigation of No Boom Threshold. In November 2012, NASA flew an F/A-18 supersonically and used microphones at Rogers Dry Lake, part of the Edwards test range, to record the phenomenon.

Evanescent waves are sometimes produced when a supersonic shockwave is refracted upward by the atmosphere, which can send evanescent waves toward the ground. Under FaINT, researchers investigated the cut-off points in aircraft weight, size and airspeed that caused evanescent waves to be heard — or remain unheard — far away from the original caustic surface.

Seeing shockwaves

NASA has mounted schlieren optics inside a pod mounted on the fuselage of one of its F/A-18s. Inside the pod is a tracking camera that keeps the optics fixed on the sun, which is used to backlight the atmosphere. A second camera captures the shockwave images, using sunlight to backlight the atmosphere. The images are ready as soon as the image is taken on the aircraft.

NASA Armstrong continues to flight-test this Airborne Schlieren Imaging System. Work on it began in 2000, seven years after NASA researcher Leonard Weinstein used ground-to-air schlieren photography to produce images of the shockwaves produced by a Northrop T-38 Talon trainer in supersonic flight.

Schlieren photography requires a backlighting source — usually the sun in NASA's sonic-boom experiments — and a knife-edge placed at the focal point of the lens. This aligns all incoming light into parallel waves and blocks out about half the light entering the camera. Since shockwaves produced by an aircraft traveling supersonically create different densities in the air, and light is refracted differently through each density, supersonic shockwaves show up as dark and light bands in schlieren images.

In the past two years, NASA has also conducted sonic-boom imaging experiments using two other schlieren techniques.

One, called Background Oriented Schlieren, has been used in the past by other NASA researchers for airflow studies; NASA Armstrong plans to publish findings from this supersonic wave-imaging work later this year. The other, a new Ground-to-Air Schlieren Photography System, yields schlieren images without the need for a knife-edge in the optics. GASPS was developed for NASA by MetroLaser, a small company in Laguna Hills, Calif., specializing in laser measurements and diagnostics.

GASPS requires the aircraft to be flown supersonically along a precise trajectory to eclipse the sun in the field of view of a ground camera. The sun, the aircraft and camera must all be aligned at the same moment. This is not a trivial task, says Jones. GASPS flights led to NASA releasing three schlieren images last September; however, these images were subsequently taken off line because of unspecified security concerns.

Ernest Arvai, president of aerospace consultancy The Arvai Group, says the images could hint at the possibility of defeating stealth by applying software to analyze variances in the refractive indices of the pixels in high-resolution, ground-to-air schlieren images. "If you put together synthetic schlieren [analysis] with gigapixel-camera technology, you've potentially got something that's interesting as a stealth eliminator," Arvai says.

Jones says NASA Armstrong hopes to use schlieren techniques to help validate its computational fluid dynamics models and wind-tunnel testing of supersonic shockwaves.

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continued from page 9

gram manager during the years when the program's fate was debated. "We're in a democracy. We have certain limits of our resources," he added.

Hale participated in a panel discussion, "Space Shuttle Missions and Memories," together with Bob Crippen, who flew on the first shuttle mission in 1981, and Sandy Magnus, who in 2011 was a mission specialist on the last shuttle flight. Magnus is now executive director of AIAA.

Hale told the audience of Smithsonian supporters at the Udvar-Hazy Center outside Washington, D.C., that the orbiters had lots of life left in them. Before the 2003 Columbia disaster, "we were planning to fly the shuttle past 2020, and certainly the system could have done that," Hale said.

Crippen said stopping the program wasn't the only option: "I think maybe we could have" launched missions "like once or twice a year, just to have it there, but that didn't happen."

Looking to the future, Magnus said lots of preparations will be needed to get ready for the next American human-rated launcher, given the gap between the shuttle and the new program. "There's a lot of skill sets and corporate knowledge and things like this that you would hate to lose, and we lost some of that — for example, the people that worked during the dynamic phases of launch and understand that, or the people who did these amazing things to these very complex shuttle engines," she said. "So now we'll have to rebuild some of that as we move forward."

The reason to keep flying would have been to avoid such a gap, Hale said. "I think the real disappointment is that we didn't get to build the second-generation shuttle that maybe would have corrected some of the deficiencies, taken the things that we learned about how to turn vehicles around more efficiently and fly them more cost effectively. That to me is the real shame."

Hale said the shuttle program was a big step toward routine human spaceflight, even though the program topped out at 10 missions in 1985 and never met early promises of dozens of flights a year. "I've talked to a number of folks that were in program management in those early days and making the decisions on the configuration, and they never believed" that rate was possible, he said. "They did think something on the order of 15 to 20 might be possible."

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Honoring Achievement: An AIAA Tradition

AIAA is proud to recognize the very best in our industry: those individuals and teams who have taken aerospace technology to the next level … who have advanced the quality and depth of the aerospace profession … who have leveraged their aerospace knowledge for the benefit of society. Their achievements have inspired us to dream and to explore new frontiers.

We celebrate our industry's discoveries and achievements from the small but brilliantly simple innovations that affect everyday lives to the major discoveries and missions that fuel our collective human drive to explore and accomplish amazing things. For over 75 years, AIAA has been a champion to make sure that aerospace professionals are recognized for their contributions.

AIAA congratulates the following individuals who were recognized from October 2013 to March 2014.

AIAA Aerospace Guidance, Navigation, and Control Award
Bernard Etkin
University Professor Emeritus
University of Toronto
Ontario, Canada

AIAA Aerospace Design Engineering Award
Michael Benjamin
Senior Engineer
GE Aviation
Cincinnati, Ohio

AIAA Dryden Lectureship in Research
Mark J. Lewis
Director
The Science and Technology Policy Institute
Institute for Defense Analyses
Alexandria, Virginia

AIAA Durand Lectureship For Public Service
Scott Pace
Director, Space Policy Institute
Elliott School of International Affairs
George Washington University
Washington, D.C.

AIAA Gardner-Lasser Aerospace History Literature Award
William Clancey
Senior Research Scientist
Florida Institute for Human and Machine Cognition
Pensacola, Florida

AIAA History Manuscript Award
Lawrence Benson
Air Force Historian (retired)
Albuquerque, New Mexico

AIAA Intelligent Systems Award
Heinz Erzberger
Senior Scientist, Aviation Systems Division
NASA Ames Research Center
Moffett Field, California

AIAA Lawrence Sperry Award
Kimberley Clayfield
Executive Manager, Space Sciences and Technology
Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Canberra ACT Australia

AIAA Mechanics and Control of Flight Award
Maruthi R Akella
Associate Professor, Aerospace Engineering and Engineering Mechanics
University of Texas at Austin
Austin, Texas

AIAA Pendray Aerospace Literature Award
Wassim Haddad
Professor of Aerospace Engineering
Georgia Institute of Technology
Daniel Guggenheim School of Aerospace Engineering
Atlanta, Georgia

Dr. Antonio Elias, 2014 von Kármán Lecturer.

Dr. Kimberley Clayfield (right), 2014 recipient of the Lawrence Sperry Award, with Dr. Michael West (left), Chair of the AIAA Sydney Section.

AIAA Structures, Structural Dynamics and Materials Award

Daniel Inman
"Kelly" Johnson Professor and Chair
Department of Aerospace Engineering
University of Michigan
Ann Arbor, Michigan

AIAA Survivability Award

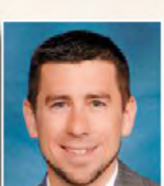
John M. Vice
President
Skyward, Ltd.
Hendersonville, North Carolina

AIAA von Kármán Lectureship in Astronautics

Antonio L. Elias
Executive Vice President and Chief Technical Officer
Orbital Sciences Corporation
Dulles, Virginia

AIAA Foundation Orville and Wilbur Wright Graduate Awards

Luis P. Zea
University of Colorado-Boulder
Boulder, Colorado



Daniel Cuppoletti
University of Cincinnati
Cincinnati, Ohio

AIAA Foundation Abe M. Zarem Award For Distinguished Achievement—Astronautics

Eliseo Iglesias
University of Texas at San Antonio
San Antonio, Texas

AIAA Foundation Abe M. Zarem Educator Award—Astronautics

Harry R. Millwater, Jr.
University of Texas at San Antonio
San Antonio, Texas

ASEE/AIAA J. Leland Atwood Award

Mark D. Maughmer
Professor
The Pennsylvania State University
University Park, Pennsylvania

Thank You, Nominators!
AIAA appreciates your time and effort in preparing the nomination package!

Michael Bailey
Dan Cyphers
G. M. T. D'Eleuterio
Christopher D'Souza
Todd Farley
Peretz Friedmann
Anthony Gross
Anthony Springer
Michael West
Vigor Yang

AIAA
Shaping the Future of Aerospace

Test time for seamless wings

The small company FlexSys predicts that its jointless, flexible flight control components will slash aircraft fuel costs by reducing drag — and soon the company will have the chance to prove it. Erik Schechter looks at the flights that could brighten the future of seamless wings.

Engineers at NASA's Armstrong Flight Research Center in California are in the process of replacing the standard mechanical flaps on a Gulfstream 3 business jet with jointless, seamless flaps for a series of flights starting in July.

The flaps were created by the 12-person company FlexSys of Ann Arbor, Mich., using a technology it calls FlexFoil. The flaps will be tested under an Air Force-NASA initiative called the Adaptive Compliant Trailing Edge project, or ACTE.

Proponents say the technology has enormous potential, and not just as add-ons like in the Gulfstream tests. The technology could be incorporated into wing designs from the start to create flexible leading and trailing edges, and it could be used in rotor blades and even windmills.

"If I had to put [its significance] on a scale of 1 to 10, it's probably an 8 or a 9," says Fayette Collier, an aerospace engineer who runs the NASA Environmentally Responsible Aviation Project, which is funding the test flights with the Air Force.

Unlike traditional wings, which are rigid affairs with hinged flaps and lots of drag, a wing with FlexFoil flaps will be a seamless structure that can quickly change shape in mid-flight.

Inside each FlexFoil structure is a flexible, jointless lattice made from "an aerospace-grade material" that FlexSys won't identify for fear of running afoul of the U.S. International Traffic in Arms Regulations. Hydraulic actuators push and pull this compliant lattice to morph the structure into the shape required by flight conditions. A few small strains on the mechanism can bend the wing's flaps and trailing edge -9 to 40 degrees, according to FlexSys. On each wing of the Gulfstream, a FlexFoil will be connected at the rear wing spar.

The compliant structure distributes stresses through the structure, unlike the focused stress one sees in a "lumped compliance" design like the plastic hinge of a shampoo bottle top, explains FlexSys CEO and founder Sridhar Kota, a professor of mechanical engineering at the University of Michigan. Distributing stress is a key to making the FlexFoil tough, he says.

During product development, company engineers subjected the flexible wing to twice the standard number of cycles a mechanical wing would normally see in its lifetime and at twice the expected load, that is, at 24,000 pounds. The FlexFoil wing was also exposed to harsh chemicals, ultraviolet light and temperatures ranging from -60 to 160 degrees Fahrenheit. "We checked all the boxes," Kota says.

Elusive goal

Aerospace engineers have long sought to develop shape-changing wings, but success has been elusive. In the 1980s, Air Force Flight Dynamics Laboratory researchers flew a Mission Adaptive Wing on an F-111 Aardvark. This experimental wing proved aerodynamically superior to regular wings, but it relied on a complex set of gears and links that added weight to the plane and made maintenance difficult.

Likewise, in the mid-to-late 1990s, a Northrop Grumman team used piezoelectric motors — which affect tension when an electric current is applied — along with shape memory alloy tubes to twist a wing. This worked to a certain extent, but the technology was not suited for a wide range of motion. "You need a number of such piezo actuators to effectuate a large deformation like the kind you're looking for in an aircraft wing," Kota notes,

FlexSys

Long hiatus: A flexible wing segment was tested in 2006 by hanging it from Scaled Composites' White Knight plane. FlexSys plans to resume flights in July by attaching flexible flaps to a NASA Gulfstream 3.

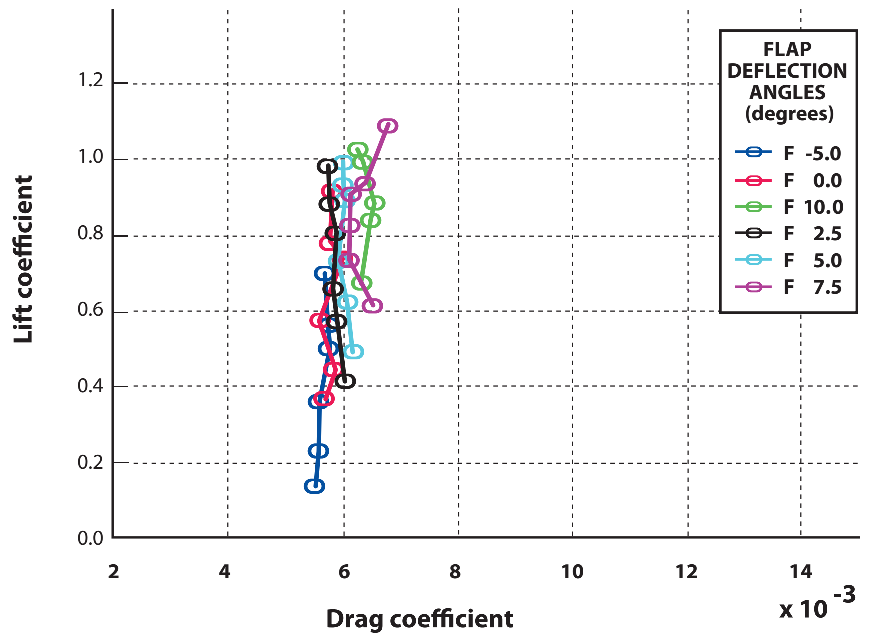
adding that the shape memory material lacked stiffness.

There are other wing design efforts as well — for instance, the X-56A Multi-utility Aeroelastic Demonstration. But the X-56A is aimed at testing a technique for actively suppressing wing vibrations called flutter. "FlexFoil is the world's first seamless, hinge-free wing whose edges morph on demand to adapt to different flight conditions," says Thomas Rigney, a NASA mechanical engineer and manager of the ACTE project. "It's a real game-changer technology."

If validated in upcoming flight tests, FlexFoil could save operators of transport aircraft hundreds of millions of dollars a year in reduced fuel burn, says mechanical engineer Don Paul, former chief scientist in the Air Force Research Lab's Air Vehicles Directorate in Ohio and now a consultant for FlexSys. Although it would be pricey to replace old flaps, those who do so would earn back their money within three years, he predicts. Second-tier airlines flying older jets would see an even greater return on their investment, because "old wings were not designed as efficiently as the new wings," Paul adds.

FlexFoil also could reduce noise levels during landings by as much as 40 percent, because there would be no gap between wing and flap. Kota says that would be particularly important as people build homes closer and closer to airports.

Look, no "drag bucket"



FlexSys

Flight tests in 2006 showed a near constant drag coefficient for a test article flown on the Scaled Composites White Knight plane. With conventional planes, the drag coefficient increases the farther the flap deflects from zero degrees.

From drawing board to runway

Kota began looking at compliant structures in the early 1990s while working in what was then the new field of micro-electro-mechanical systems, or MEMS. He was addressing an optical switching application for telecommunications, and he needed a very thin structure — only a few microns wide — to lift a microscale mirror off a plane and tilt it in three dimensions. After much trial and error, he developed a one-piece deformable structure that worked better than a jointed mechanism.

Not long afterward, he realized that his compliant structure could be scaled up to the macro level, and he began thinking about airfoils and how at high speed, a little change in shape goes a long way. However, Kota sat on his idea for more than a year, unsure if anyone would be interested in it. Then in 1994, after reading an article about the Mission Adaptive Wing, he finally placed a call to the Air Force Research Lab.

It turned out that the Air Force scientists were very interested in Kota's idea and called him in to expound on it. "I had a great meeting. They said, 'Wow! This is great. It's a refreshingly different idea than what we've been working on,'" he recalls.

A couple of years later, the Air Force lab awarded Kota a Small Business Innovation Research grant. In 2001, he formed FlexSys. With backing from the Air Force, company engineers developed a 3-foot-long test article whose performance they tested in wind tunnels at the University of Michigan and Ohio State University. Then, in 2005, they and Air Force lab researchers conducted more advanced wind tunnel tests at the Subsonic Aerodynamic Research Laboratory at Wright-Patterson, says Peter Flick, an aerospace engineer and the Air Force lab's program manager for supporting FlexSys.

The grant and the wind tunnel tests culminated in multiple flight tests in 2006. The team affixed a 36-inch span of FlexFoil to the bottom of the Scaled Composites Model 318 White Knight test aircraft and tested the compliant structure under more realistic temperature and flight conditions above the Mojave Desert. The test item was able to morph from -10 to 10 degrees. "We were very happy [with the results], but we realized that that was not enough to transition the technology to a real aircraft application, because it was relatively small scale and it wasn't a critical surface on the aircraft," Flick says.

A long series of flight tests followed, and in 2009 the team received a Small Business Innovation Research-3 grant for the activity. The next step will be the ACTE flight test, which will have a modified Gulfstream 3 fly with two FlexFoil-equipped wings at NASA Armstrong. This will determine whether computational fluid dynamics models predicting 5 percent to 12 percent fuel savings will bear out. In general, program officials are optimistic about ACTE, but they are also not taking any chances. They chose the business jet as a test bed because, besides having large flaps and being capable of transonic flight, "the aircraft was capable of taking off and landing without the flap deployed," Flick says.

Flight testing is set to begin in July and continue through February of next year. In the meantime, test pilots are undergoing training in a simulator at Armstrong in order to get used to the FlexFoil wings. NASA engineers also are putting the ACTE through ground vibration tests to make sure the wings won't be damaged by flutter. This entails suspending a FlexFoil wing by bungee cords from horizontal beams and vibrating it to "find out what its natural frequencies are," says NASA Armstrong's Rigney.

As for the flight testing regime, the Gulfstream 3 wing won't actually flex in mid-air, because building real-time actuation was deemed too expensive. Instead, officials have decided that the wing will be set at a different angle each time the jet goes up, Collier says.

Looking to the future, FlexSys and Boeing have submitted a joint proposal to the Air Force lab to retrofit a KC-135 Stratotanker with FlexFoil trailing edges to measure fuel savings. But Kota and company are also looking to bring their technology to new aircraft, a move that Paul expects will influence new wing designs. "If you tell a wing designer, 'I got this technology that lets you droop your leading edge and droop your trailing edge any time you want,' well, that changes the way you think about your wing," he says.

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The man behind the icon

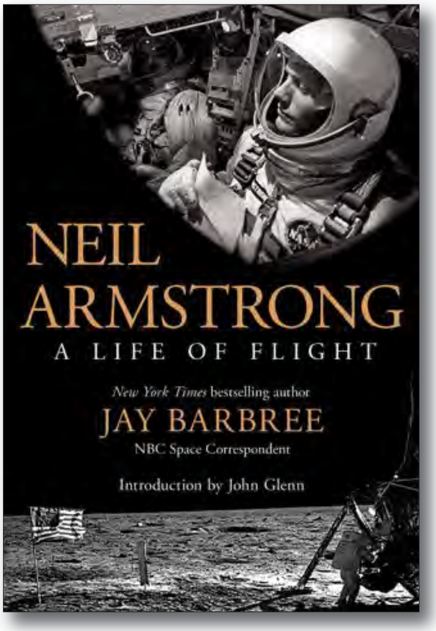
"Neil Armstrong: A Life of Flight," by Jay Barbree

Reviewed by Craig Covault

NBC space correspondent Jay Barbree's "Neil Armstrong: A Life of Flight," set for release on July 8, places the famed test pilot and astronaut in the broad context of the Cold War era. In parallel, the book focuses on his friendships, drawing a portrait of Armstrong at closer range as well.

Barbree has covered every NASA manned space mission and was a friend of the astronaut for more than 50 years.

Emerging clearly in Barbree's narrative are Armstrong's humility and integrity — bedrock values that remained with him throughout his life. The well-illustrated volume also conveys the importance he placed on excellence in flight.



Highlights from the book:

■ *Emergency escapes:*
The volume provides new details on how Armstrong nursed his badly damaged Navy Grumman F9F Panther jet back to friendly lines for a safe ejection after a North Korean anti-aircraft cable severed the plane's right wing. There is also a discussion detailing the failure sequence that would later necessitate Armstrong's ejection from a lunar landing training vehicle.

■ *Astronaut decision:*
While still flight testing the X-15, Armstrong chose not to apply to become one of NASA's original seven astronauts. Barbree writes that Armstrong questioned that decision after seeing Project Mercury develop. He successfully applied for the second astronaut group, "The New Nine."

■ *Edwards test piloting:*
Armstrong helped save a badly damaged B-29 at Edwards Air Force Base, Calif. Barbree also describes an X-15 flight in which Armstrong accidentally skipped off Earth's atmosphere, flying past Edwards' lakebed landing strip at Mach 3 and 100,000 feet, unable to reverse course until he reached Pasadena.

■ *The dearth of photos of Armstrong on the Moon:*
Armstrong told Barbree that no one should blame Buzz Aldrin for that, because Armstrong had the camera and it was not Aldrin's job to take photos. Armstrong said he personally liked the image Aldrin took of him packing lunar samples.

Some space experts might take issue with a few terms in Barbree's 416-page book, such as use of the word "flames" in reference to the lunar module rocket engines — which actually had flameless plumes that burned invisibly. Outweighing any flaws, however, are Barbree's excellent descriptions of missions such as the 10 manned Gemini flights, including Gemini 8's launch on a Titan 2 carrying Armstrong and Dave Scott. The two astronauts were bound for docking with an Agena spacecraft, an effort they had to abandon in a life-threatening emergency. According to Barbree, the ascent atop the Titan rocket reminded Armstrong of riding his old bike down [a] rutted road when he was 12 or 13, bouncing along to his job. The author writes, "His rocket was now shaking and twisting his limbs as did that old bicycle, and he managed a quick laugh remembering how his dog Skip would run along barking… he loved that dog."

Barbree also writes that Armstrong, who died on Aug. 25, 2012, often said that any one of his fellow astronauts or test pilots could have led Apollo 11 and placed humanity's first footsteps on the Moon.

"His rocket was now shaking and twisting his limbs as did that old bicycle, and he managed a quick laugh remembering how his dog Skip would run along barking…he loved that dog."
Jay Barbree

NASA's asteroid hunter

If there's a space rock out there that might threaten Earth, it's ***Lindley Johnson's*** *job to make sure NASA and a large supporting cast of astronomers find it, calculate its trajectory and predict its composition and shape. Lately, though, the retired Air Force lieutenant colonel has assumed an additional role in his position as NASA's Near Earth Objects program executive. He's helping NASA identify the asteroid it should go after in the proposed Asteroid Retrieval Mission, which calls for hauling a space rock back to lunar orbit so astronauts can travel to it and study it. Johnson spoke to Ben Iannotta in his office at NASA headquarters about asteroids, Chelyabinsk and the latest thinking on ARM.*

Ben Iannotta/Aerospace America

How has your Air Force career affected your work here?

My Air Force career and almost my entire life provide background and experience that I think is very key to this job. I was in Air Force ROTC [Reserve Officers Training Corps] in college. As opposed to my college professor whose interest was cepheid variables and measuring the distance to galaxies, I wanted to stay a lot closer to home. My interest is with planetary astronomy, particularly in orbit determination. I was in the Space Computation Center in Cheyenne Mountain in the '80s tracking satellites. I became the officer who was responsible for doing reentry predictions of debris and large satellites. At that time, the Russians had their radar satellites with their radioactive power supplies.

There was that one that came down in Canada.

I didn't work the one in Canada because I wasn't in the service yet. But I worked one after that, Kosmos 1402, the one that ended up coming down in the South Atlantic. That got excitement and headlines, because of the Canadian event that occurred a few years earlier. I got a lot of experience in high precision orbit tracking and determination and experience in using optical facilities for tracking things in space.

What technologies don't you have that you'll need for the ARM mission?

The science mission directorate's part of ARM is in identifying and characterizing what may be the potential object that would be brought back. We are using our existing near Earth object observation network to do that. In the kind of timeframe we're talking about, there's not enough time to develop additional technology or even

Interview by by Ben Iannotta

to be able to put up a space-based asset, which would be the most beneficial thing for detecting and tracking near Earth asteroids.

Will this new DARPA Space Surveillance Telescope in New Mexico help you identify candidates?

The Space Surveillance Telescope is one of the things that we were already looking at bringing into our line of assets. The team that worked with DARPA to build that asset is the same team that has been running our LINEAR [Lincoln Near-Earth Asteroid Research] asteroid search program since 1998 – the very same guys. So they are very up to speed on what it takes to bring such an asset onboard into our network for detecting and tracking asteroids. This last year they did some initial testing on the asteroid detecting capability, and we have some additional testing to complete that phase. We hope to make it a routine contributor to providing observations. The one thing about the Space Surveillance Telescope, though, is that the plans are to move it to Australia in a year or two. That would take it down for 18 months or so, but when it goes up in Australia we'd have that capability in the Southern Hemisphere, which we sorely need – a good Southern Hemisphere asset. So there's pluses and minuses there.

Where are you in terms of selecting candidates?

There are candidates that we're looking at now for the reference mission, but we're also looking at an alternative approach to go to a larger asteroid, one that we are better able to characterize prior to the mission. We would pick up a large boulder off of it and bring that back. The size of the object would be roughly the same. Maybe a little smaller on the pickup of the boulder. The larger asteroids – thank goodness – are usually further away from the Earth, and so the energy needed to bring it back necessitates that the mass be smaller. So we have a list of very small asteroids that we're looking at for the reference mission – the initial concept – and then we have a list of asteroids that we're looking at for alternative approach.

So there has to be a decision made on which of these to do?

And that's the work that's going on right now – to look at the pluses and minuses. What would be the benefits to not only the human exploration mission but also science of these various concepts? But also, one of the other objectives is demonstration of a capability for planetary defense – deflection of an asteroid if we ever had to do that – testing at least the operations and techniques that you might use. And so both those concepts are being assessed. That is one of the figures of merit: What benefit does it bring to the planetary defense issue?

So, the reference approach, a sub-10-meter asteroid –

Something that small we would not typically worry about because the Earth's atmosphere protects us from those small asteroids. Chelyabinsk was probably about 20 meters in size. Now it did some damage by a blast wave breaking a bunch of windows and getting people cut by glass, but other than that there were no effects on the ground. So it takes an object probably 25, 30 meters, certainly larger than a Chelyabinsk object, before we get worried what the impact effects might be. But prior to Chelyabinsk we were saying that we didn't have to worry about anything smaller than say 30, 40 meters in size. Chelyabinsk has caused us to want to reassess that a little bit.

For ARM, what would be the link to planetary defense?

The techniques and capabilities that we are using and enhancing increase our ability to detect and characterize any hazardous object. Since these are very small objects, they have to be close to Earth for us to see them. We have to have a rapid response capability: Once we detect the object, getting more follow-up observations, getting the orbit nailed down, then observations to characterize its size, shape and composition. We've got to get larger telescopes on it, do spectroscopy, and also hopefully radar, using our two planetary radars, one at Goldstone and one at Arecibo.

Rapid response being look at it, characterize it –

We have to understand what we're dealing with as rapidly as possible. Over on the mitigation side of planetary defense, some of the techniques that you might need to go up and interact with this object, go up and deflect it, move it around, could be tested as a part of the robotic spacecraft's operation to grab this object and bring it back. One could say that interacting with a larger object may be of more benefit than this 10-meter one that we aren't concerned about at all. But there are things that could be done both ways, and the ARM mission needs to be driven more by what is possible to do to achieve the human spaceflight goals that it has.

Is it still 50-50 on each ARM option, reference or alternative?

They're still both in the running. That's all I can say right now. We've got to have a whole integration team setting up figures of merit to be able to assess the two concepts.

Has there been a serious discussion about showing how you would change an asteroid's orbit?

Sure, we've got a couple concepts that proposals have been developed for that we've been working on. One is a JPL program called ISIS [Impactor for Surface and Interior Science] They would do their demonstration in coor-

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Tech Forecast: Airborne intelligence growth

The military airborne intelligence, surveillance and reconnaissance market will continue to grow over the next eight years for U.S. companies, but that doesn't mean there will be no pain for businesses in some ISR segments. Teal Group analyst David Rockwell gives his company's forecast.

Even as the U.S. brings forces home from Afghanistan, the overall airborne intelligence, surveillance and reconnaissance market will continue to grow through fiscal 2022, although more modestly than over the past 10 years.

This forecast is assembled from individual funding forecasts for all major research and development and procurement programs. It shows continuing growth for electro-optical and infrared video cameras and associated equipment; cloud-piercing synthetic aperture radars; unmanned aircraft and traditionally piloted ISR planes. Only the airship and aerostat markets are forecast to decline substantially.

The overall continuing growth won't equate to an entirely smooth ride for the industry. There are signs of challenges. In late 2013, FLIR Systems, Inc., long a darling of Wall Street, announced plans to close up to six sites in the U.S. and Europe and consolidate its optics and laser manufacturing businesses. The company cited lower-than-expected sales and "ongoing uncertainty in the U.S. government."

As aircraft numbers continue to decline through retirements and reduced future procurements, more funding will be devoted to sensor upgrades for legacy aircraft and for installing better sensors on smaller numbers of new aircraft.

Electro-optical and infrared video camera turrets are the default sensors for the vast majority of unmanned planes. The forecast shows steady growth in near-term EO/IR system funding, rising from $694 million in fiscal 2013. Production has now ramped up for the Army Gray Eagle unmanned planes, and we expect continuing orders beyond current plans. But with hundreds of Air Force Predators and Reapers already in service, and Block 30 Global Hawk production ending early, spending might shrink somewhat for EO/IR systems on unmanned planes, with a shift of funding toward maritime patrol and over-sea mission sensors.

In addition, new technologies like wide field-of-view and hyperspectral imaging have a strong future, based on comments by defense officials.

Development and production of increasingly sophisticated sensors for mini and nano tactical unmanned aircraft will continue. The sensing capabilities on larger unmanned craft will trickle down to smaller aircraft. Spending on sensors for unmanned combat air vehicles should surge in the out-years.

The spending won't be uniform within the EO/IR market. It will grow more slowly in the manned segment than in the unmanned segment. The manned EO/IR market will grow at a modest 0.6-percent compound annual growth rate from fiscal 2013 to 2022, or $911 million rising to $974 million.

But if manned fighter and attack helicopter targeting systems are included — they share much ISR technology — the manned EO/IR market would be worth more than four times the unmanned aircraft market in fiscal 2013.

This should put unmanned aircraft sensors in some perspective: They will be the fastest growing segment of the EO/IR market over the next decade, but there are still a lot of inexpensive off-the-shelf sensors going on these unmanned planes today, and the total value is not as large as many think.

Tactical reconnaissance revival?

The market for cameras on tradition-

U.S. Air Force

Steady growth: A Multi-Spectral Targeting System camera on a remotely piloted plane.

ally piloted fighter planes has been one of the only consistently declining EO/IR markets since the Cold War, with tactical reconnaissance systems retired en masse in the 1990s, including several hundred Air Force RF-4Es. The next blow was the shift from extremely high-resolution film cameras to lower-resolution, but more accessible, digital cameras. Many nations kept their old film cameras until retirement, when they acquired either a much-reduced replacement fleet or in most cases simply retired their fighter tactical reconnaissance capability.

In the view of some, the advent of unmanned planes has reduced fighter reconnaissance almost to irrelevance. In fact, a core capability continues, and the U.S. Navy especially has newish systems for carrier-borne Hornets and Super Hornets — remember, the X-47B is an experimental unmanned jet and there still is no carrier-based equivalent to the Hornets.

The Defense Department pivot to Asia may rejuvenate tactical reconnaissance, as most unmanned planes are defenseless in contested airspace, known as "anti-access, area denial airspace" in U.S. military parlance. Though extremely high-altitude and stealthy unmanned aircraft might be able to fly over such airspace, and satellite use has grown, there will be growing emphasis on at least the ability to provide quick-reaction tactical ISR, both from carriers and from land bases.

So far, there are no major new tactical reconnaissance pods in the unclassified budget, and our conservative forecast reflects this. But we believe there might be substantial funds for them in classified budgets and if so, there's potential for growth. Only two major tactical reconnaissance players survive, United Technologies Aerospace Systems, which includes the former Goodrich, and BAE Systems, both of which have gone through several mergers, acquisitions and restructurings. United Technologies' DB-110 still-photography pod, developed by Goodrich, has become the primary long-range oblique photography system for world markets, superseding BAE's airborne reconnaissance systems.

Radar market

Sophisticated radars will be the main future competitor to EO/IR video cameras, because their radio signals can penetrate all weather. They can be operated in synthetic aperture radar imaging mode, or they can detect the location of moving objects by the Doppler shift in radar reflections in moving-target-indicator mode. Historically the radars aboard large manned aircraft such as the Joint Surveillance Target Attack Radar System — Joint STARS — planes have had limited resolution and limited uses for targeting and narrow-field-of-view spot surveillance, but this is changing.

Radar research has been well funded since the wide-field-of-view surveillance needs in Afghanistan replaced narrow-field-of-view road reconnaissance and targeting requirements in Iraq. Sierra Nevada's EO/IR wide-field-of-view Gorgon Stare pods on a limited number of Air Force Reaper unmanned planes have been followed by several new research, development, test and evaluation programs involving radar. With their acknowledged all-weather advantage, these newer systems only need improvements in resolution, and in processing, exploitation and dissemination, to match many EO/IR wide-field-of-view benefits. In the future, radar imaging resolutions may improve enough to replace EO/IR even for primary sensing aboard medium and smaller aircraft. But this stage is likely many years off, and radar imaging will probably remain more expensive.

Hundreds of millions of dollars have already been devoted to major radar programs such as Joint STARS, the Airborne Standoff Radar, and the Multi-Platform Radar Technology Insertion Program, and this spending is likely to continue. Large traditionally piloted radar planes will be retained, including Joint STARS; the Navy's P-3Cs equipped with the AN/APS-149 radars; and the new P-8A with Advanced Airborne Sensors. But the heyday is over for small radars, including Raytheon's Advanced Synthetic Aperture Radar System-2 on U-2 spy planes.

U.S. Air Force

A canoe fairing protects the radar carried by an E8-C Joint Surveillance Target Attack Radar System plane. Radars could challenge video cameras for roles in targeting and surveillance.

Funding will remain for a while for smaller radars for helicopters, including the Telephonics AN/APS-147 and AN/APS-153 radars on the Navy's MH-60R Seahawks. But unmanned aircraft will be the next major radar market for small radars. Funding will shrink quickly for small radars on traditional piloted aircraft once the AN/APS-153 production ends in a few years, until production takes off for Advanced Airborne Sensors on the P-8s.

Radar funding for unmanned aircraft will rise every year, at least through fiscal 2020, on all sizes of unmanned planes. Funding will be buoyed by production of the Air Force Multi-Platform Radar Technology Insertion Program radars for the Block 40 Global Hawks. If the Block 40 program is truncated, as military officials reportedly have discussed, expect a delay but eventual domination by unmanned aircraft radars, because long-endurance unmanned planes are ideal for the all-weather radar.

Airships deflate

With ISR for both manned and unmanned aircraft predicted to remain important, the forecast calls for a tenuous future for airships and aerostats, which saw a huge surge in funding during the war in Afghanistan. In May 2012, about 90 aerostats were operating in Afghanistan, up from barely a handful in 2008. About 120 were operational by late 2012. By early 2013, the Army was considering combining elements of the existing Persistent Ground Surveillance System aerostat program with the Persistent Threat Detection System aerostat program to create a unified Persistent Surveillance System-Tethered program.

The budget request for 2013 shot down many aerostat and airship programs. Research, development, test and evaluation funds were lowered dramatically and funding was cancelled for several key programs. In June 2010, the Army awarded a $517-million contract to Northrop Grumman — chosen over Lockheed Martin — to develop the Long Endurance Multi-intelligence Vehicle, planned as a medium-sized hybrid airship that would combine aerodynamic lift with lift from helium to deliver a three-week endurance.

U.S. Army

A Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System, or JLENS. Plans to fly the radar-equipped aerostats near Washington, D.C., are uncertain.

In April 2013, following "technical and performance challenges," the Army decided to discontinue the program, with nearly $60 million budgeted in fiscal 2014 for the "disassembly and disposal of" the developmental airship. The Air Force in 2012 cancelled a similar program, the Blue Devil Block 2 airship, named for its proposed sensor package.

The Air Force's Integrated Sensor Is Structure airship program also foundered, with $21.0 million of funding scheduled in fiscal 2013 and $2 million-$3 million per year through fiscal 2016. It was a major scaling back from the vision in 2009, when the Defense Advanced Research Projects Agency awarded Lockheed Martin Skunk Works a $400-million contract to build, test and fly a one-third-scale demonstrator.

With the future airship sensor market now mostly dead, a bigger question is what to do with all of the Army's smaller aerostats already in service. They are proving to be more expensive to operate than originally planned.

After past wars, most of these airships would simply have been retired because of their narrow, force protection application. It is now up to the U.S. to decide whether to maintain dozens and dozens of tethered airships bought for wars of occupation, or admit that these craft are surplus to needs. There is little need for a tethered aerostat in a pivot to Asia.

The Army has looked at providing some of its Persistent Threat Detection System aerostats for the Customs and Border Patrol's homeland defense mission. This echoes suggestions a few years ago that U.S. set up aerostats around airports to protect airliners from shoulder-fired rockets, an idea that conjured comparisons to London and the Battle of Britain. Wiser heads prevailed.

But the southern border with Mexico offers a much less conspicuous area for operating aerostats and airships, and there is a good chance some of the surplus Army craft will be moved there. On the other hand, a media storm was touched off last year when news broke of a plan to fly a pair of radar-equipped aerostats, called a Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System, over Washington, D.C., starting in 2014.

The Army discovered that popular concerns sparked by occasional flights of an unmanned aircraft in civil airspace pale in comparison to the privacy concerns raised by the thought of blimps flying over backyards. Plans to fly aerostats in the D.C. area are now uncertain.

Overall, Teal Group believes the country will not be seeing "Fortress America" in the continental U.S. anytime soon, and many aerostats will be retired. The EO/IR systems may be removed for other uses, but that should not have a large impact on demand for new EO/IR systems.

Aside from cases like aerostats for base security and force protection, the airborne ISR market should continue to grow consistently as new technologies and new systems are required for manned and unmanned aircraft.

David L. Rockwell
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continued from page 21

dination with the OSIRIS-Rex mission. Osiris and Isis were husband and wife in mythology. So after OSIRIS-Rex collects its sample at the asteroid Bennu, it has to actually hang around for several months before the orbit alignment is right for it to start its return to Earth with the sample. So during that period of time, the ISIS impactor spacecraft would come and impact Bennu to try to give it enough of a shove to demonstrate a kinetic impact orbit adjustment method. That's one study that was done here in the last year. Certainly from a technical aspect it had a lot of promise, but we simply don't have the funding in the planetary science program to do something like that right now.

Couldn't you just attach an ion thruster on an asteroid?

The problem is these asteroids are spinning and rotating all the time, so you can only thrust when things are lined up right for the thrust vector and the direction you want to go. So, for deflection there are two areas. There's instantaneous impulse. If the object is small enough, with a kinetic impactor it gives it an instant shove. You can do several impacts actually. Of course, if time is short, or the object is larger, you've got to have something with more energy. That's where a nuclear standoff device might have to come into play, to give it that instantaneous thrust. The other area are what we call slow push techniques. A concept called a gravity tractor, where if the object is small enough, you take a spacecraft with ion thrusters and have it hover in a certain position relative to the asteroid. The gravity attraction between the two acts as a virtual tow rope to slowly pull the asteroid off the trajectory. Now, that type of technique takes weeks, months to years, depending on the relative size between the spacecraft and the asteroid. Once the asteroid gets to several hundred meters in size, it takes so long that it's kind of impractical. But it may indeed be one of the techniques that we're able to demonstrate as part of the ARM mission.

My impression is early on in ARM there wasn't an embrace of the kind of planetary demonstrations you're talking about.

The grand challenge that started last year – finding all hazards and knowing what to do about them – led to the impetus to try to bring these things together, because they can be related. And to get the most benefit out of everything we're trying to do in the near Earth object realm.

Is there a particular date to have the candidates selected?

We'd certainly want to have the eventual target identified six months to a year – the longer the better – prior to the launch of the robotic spacecraft. So we're kind of notionally driving toward having a target identified in the 2017 timeframe. Notionally, in order to have the asteroid back in lunar orbit by 2025, you need to have captured the object and started the return journey two or three years before that. We would need to have an object that would have a close Earth approach sometime in the '21, '22, '23 timeframe. That means you've got to launch your robotic spacecraft two or three years before that to be able to get out to it.

Have amateur astronomers figured into any candidates that you have?

Not on the reference mission size, because those objects are so small. They're not just visible to amateur equipment. Some of the larger objects for the alternative approach, there's probably amateurs that provided some follow-up observations to help us determine the nature of the orbit. Certainly, Bennu is one of the potential destinations for the alternative approach. It's a carbonous asteroid. It may have some of the elements of creation of life in the solar system, so it would be very interesting.

But with the larger asteroids, it seems like they're often discovered by amateur astronomers.

Those certainly larger than a kilometer or several hundred meters in size have been found by amateurs in the past, but we are now entering the area where amateur systems just don't have the capability to detect these objects. They are so dim. For instance, in the last year, of the a little over a thousand objects that we detected, a thousand of them were detected by our professional survey systems. There were 1,037 previously unseen NEOs found in 2013.

If asteroid 2012 DA14 came about now, would that be more likely to be found by a professional?

Much more likely. First of all, there are the large aperture telescopes and the wide field of view cameras with CCD [charged-coupled device] detector technology and the computer processing of those images. There's a lot of digital processing and techniques that are used to pull very dim objects out of the images.

How did you learn about Chelyabinsk?

We were at the United Nations Committee on Peaceful Uses of Outer Space scientific and technical subcommittee meeting in Vienna. The team had put together recommendations about the methods and protocols the member states are going to [use] to address the threat of asteroids impacting the Earth. We thought the big event that day was going to be the close passage of 2012 DA14. I woke that morning to messages coming in about this event in Chelyabinsk. Mother Nature upstaged us.

Was your first, "Did we get something wrong about DA14?"

No, I was pretty confident. Chelyabinsk occurred several hours earlier than DA14. I wondered first about terrestrial sources – a rocket gone astray. The first time I saw the footage collected by the dash cams I knew immediately that it was a large meteor. All of us working in the business knew immediately what it was.

You knew it couldn't have been a piece of DA14.

A quick analysis of the trajectory [showed] it was coming from a completely different direction.

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Funding the triad

Modernizing and maintaining U.S. nuclear forces could require $355 billion over the next decade. Support for the triad remains bipartisan, but there is no consensus over exactly which work is necessary or how it will be squeezed into the long-term budget, reports Marc Selinger.

When U.S. Sen. Jeff Sessions, R-Ala., spent a night aboard an Ohio-class submarine, he received a close-up look at why the Navy says it will need to start replacing the vessels next decade.

"I was surprised at how old it was," Sessions recalled during a March hearing. "Things are always breaking. They spend a considerable amount of time on our nuclear submarines fixing the smaller things."

The Navy calculates that most of the Ohio subs have lots of years left, but pushing operations beyond the late 2020s would be more than an inconvenience. That would risk a breach of the sub's pressure hull—the inner hull that protects the sailors—because, say experts, a hull has only so much life. When the first Ohio-class subs took to the sea with nuclear missiles back in 1981, Sessions was still a prosecutor in southern Alabama.

The Ohio subs remain a key element of the nuclear triad—the weapons the U.S. keeps ready on land, in the air and at sea to convince any would-be attacker that a first strike would leave enough fire power intact to assure the aggressor's destruction.

For Sessions, the top Republican on the Senate Armed Services Committee's strategic forces subcommittee, visiting the sub reinforced his support for modernizing the three legs of the U.S. strategic nuclear triad.

"The neglected modernization since the end of the Cold War requires a replacement of the triad," Sessions said at the hearing. "It just does."

But the plan to buy a dozen new subs at a projected cost of $4.9 billion each also exemplifies the challenge Sessions and other lawmakers face. Hundreds of billions of dollars will be required to modernize missiles, subs and aircraft that are decades old. Still missing, experts say, is an explanation of how this work would be paid for in the long run.

The shortfall could arise sooner, should there be a new round of automated budget cuts called sequestration.

The Obama administration and Sessions don't agree on much, but they agree on the need for new subs and other upgrades to maintain the triad. At the same hearing where Sessions talked about the Ohio subs, M. Elaine Bunn, deputy assistant secretary of defense for nuclear and missile defense policy, said "many of these systems are aging out of service, and we must now invest in extending the life of some and replacing others."

It was a rare recognition that President Obama's vision of a world without nuclear

U.S. Air Force

U.S. Navy

U.S. Air Force

arsenals won't happen soon enough to avoid the need to upgrade the weapons the U.S. will rely on until then.

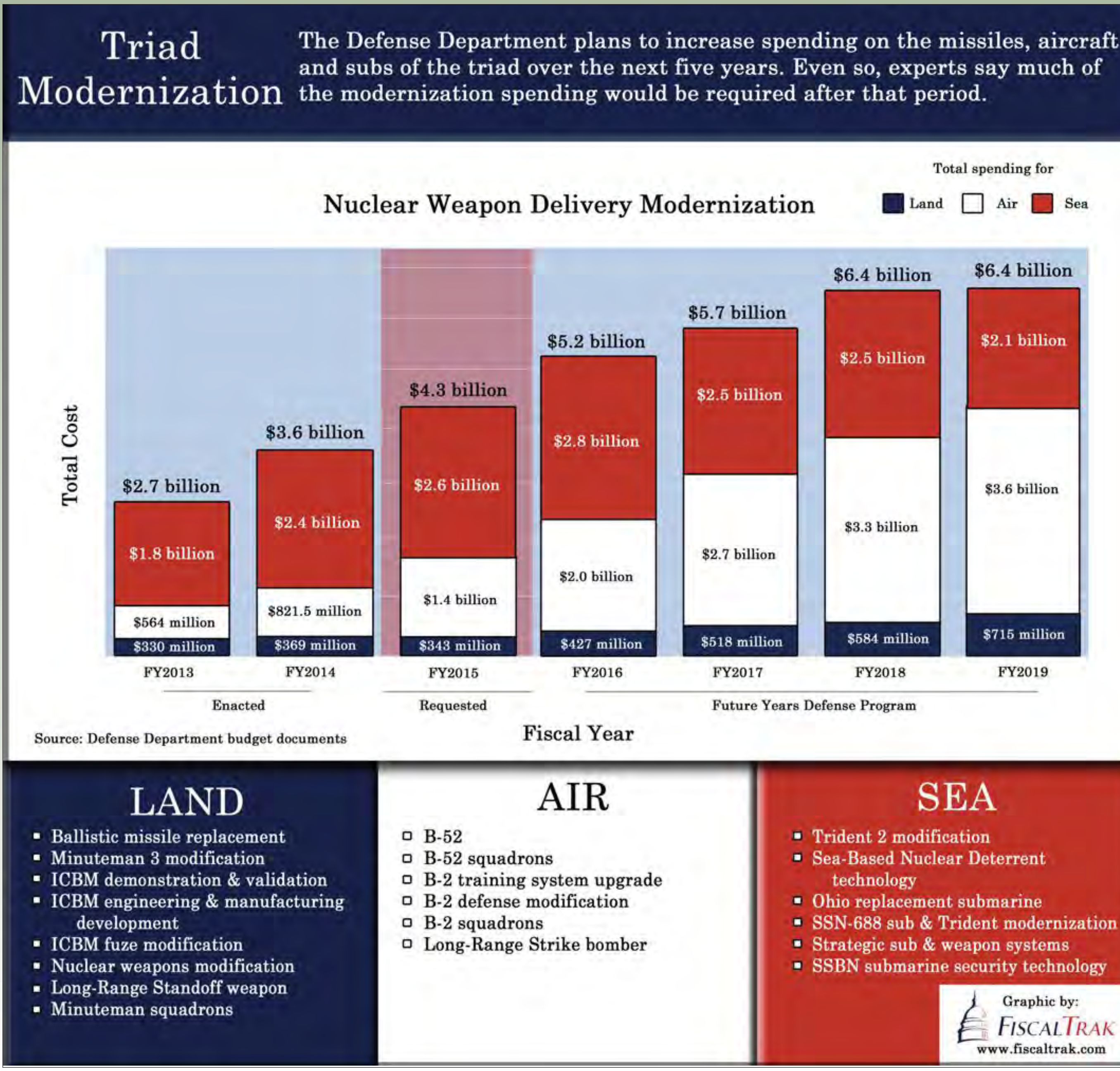
The Pentagon told lawmakers last June that it needs to maintain "strategic stability with Russia and China" and deter other potential adversaries it did not name. Retaining all legs of the triad would do that at "reasonable cost," the report said.

Despite the bipartisan support for keeping and modernizing the triad forces, paying for the work won't be easy. Most of the required funds would be needed in the years beyond the Future Years Defense Program that runs through 2019 and accompanied the Obama administration's 2015 spending request in February. The 2015 request includes funds for preliminary work on the new subs, a Long-Range Strike bomber and work-to-be-decided on U.S. Minuteman 3 intercontinental ballistic missiles. The big money won't be needed until procurement.

All told, the Congressional Budget Office estimates the Obama administration will need to spend $355 billion over the next 10 years on nuclear forces, including sustaining and modernizing weapons and delivery systems and funding work at nuclear weapons laboratories.

Sequestration remains a wild card. December's Bipartisan Budget Act relieved some of the pressure on the Pentagon, but it did not reflect an agreement on spending levels beyond 2015. In a statement submitted at the March hearing, Defense Secretary Chuck Hagel said that a return to sequestration-level cuts in 2016 would create "unavoidable decisions."

By Marc Selinger



The Pentagon's Bunn said the administration would unveil more details about its triad modernization plans when it submits its "1043 Report" to Congress in April. The document is named after the section of the fiscal 2012 Defense Authorization Act that directs the president to provide lawmakers an unclassified annual report on the nation's nuclear arsenal.

The bipartisan acceptance that the triad enjoys in Congress doesn't translate into consensus over which modernization work is necessary. Sens. Edward J. Markey, D-Mass., and Jeff Merkley, D-Ore., and House Democrat Rep. Earl Blumenauer of Oregon have introduced bills that would cut triad spending by $100 billion by reducing the number of new submarines from 12 to eight and delaying until the mid-2020s development of the Long-Range Strike bomber and a possible successor to the Minuteman 3 ICBMs. Markey introduced the Senate bill in February by saying the funds would be better spent on education and research into diseases.

"The political reality is we will have the triad for a long time," says Tom Collina, research director at the Arms Control Association, which supports the legislation. "The question is how much" money will be spent on it, he added.

AIR

The Air Force flies nuclear weapons on B-2 and B-52 bombers (the B-1 used to carry nuclear arms but now flies with conventional weapons). By any measure, the B-52H is an ancient airplane, having entered service more than 50 years ago. Many of its systems cannot be replaced and require extensive maintenance. The engines need lots of fuel but provide relatively little thrust. With its large radar signature, the plane also has difficulty penetrating defended air space, says analyst Richard Aboulafia of the Teal Group consulting firm.

The stealthy B-2 is young by comparison, having achieved its initial operational capability in 1997. But the Air Force has only 19 operational B-2s, compared to 76 B-52s.

To modernize its bomber fleet, the Air Force is pursuing the Long-Range Strike bomber, which it calls one of its top three modernization priorities, along with the F-35 fighter and KC-46A tanker. The Air Force plans to buy 80 to 100 bombers for $550 million each and begin fielding them in the mid-2020s.

The new bombers are supposed to be better than existing bombers at penetrating modern air defenses, and they would be able to strike targets anywhere on the globe. The Air Force expects to certify the new bomber to carry nuclear weapons two years after the aircraft achieves initial operational capability as a conventional bomber. The new plane would initially be configured for only manned flight but would operate in unmanned mode sometime in the future.

The Air Force is refining requirements for the new bomber and hopes to issue a request for industry proposals this fall. The competition is expected to pit a Boeing-Lockheed Martin team against Northrop Grumman. Boeing, which built the B-52, and Lockheed Martin, the producer of stealthy fighter jets, have announced that they would join forces to compete for the new bomber, with Boeing as the prime contractor and Lockheed Martin as the "primary teammate." Northrop Grumman, which built the B-2, declined to comment on the new bomber but is seen as a likely bidder.

Developing the bomber will have impacts beyond assuring deterrence, says Aboulafia of the Teal Group.

"Imagine designing engines big enough for a large payload, efficient enough for long-range cruise, capable of providing the power needed for supersonic speeds, at least for a dash, and with a reasonably low heat and radar signature," he says.

Cost estimates for modernization include upgrades to the B-2's communications, computing and threat awareness equipment.

U.S. Air Force

U.S. Air Force

B-52H bombers began flying more than 50 years ago. Upgrades will include new brakes and improved communications.

In Aboulafia's view, the modernization work could drive advances beyond the triad:

"These are the kind of challenges that advance the aeronautical arts. While potentially expensive, they are not show-stoppers, and they will yield dividends for other civil and military aerospace sectors," he adds.

With the new bomber still years away, the $355 billion cited by the Congressional Budget Office would include upgrades to the B-2s and B-52s. Work is under way to improve the communications, computing and threat awareness equipment on the B-2s. The B-52s are in the process of being equipped with improved data and voice communications, increased smart-weapons capacity, a modernized identification-friend-or-foe system, and a replacement for the original anti-skid braking system.

The Air Force also plans to replace the Air Launched Cruise Missiles carried by B-52s with a proposed Long-Range Standoff

U.S. Air Force

The Air Force wants to replace the Air-Launched Cruise Missile with a proposed Long-Range Standoff nuclear cruise missile.

nuclear cruise missile that eventually would be carried by the new bomber too. Potential competitors include Boeing, which built the existing missile, as well as Lockheed Martin, Northrop Grumman and Raytheon.

The new cruise missile "will be capable of penetrating and surviving advanced integrated air defense systems… from significant standoff range to prosecute strategic targets in support of the Air Force's global attack capability and strategic deterrence core function," according to the Air Force.

In addition, the B61 nuclear bomb, flown from 1978 to 1990, is going through a life-extension program that involves refurbishing and replacing components. The bomb has been carried by the B-2 and B-52 and is expected to fly on the new bomber.

U.S. Air Force

A Minuteman 3 missile is tested from Vandenberg Air Force Base, Calif. An analysis of alternatives is under way to decide the fate of the missiles within the triad.

LAND

A classified study, formally called the Ground Based Strategic Deterrent Analysis of Alternatives, is assessing options for upgrading or replacing the Minuteman 3 ICBMs. It is due to be completed in late June or July, according to Air Force Global Strike Command.

If the Air Force decides to upgrade the missile, it could pursue "more-effective modular components, such as a new guidance system, to meet emerging threats while maintaining the existing silo infrastructure," the Government Accountability Office wrote in a September 2013 report on ICBM modernization. The Air Force would need to begin designing a new ICBM "around 2018" to ensure it was available by 2030, the year the test-missile inventory is expected to run out, according to the Congressional Budget Office.

Several basing options could improve the new missile's ability to survive a first strike, the GAO said. These include "super-hardened," fixed silos; a mobile transport system that disperses ICBMs to launch points during alert periods; and a hardened underground tunnel system that periodically moves missiles along a 10-to-20-mile track to increase "positional uncertainty." The current inventory consists of 450 Minuteman 3s in underground silos at three Air Force bases: Malmstrom in Montana, Minot in North Dakota and F.E. Warren in Wyoming.

However, in a 2014 report prepared for the Air Force, the Rand Corp., an independent think tank, concluded that mobile basing is probably unaffordable and not needed.

"Cost and survivability assessments will likely limit basing options to existing missile silos and infrastructure for the foreseeable future," the Rand authors wrote. "Any follow-on system should be compatible with existing Minuteman silos."

To set the stage for sustaining the Minuteman 3s until 2030, the Air Force has already upgraded the guidance and propulsion systems. It is currently developing better encryption for command-and-control data and replacing outdated test gear and worn-out transport equipment. It is also working on technology for a new guidance system whose future will be "informed" by the results of the ICBM study, according to Air Force Global Strike Command.

SEA

The Navy's Ohio-class, nuclear-powered submarines, armed with Trident 2 D5 nuclear ballistic missiles, began patrols more than 30 years ago. Last year, Adm. Jonathan Greenert, chief of naval operations, told

U.S. Navy

A single Ohio-class replacement submarine, seen here in an artist's rendering, would cost $4.9 billion.

Lockeed Martin

lawmakers that the Ohio replacement program, or SSBN(X), "is the top priority program for the Navy."

Construction of the first hull is scheduled to begin in fiscal 2021. The Navy projects it can replace the existing 14 Ohio-class subs with 12 SSBN(X)s because advances in nuclear reactor design mean the new subs won't need to be put in dry-dock for a lengthy midlife refueling process.

The Navy has already extended the service lives of the Ohio-class subs from 30 years to 42, and the service plans to start retiring them in 2027.

"As such, the Ohio replacement program… must stay on schedule," says Adm. Cecil Haney, a longtime submariner and head of U.S. Strategic Command, which oversees U.S. nuclear forces. "No further delay is possible."

General Dynamics Electric Boat was awarded a $1.8-billion contract in December 2012 for the preliminary design phase of the Ohio replacement and for continued development of a missile compartment with the U.K., which plans its own new submarine, the Successor-class SSBN. The Ohio replacement is expected to enter the "detail design" phase in 2017 and to begin patrols in fiscal year 2031.

The Navy says the SSBN(X) will have "enhances in stealth" that will keep U.S. subs ahead of anything adversaries might develop this century. To keep costs down, the new submarine will have 16 ballistic missile launch tubes, compared to 24 on the existing "boomers," also built by General Dynamics Electric Boat.

At least initially, the SSBN(X) will carry the 44-foot-long Trident 2 missile. Hundreds of these missiles are slated to undergo modifications to extend their lives through 2042. The program, whose prime contractor is Lockheed Martin, involves updating six electronics packages. Modern digital components will replace 1970s and 1980s analog technology.

"Today, we have no identified aging issues" with the existing electronics, says Capt. Johnny Wolfe, technical director of the Navy's Strategic Systems Programs. But "we can't afford to wait until things start failing. Most of these missiles are deployed; it's not like you can just go get them immediately."

A Trident 2 D5 missile is tested from an Ohio-class ballistic missile submarine.

A Delta 4-Heavy lifts off from Vandenberg Air Force Base.

U.S. Air Force

With the advent of lower cost launchers, satellite designers should rethink some of their traditional assumptions about how to control costs. Gary Oleson, a senior engineer at TASC, explains how to thrive in today's dynamic launch vehicle market.

Advice to satellite designers: "Carpe

diem”

VIEWPOINT

By Gary Oleson

The changing economics of launching satellites is creating dramatic cost-saving opportunities for designers and manufacturers of spacecraft. Over the last decade, the United Launch Alliance has offered performance upgrades within its Delta 4 and Atlas 5 launcher series. Customers have the option of adding strap-on solid rocket boosters at a cost of about $10 million each. This makes it affordable for mission planners to greatly increase the mass allowable for many spacecraft. Meanwhile, SpaceX is introducing launch vehicles that can launch medium, intermediate and heavy spacecraft at much lower prices than were previously available, and Orbital Sciences Corporation may soon offer lower prices for smaller vehicles through its new Antares launcher.

These lower cost offerings should change the launch cost calculations of customers in important ways. Design engineers no longer need to spend large amounts of time and money figuring out how to reduce mass to stay on the smallest possible launch vehicle. They can allow spacecraft mass to grow while taking pressure off their budgets. This, in effect, is a new cost reduction strategy, at least for the U.S.

Design engineers typically work within a rigid mass margin, which is the difference between the maximum possible mass permitted by the launch vehicle and the maximum expected mass of the satellite under the current design. Mass margin ensures, for example, that if the mass of a part increases during development, the satellite can still be launched on the same rocket. Mass margins typically range from around 5 percent for well-known hardware to around 25 percent for new systems, according to “Space Mission Engineering: The New SMAD,” a reworked version of the “Spacecraft Mission Analysis and Design” manual used by many design engineers. Engineers traditionally work hard to stay within mass limits, so they don’t break into the margin unnecessarily.

Now, however, shifting to a more powerful rocket of about the same cost as the planned rocket allows engineers to relax a satellite’s mass limit while keeping the margin the same or even increasing it. If a spacecraft with a mass margin of 25 percent was planned for a launcher that can put 5,000 kg in orbit, then the mass limit for the spacecraft would be 4,000 kg. But if the customer could afford a 6,000-kg launch capability, either by changing launchers or adding a strap-on booster, the mass margin would jump to 50 percent. The mass limit of the satellite could be relaxed to 4,800 kg without exceeding the original 25 percent margin. Lower-cost components could be incorporated that were too heavy to be considered under the previous mass limit. For example, a spacecraft with a 10 percent mass margin launching to LEO — low Earth orbit — on an Atlas 5 501, rated at 8,210 kg, could increase its margin to 47 percent by upgrading at a cost of about $10 million to an Atlas 5 511 rated at 11,000 kg.

This is just one part of the new paradigm that’s being opened by changes in the launch market.

REDUCING SPACECRAFT COSTS

The new paradigm promises to reduce the cost to satellite designers and mission planners in three ways:

- Savings from forgoing expensive mass-reduction and power-reduction investments;
- Savings from replacing current design features with lower-cost, higher-mass alternatives; and
- Savings in the cost of the launch itself.

Designers planning to launch on an Atlas 5, for example, should investigate the potential benefits for LEO missions with expected masses of up to about 14,000 kg; for polar LEO missions up to about 11,000 kg; and for geostationary transfer orbit missions up to 6,600 kg, in which payloads are put into elliptical orbits preceding their final geostationary orbits at 36,000 kilometers.

In fact, in the current budget environment, it should be regarded as an imperative to assess changes in the launch market, identify where the greatest cost savings are likely to be found, and identify what barriers and limits must be addressed to realize the savings.

FUTURE LAUNCHER DEVELOPMENTS

SpaceX is currently developing the Falcon Heavy to launch spacecraft of up to 53,000 kg to LEO, which would be about 86 percent more capacity than the comparable Delta 4 Heavy. Based on flight data from the first Falcon 9 V1.1 flight using the new Merlin 1D engine, SpaceX upgraded its estimated geostationary transfer orbit capacity for the Falcon Heavy to 21,200 kg, about 53 percent more than the Delta 4 Heavy. If the Falcon Heavy is successful, SpaceX will be able to offer both cost and performance advantages for any spacecraft heavier than about 5,500 kg, and many lighter spacecraft as well.

Since the Falcon Heavy is currently priced at or below the cost of many Atlas 5 and Delta 4 launchers, many intermediate spacecraft with mass higher than the maximum payload of the Falcon 9 could be considered for the Falcon Heavy and derive savings both in spacecraft costs and in launch costs.

The Falcon Heavy has three flights scheduled in the next few years: an initial test flight in 2015 followed by flights contracted for the Air Force and Intelsat. De-

Market maker: A Falcon 9 in a hangar at Cape Canaveral, Fla.

SpaceX

signers of heavy spacecraft who have not begun their work should begin considering the new cost paradigm for their spacecraft and develop contingency plans to enable rapid adoption in the event that the Falcon Heavy proves reliable.

Designers of medium-weight spacecraft designers may face a complex choice regarding which launcher and which paradigm to employ. The low cost of the Falcon 9 may cause the break-even cost point to fall somewhat below 4,000 kg to LEO. If the new Orbital Sciences Antares medium-class launcher (rated at over 5,000 kg to LEO) is priced significantly lower than the Falcon 9, it may extend the relaxed-mass-limit paradigm to even smaller spacecraft. In the meantime, the current unavailability of certified medium launchers is forcing some medium-weight satellites onto intermediate launchers, including the lowest capacity versions of Delta 4 and Atlas 5. These satellites will inherit huge mass margins and are prime candidates to benefit from relaxed mass limits.

COST-SAVING OPPORTUNITIES

The dynamic economics of the launch market are opening important opportunities for satellite designers, but those designers should guard against the impulse to increase performance by adding more instruments, designing more powerful instruments, or adding secondary payloads. Each of these options could increase mission cost, risk and complexity. The opportunity to use relaxed mass limits to reduce costs is less traditional, but more responsive to the current budgetary environment. Designers could start by holding performance constant while using higher spacecraft mass limits to reduce the total mission cost as well as the risk of cost growth or schedule slips.

High and growing launch costs have created historical incentives for designers to launch spacecraft on the smallest possible launchers. The universal practice has been to invest in designs, materials and technologies that are more expensive, but enable decreases in spacecraft mass. The new launch market enables spacecraft designers to forgo most, if not all, of these expensive investments. Many programs may be able to save money by purchasing commercial-grade systems and instruments that would otherwise have required alteration or substitution due to mass limits. Savings such as these may comprise a significant portion of total program costs.

Flawless so far: An Orbital Sciences Corporation Antares rocket at NASA's Wallops Flight Facility.

Forgoing mass reduction investments and using off-the-shelf systems could bring added benefits, such as shortening project schedules for additional time-related savings, and putting satellites into service earlier. More rapid mission tempos might be enabled for recurring missions. Enabling greater use of off-the-shelf systems could also make it easier to adopt a distributed architecture strategy or use commercial satellite buses, as discussed by Air Force Lt. Gen. Ellen Pawlikowski and her co-authors in the Spring 2012 edition of Strategic Studies Quarterly.

Low-cost launches would also enable current design features to be reconsidered for potential cost savings. For example, designers might:

- Use heavier, cheaper materials;
- Reduce machining of parts to reduce mass;
- Add heavier shielding against radiation to reduce electronics costs;
- Cut back on mass management processes.

Many of these cost-saving design changes could also produce spacecraft that are more robust and reliable, in turn reducing project risk.

After the initial mass-related cost savings have been identified, budgets may also allow for relatively low-cost performance improvements, such as:

- Adding more fuel for longer satellite life or better mission performance;
- Adding larger solar arrays and batteries to power systems;
- Adding larger thermal control systems;
- Increasing the bandwidth of the communications system, enabled by increased power and mass.

These improvements could also enable a cascade of additional savings. Greater fuel loads could increase life-cycle benefits by extending spacecraft lifetimes. Adding more power production could eliminate the need for some expensive investments to reduce power consumption, for example,

Dynamic marketplace

Vehicle	Class	LowEarth orbit (kg)	Low Earth orbit polar (kg)	Geostationary transfer orbit (kg)	Prices ($ millions)	Year
Antares	Medium	4,500-5,500		1,400	unavailable	
Delta 2	Medium	5,089		1,818	$65-137	2012
Atlas 5	Intermediate	8,210-18,850	6,770-15,760	3,780-8,900	$187-223	2009-2013
Delta 4	Intermediate	9,190-13,730	7,690-11,600	4,210-6,890	$100-180	2009
Delta 4 Heavy	Heavy	28,370	23,560	13,810	$370-435	2011
Falcon 9 v1.1	Intermediate	13,150		4,850	$82-97	2012
Falcon Heavy	Heavy	53,000		21,200	$165	2012

Two newcomers could soon shake up a U.S. launch vehicle market that was already dynamic: The Falcon Heavy is expected to make its first flight – a demo – from Vandenberg Air Force Base, Calif., later this year or in 2015. Orbital Sciences' Antares has launched twice with good performance reviews.

and increased bandwidth could reduce the need for expensive onboard data processing. Broad relaxation of limits on power, in addition to mass, could further ease the challenge of inserting new technologies.

The cost-saving benefits could cascade from mass to power and thermal control and then to mission systems. The cumulative effect is likely to improve the benefits and decrease the costs of using modularized or standardized systems. Relaxed mass limits could make it easier to insert new technologies that have not yet been optimized to reduce their mass. The design space for spacecraft will expand in many dimensions. Adding more expensive design features could still be considered as a final step, budgets permitting, but only after the sum of the earlier efforts has defined a new cost floor.

EXPANDED SYSTEMS ENGINEERING OPTIONS

The new engineering paradigm created by these cost-saving opportunities will create two tradeoff domains with very different dynamics. A "tight-mass-limit" domain will continue for smaller spacecraft, which will still benefit from traditional mass-control practices in order to use small launchers. A "relaxed-mass-limit" domain will be appropriate for many larger payloads, which will be able to pursue aggressive cost reduction strategies. For future super-heavy missions, such as NASA human missions to the moon or Mars, the tight-mass-limit paradigm may again be appropriate. Many spacecraft engineering organizations will need to develop an ability to toggle back and forth between the two paradigms. Aerospace engineers will need to develop and maintain an ability to operate in either paradigm.

In addition, the trend toward lower-mass and lower-power engineering in the broad global marketplace will continue. Aerospace engineering can and should continue to benefit from engineering investments made by others, especially if low mass and power consumption in one part of a design supports the relaxed-mass-limit paradigm in others.

CULTURAL CHALLENGES

Seizing this opportunity will go against one of the central traditions of our aerospace engineering culture. Most aerospace engineers have been trained by their education and career experience to optimize mass as a matter of course. As a result, they may find the new paradigm counter-intuitive. Some engineers may resist low-cost low-tech designs simply because they are not high-tech and therefore not interesting.

This reaction will be compounded wherever engineering practice focuses exclusively on requirements without consideration of opportunities. All established requirements are predicated on often unspoken assumptions about what is possible and will therefore tend to be unresponsive to opportunities created by changing circumstances. In addition, the aerospace industry has a bad habit of accepting large cost risks and tolerating cost overruns. This habit will be hard to break even with the best intentions. Some in the aerospace industry do not believe that significant cost reductions are possible without compromising performance or reliability, and will therefore refuse to make the attempt.

There will be practical limits and challenges in addition to cultural resistance. Some companies will have lost the skills or facilities needed to implement lower-tech solutions. It may be necessary to go beyond the aerospace vendor community to find needed capabilities. In some cases, the cost of engineering a new design will be greater than the potential savings in manufacturing costs. Volume constraints may replace mass constraints for some spacecraft.

Processes for managing a cost-reduction strategy that is independent of mass constraints may have to be developed. In particular, many engineering organizations may not have the ability to do the type of cost tradeoff analysis needed to take advantage of opportunities in an expanded trade space. Most of all, new paradigms always suffer from start-up errors as some people learn how to apply them while others resist or fumble the change.

The cost models employed by cost estimators will require major modifications and expansions. Many mass-based cost estimating relationships will become obsolete under the new paradigm and will need to be re-estimated or replaced. The cost per pound for some components will reverse their historical upward trends and drop suddenly to much lower levels. Cost estimators may end up needing either a separate set of methods for each paradigm or substantially different methods that are flexible enough to cover both.

Systems engineering and integration is likely to be more challenging under the new paradigm. As the new paradigm is accepted, some may be tempted to relax or abandon engineering discipline. In fact, adopting the new paradigm will require more discipline, especially to resist the temptation to fill higher mass limits with costly new features.

As the engineering trade space grows and adds new dimensions, it will also grow more complex. The risk of design errors early in the design phase may increase. Choosing the wrong paradigm at the beginning of a program could have significant negative consequences. Rigorous systems engineering at the beginning of every program will therefore be essential.

The reward for getting the design paradigm right from the beginning is likely to be achieving the required performance at greatly reduced cost. Minimizing the cost of spacecraft structures and utilities could create budgetary space for insertion of new technologies or improvement of current technologies. If the new paradigm also enables more standardized core systems and interfaces, it could also allow for insertion of new technologies later in the design process. All of these should have high value to spacecraft buyers who are facing unprecedented budget constraints.

One way to get early indications of the nature and extent of the relaxed-mass-limit paradigm would be to use it as a source of student projects in universities. Students could be challenged to look at trade study scenarios and articulate which choices in each scenario would provide the greater advantage and why. The following scenarios present two possible trades:

- A near-5,500 kg spacecraft can fly on an Antares with savings in launch costs and a tight mass margin, or fly on a Falcon 9 with more than 100 percent mass margin and save on spacecraft costs.
- An 8,000-kg spacecraft can fly on a Falcon 9 and save money by using the 5,000-kg mass margin or cut launch costs by taking on a secondary payload.

In each case, which choice provides greater advantages?

SUPPORTING DEVELOPMENTS

Pioneering efforts to explore the relaxed-mass-limit paradigm will have great value to the aerospace industry. There is an immediate need for studies to explore the structure and dynamics of the new paradigm. Case studies could be conducted on experiences of spacecraft design programs that launched spacecraft on vehicles much larger than they needed or that were forced to spend large sums to meet artificially low mass limits. Analytic studies should be conducted to support any new spacecraft development that might benefit from the new paradigm. Opportunities may also be found to test the new paradigm on a smaller scale by significantly relaxing mass limits on only a subset of a spacecraft's systems.

TASC is exploring the relaxed-mass-limit paradigm with a view toward providing systems engineering frameworks to help spacecraft developers exploit the new paradigm while avoiding the inevitable pitfalls. In particular, TASC is studying what modifications and expansions current cost estimating methods will need to remain relevant to the new engineering practices that will develop out of the relaxed-mass-limit paradigm and other major innovations.

Efforts to exploit these opportunities demand that a new set of cost/performance relationships be developed as part of a cost analysis that is directed not just at cost assessment, but actively at cost reduction.

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Tanker drama

The Air Force is anxious to start flying new tankers to refuel U.S. and allied warplanes on the way to distant operational theaters, a capability more critical than ever given the military's pivot to the vast Asia-Pacific region.

Boeing seemed on track to develop and deliver a fleet of KC-46A Pegasus tankers derived from the company's twin-engine 767. Now, though, the tanker program's pace and preparedness are being questioned by the Defense Operational Testing and Evaluation office. In a report issued at the end of January, evaluators concluded there is a "high risk" that the planes won't be ready to begin a series of initial operational test and evaluation flights in May 2016 as scheduled. The planes must pass those tests for prime contractor Boeing to put production into high gear. A delay woud likely add to development and production costs. For their parts, the Air Force and Boeing insist the program remains on track to meet the current schedule. The competing judgments set the stage for a dramatic 18 months of development work at a time when the Air Force's budget can ill afford overruns.

Global reach, global power

KC-135 tankers have served the Air Force well — many of them since the Eisenhower era. The first jet-powered tanker, the KC-135 was an offshoot of Boeing's 707 commercial transport, and was designed to refuel U.S. bombers on Cold War strategic missions. The tanker has done that and a lot more, gassing up the bombers, fighters and other combat aircraft of the Air Force, Navy, Marine Corps and allied air forces. The newer, larger Air Force tankers, the KC-10s, began flying more than 30 years ago.

The combined capability of the two tankers gave rise to the Air Force's "global reach, global power" maxim in the early1990s. But the fleet is showing its age, and has been for some time. A study released in 2000 by the Government Accounting Office, now the Government Accountability Office, pointed to shortfalls in air refueling prowess, citing the increasing maintenance needs of the two tankers and

Boeing

Time to fly: The KC-46A, shown in an artist's rendering, could fly for the first time in June.

the shortage of spare parts for each. Those maintenance costs have become altogether too high, the Air Force says.

Replacement plan

Three years ago, the Air Force chose Boeing to develop the KC-46A to replace nearly half of its more than 400 Boeing KC-135s. Later this year the service is expected to issue a revised figure for the development program's cost, earlier estimated at $5.7 billion. The plan is to acquire 179 KC-46A tankers from 2015 to 2028. Low-rate initial production is scheduled to begin with seven airplanes in fiscal 2015 and 12 the following year. Full-scale production would follow at a rate of 15 tankers a year until the program ends. Boeing says it will be able to step up production to accommodate any foreign customers.

In a speech to the Air Force Association in September, Maj. Gen. John Thompson, the service's tanker program executive officer, called the KC-46A "the Air Force's number-one modernization program." He said he was "very pleased with its progress" and expressed high confidence in its success. He also noted that "no engineering changes to date" had been required in the plane's development process, and he predicted that Boeing will deliver the first 18 KC-46As by 2017, as specified in the Air Force contract.

Challenge and response

Then, out of the blue, the Pentagon evaluators demurred. Their January 29 report warned of a possible six to 12 month delay in the start of initial operational test and evaluation flights.

The report said the ALR-69A radar warning receiver, built by Raytheon, "has shortfalls that require resolution prior to integration on the KC-46A." Operational testing aboard a C-130H aircraft demonstrated that the ALR-69A "was not effective due to integration and performance problems," said the document. It acknowledged that Boeing and Raytheon have modified the warning receiver's software and hardware, including antennas and wingtip inertia units, but said the improvements "have yet to be proven in testing."

By James W. Canan

Raytheon declined to comment on the Pentagon report, referring questions to Boeing and the Air Force. They predict that the radar warning receiver will pass muster as a result of modifications already made. Spokesman Ed Gulick, in an Air Force statement issued in response to the Pentagon report, called the aircraft's testing schedule "aggressive but achievable" and said it "remains intact," with initial operational testing and evaluation scheduled for May 2016.

"The Air Force believes the [radar receiver's] performance issues have been corrected with a software change," said Gulick. "The radar warning receiver issues" referenced in the January report "are not expected to affect KC-46 performance and effectiveness," he said.

The tanker program office says there is a 90 percent probability that Boeing will be able to meet its contractual requirement to deliver 18 tankers by August 2017, according to the Air Force statement.

Boeing said it is optimistic too: "We remain confident in our plan to support initial test and evaluation for the KC-46A tanker and we continue to meet our contractual requirements," said spokesman Jerry Drelling. "Our current assessment confirms that we have a valid flight test plan in place, and that we remain on plan to deliver the first 18 combat-ready tankers to the U.S. Air Force" on schedule.

Radar's critical role

The stakes are huge for Boeing and the Air Force because the radar warning receivers are closely tied to the concept of operations for the new fleet. The KC-46A Pegasus will be the first Air Force tanker designed to operate in contested airspace over hostile territory, and the first to have a radar-warning receiver and electronic countermeasures to avoid or fend off missile attacks.

The tanker's radar warning receiver, the ALR-69A.

Raytheon

Raytheon says the ALR-69A's "cutting edge digital radar warning receiver technology" allows for "accurate, timely detection of unseen threats" and was selected by Boeing to improve situational awareness and survivability for aircrews. It will be used initially by the Air Force AC/MC C-130 airlifter and F-16 fighter, says Raytheon.

The ALR-69A is designed to improve on the ALR-69 — the Air Force's primary radar warning receiver — in areas including "detection range and time, accuracy of threat identification, location of threat emitter systems, performance in a dense signal environment, and reliability and maintainability," according to the Pentagon evaluators' report from the previous year, issued in December 2012. Core components include the radar receivers, countermeasures signal processor, control indicator and azimuth indicator, the 2012 report said.

Checkered past

Air Force and Boeing officials reject any notion that the current program's issues may be linked to the fits and starts that occurred in their tanker acquisition attempts of the recent past. But the prolonged competition for the new tanker contract was an erratic and often rancorous process.

Eleven years ago, the Air Force made a leasing agreement with Boeing to acquire 767s reconfigured as air-refueling tankers. That arrangement was killed a year later amid a procurement scandal. The Air Force later tapped Boeing and the transatlantic partnership of Northrop Grumman and the Airbus segment of EADS to compete for a new tanker development contract.

Airbus was victorious with a variant of its A330 airliner, but Robert Gates, then secretary of defense, nullified the award after the auditing arm of Congress found the competition flawed. The Air Force then redefined the tanker's performance and price requirements, reopened the competition in 2009, and in 2011 chose Boeing over EADS, with Northrop Grumman having dropped out.

Many missions

The Air Force has a lot riding on the KC-46A. Its day-and-night, all-weather refueling flights will aid six primary missions — nuclear operations, global strike, air bridging operations, long-haul aircraft deployments, combat theater support and special operations.

Secondary missions will include airlift,

The KC-46A tanker will be about 20 percent larger than the KC-135 top, and about 20 percent smaller than the KC-10.

Boeing

aeromedical evacuation, air sampling, emergency aerial refueling and combat search and rescue. New equipment will enable the tanker to operate in a hostile chemical or biological environment and to serve as a communications node and gateway for network-centric air combat operations.

As of now, the KC-46A program seems well insulated from future budget drawdowns. Air Force Chief of Staff Gen. Mark Welsh and other Air Force leaders have called it one of their top priorities and have walled off its current and projected funding.

For testing and evaluation, Boeing is building four engineering and manufacturing development aircraft — derivatives of the company's 767 airliner. Flights of the first one, scheduled for the middle of this year, will seek to show the aircraft can meet basic requirements such as reaching maximum altitude and taking off and landing within prescribed distances. The first and third test aircraft, each designated 767 2C, will be modified incrementally to become full-fledged tankers as the testing proceeds.

The Air Force and Boeing plan to produce 179 KC-46s by 2027 to start the process of replacing the KC-135.

A closer look

The KC-46A will be about 20 percent larger than the KC-135 and about 20 percent

The tanker's digital cockpit design draws heavily on that of Boeing's 787 Dreamliner.

Boeing

smaller than the KC-10. Powered by Pratt & Whitney engines, the new tanker would be able to transport 212,000 pounds of fuel and 65,000 pounds of palletized cargo. The tanker would also conduct aeromedical evacuation of wounded troops. Thompson noted in his September speech that it could take "about three times as many standard cargo pallets as the KC-135, about two times the passengers, and more than double the number of [medical] patients on litters."

Boeing

Efficiency drive: Boeing will build the KC-46A tanker on the 767 production line at Everett, Wash.

The KC-46A would be able to refuel more than one aircraft at a time by means of a central fuselage boom and drogue-probe systems on both wings. The design also provides an air-refueling receptacle that would allow the plane to be refueled by other tankers.

The tanker's digital cockpit design draws heavily on that of Boeing's 787 Dreamliner. "We are taking much of the glass from the 787," Thompson said. He emphasized, however, that the KC-46A electrical system and batteries will be akin to those in the Boeing 767, not the 787. The tanker's batteries will be nickel cadmium—not the lithium ion kind that initially caused problems in the Dreamliner—and its electrical system will be "completely different," said Thompson.

The January report portrayed the KC-46A as susceptible to fires flaring up in emptied fuel bays. A fire suppression system "was not considered in the design, even though it could have reduced KC-46A vulnerability more than cockpit armor against more operationally realistic threats," declared the report. The Air Force and Boeing did not comment on this, and both seem undaunted by the critique and upbeat in their outlook.

After visiting Boeing's KC-46A assembly plant in Everett, Wash., early this year, Gen. Welsh predicted that the first development model of the Pegasus "will be flying in June. It's a real thing now."

25 Years Ago, April 1989

April 2 The European Space Agency launches an Ariane 2 rocket carrying the TELE-X Nordic communications satellite into a temporary elliptical orbit. The spacecraft then boosts itself into a geosynchronous orbit 22,300 miles above the Earth. NASA, Astronautics and Aeronautics, 1986-1990, Page 211.

April 13 President George H.W. Bush appoints Adm. Richard Truly NASA administrator. A former astronaut and chief of the space shuttle program, Truly replaces outgoing administrator James C. Fletcher. NASA, Astronautics and Aeronautics, 1986-1990, Page 211.

50 Years Ago, April 1964

April 1 Japan's Institute of Space and Aeronautical Science is formally established at the University of Tokyo, where it has been developing solid-propellant Lambda sounding rockets. The group will change its name in 1980 to the Institute of Space and Astronautical Science. In 2003, it will merge with the National Aerospace Laboratory, formed in 1955, and with the National Space Development Agency — formed in 1969 — to become JAXA, the Japan Aerospace Exploration Agency. D. Baker, Spaceflight and Rocketry, Page 165; Japan, Space Program file, NASM.

April 8 A Titan 2 rocket launches the first unmanned Gemini spacecraft into orbit to test the craft's structural integrity. The rocket places the spacecraft in an orbit of 204 miles apogee and 99.6 miles perigee. Within a few days, as planned, the craft reenters the atmosphere and disintegrates. Aviation Week, April 13, 1964, Page 29; NASA Release 64-70.

April 8 The X-15 No. 1 rocket research aircraft, flown by Air Force Capt. Joe Engle, reaches a maximum speed of 3,477 mph — Mach 4.8 — and an altitude of over 33 mi. in a test to prepare for higher altitudes. On April 29, Air Force Maj. Robert Rushworth flies the same plane to a speed of 3,903 mph — Mach 5.72 — and an altitude of 102,000 ft. Washington Post, April 9, 1964, and April 30, 1964.

April 8 A model Gemini spacecraft is dropped from a Fairchild Stratos C-119 aircraft from above 10,000 feet over Trinity Bay near Houston, to test the parasail method of spacecraft recovery. The drogue chute opens, but the parasail fails to deploy properly after its nylon lines snap. Another test is completed on April 30, but ultimately NASA does not adopt this recovery system. Aviation Week, April 27, 1964, Page 32; Aviation Week, May 4, 1964, Page 27.

April 9 The 33rd and last research and development version of the Titan 2 intercontinental ballistic missile flies 5,000 miles from Cape Kennedy, Fla. The missile was chosen as the launcher for the Gemini program in January 1962. Aviation Week, April 20, 1964, Page 29.

April 9 TASS, the Soviet news agency, reports that a huge monument commemorating the world's first manned spaceflight will be built in Moscow. A bust of cosmonaut Yuri Gagarin, who made the flight in 1961, will be displayed on the monument's 80-foot-high pylon. On April 12 Cosmonautics Day is celebrated to mark the flight. New York Times, April 10, 1964, and April 13, 1964.

April 9 The de Havilland DHC-5 Buffalo short takeoff and landing transport makes its inaugural flight in Canada. F. Mason and M. Windrow, Know Aviation, Page 63.

April 13 NASA announces that astronauts Virgil Grissom and John Young are to pilot the nation's first two-man Project Gemini spacecraft. Aviation Week, April 20, 1964, Page 38.

April 14 An Atlas D rocket lifts NASA's 200-pound Project Fire spacecraft more than 500 miles into space from Cape Kennedy, Fla., to obtain data on reentry heating of spacecraft for future lunar missions. When the craft falls back to Earth propelled by an Antares 2 rocket motor, it reaches a reentry speed of 26,000 mph, said to be the highest speed ever attained by a man-made object in free flight. Washington Post, April 15, 1964.

April 16 The Telstar 2 satellite carries Japan's first TV transmission signals to Europe. The transmission is received in Pleumeur-Bodou, France, then redirected for Europe-wide viewing. Baltimore Sun, April 17, 1964.

April 17 Geraldine Mock becomes the first woman to fly around the world solo when she lands her Cessna 180 at Columbus, Ohio, after a round trip of 29 days, 11 hours and 59 minutes, with 21 stopovers. The flight covered nearly 22,860 miles. National Aeronautics Association release; Jerrie Mock file, National Air and Space Museum.

April 19 A Soviet 25-passenger single-rotor V-8 helicopter covers a distance of

Past

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

1,530 miles in 12 hours, 3 minutes and 34 seconds, a new world record for nonstop helicopter flights. Washington Evening Star, April 20, 1964.

April 22 The World's Fair opens in New York City. Exhibited at its U.S. Space Park are full-scale mockups of the X-15, the Saturn 5 first stage, and the Gemini-Titan, Mercury-Atlas and Delta launchers. Goddard News, April 5, 1964, Page 3.

April 29 At Kansas City, Mo., TWA takes delivery of its first Boeing 727 mid-size narrowbody three-engine jet aircraft, which can carry up to 189 passengers. Following pilot training, it will serve the New York-to-Indianapolis route. Aviation Week, May 18, 1964, Page 42.

75 Years Ago, April 1939

April 1 The Imperial Japanese Navy's prototype Mitsubishi A6M1 monoplane fighter makes its first flight at Kagamigahara, Japan. The plane, designated the Zero, becomes one of Japan's best known aircraft. During World War II it receives the Allied code name Zeke. R. Francillon, Japanese Aircraft of the Pacific War, Page 364.

April 4 Great Britain launches its newest and largest aircraft carrier, the HMS Illustrious. The ship displaces 23,000 tons, is 753 feet long and accommodates about 70 airplanes. It is the first of six carriers in its class. Flight, April 13, 1939, Page 375; Interavia, April 11, 1939, Page 12.

April 4 Several hundred men in the Rolls-Royce aero engines plant at Crewe, England, go on strike because women laborers are hired to operate machines. Interavia, April 11, 1939, page 10.

April 14 The U.S. air transportation industry's first strike takes place when Eastern Air Lines mechanics stop work for wage increases and union recognition. Interavia, April 18, 1939, Page 6.

April 15 United Air Lines announces that it will soon offer round-the-world air service. The round trip will take 14 days and cover 14,300 miles, with overnight stops at about a dozen points. A ticket will cost about $1,785. Interavia, April 28, 1939, Page 8.

April 16 The Boeing 314 flying boat Yankee Clipper returns to Baltimore after its shakedown cruise across the North Atlantic and back, having covered 11,060 miles at an average speed of 133 mph. The trip began at Baltimore on March 26. The fare for single crossings of the Atlantic will be between $400 and $500. Interavia, April 18, 1939, p. 5.

April 17 British Airways extends its London-Berlin service to Warsaw and Budapest. The daily service uses Lockheed 14s. The London-Warsaw link is significant because Poland and England have come close to an agreement on the defense of Poland. Flight, April 20, 1939, Page 399; Flight, May 4, 1939, Pages 447-448.

April 18 The War Department calls Col. Charles Lindbergh into active duty and assigns him to the Office of Maj. Gen. Henry Arnold, chief of the Air Corps. Arnold orders him to make a survey of all the weak points in the rearmament and training of this branch. Interavia, April 21, 1939, Page 4.

April 20-21 Experiments with a four-bladed controllable propeller mounted on a Curtiss P-36 begin at Wright Field, Ohio. E. Emme, Aeronautics and Astronautics 1915-60, p. 37.

100 Years Ago, April 1914

April 20 The second competition for the Schneider Trophy takes place at Monaco. The winner is Great Britain's Howard Pixton, who flies his Sopwith Tabloid floatplane 86.78 mph. Although little noted in the press at the time, in the 1920s the yearly contest will become the preeminent air race series, where new aircraft designs, engines and fuels are pioneered and tested. D. James, Schneider Trophy Aircraft, 1913-1931, p. 4.

THE UNIVERSITY OF MISSISSIPPI

NCPA

JAMIE L. WHITTEN • NATIONAL CENTER FOR PHYSICAL ACOUSTICS

The University of Mississippi's National Center for Physical Acoustics (NCPA) is seeking a Research Scientist that will assume a leadership role as a Principal Investigator within the Aeroacoustics Research Group (http://www.olemiss.edu/depts/aeroacoustics/) and team with the other researchers to grow and broaden the aeroacoustics research activities at The University of Mississippi.

The candidate will utilize modern testing techniques to measure and characterize turbulent flows and their interaction with acoustics. The candidate shall also support the continued development of aeroacoustics research infrastructure at the NCPA and teach and mentor students in the University's Graduate Program in Aeroacoustics. The candidate will be expected to develop and sustain outside funding for research efforts commensurate with their expertise and mentor graduate students on related research projects.

The position requires an earned PhD in Aerospace, Mechanical Engineering, Engineering Science, Applied Physics, or a closely related field. Three years experimental research experience in the field of Acoustics, Aeroacoustic, Turbulence, Fluid/Structure Interaction or an allied field is required.

The selected candidate must be eligible for U.S. Security Clearance.

Apply online at jobs.olemiss.edu. The University of Mississippi provides equal opportunity in education and employment for all qualified persons without regard to race, color, religion, national origin, sex, age, sexual orientation, genetic information, physical or mental disability, or veteran status.

THE AIAA SUGGESTION PROGRAM

AIAA welcomes suggestions from members on how we can better serve you. All comments will be acknowledged. We will do our best to address issues that are important to our membership. Please send your comments to:

Merri Sanchez
VP Member Services
AIAA
1801 Alexander Bell Drive
Suite 500
Reston, VA 20191-4344

AIAA

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Assistant Professor (Tenure Track) of Fluid Dynamics

The Department of Mechanical and Process Engineering (www.mavt.ethz.ch) at ETH Zurich invites applications for a tenure-track assistant professorship in Fluid Dynamics with a focus on experimental aspects.

The successful candidate should have an outstanding record of accomplishments (research and teaching) in experimental fluid dynamics and show clear potential that he/she can establish an exceptional research program with a significant experimental component in this field. Topical areas may range from micro-scales (micro-fluid dynamics, molecular fluid-surface interactions) to macro-systems (environmental and industrial flow problems) and broader engineering applications such as energy-related issues, with a strong link to fundamentals.

Teaching duties include the participation in both introductory and advanced courses in fluid dynamics both for students in Mechanical and Process Engineering and other non-engineering disciplines at the Bachelor level (in German or English) and Master level (in English). Apart from a PhD degree in Mechanical Engineering or a closely related discipline, the successful candidate should have demonstrated the capability to work on interdisciplinary projects and to co-operate with professionals from other fields. Furthermore, the willingness and ability to interact with colleagues inside and outside of ETH Zurich is a prerequisite.

This assistant professorship has been established to promote the careers of younger scientists. The initial appointment is for four years with the possibility of renewal for an additional two-year period and promotion to a permanent position.

Please apply online at www.facultyaffairs.ethz.ch

Applications should include a curriculum vitae, a list of publications, and a statement of your future research and teaching interests. The letter of application should be addressed t**o the President of ETH Zurich, Prof. Dr. Ralph Eichler. The closing date for applications is 15 May 2014**. ETH Zurich is an equal opportunity and family friendly employer and is further responsive to the needs of dual career couples. In order to increase the number of women in leading academic positions, we specifically encourage women to apply.

AIAA Bulletin

At Congressional Visits Day on 12 March, Team Kansas gathered in the Hart Senate Office Building lobby. AIAA's Congressional Visits Day program brings over a hundred aerospace engineers and scientists to Washington, DC, each year for a day of meetings and advocacy on behalf of aerospace engineering and science with lawmakers on Capitol Hill. See the key issues that were discussed on pages **B14–B17**.

APRIL 2014

AIAA Directory

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

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

Other Important Numbers: ***Aerospace America*** / Greg Wilson, ext. **7596*** • ***AIAA Bulletin*** / Christine Williams, ext. **7500*** • **AIAA Foundation** / Karen Thomas, ext. **7520*** • **Book Sales** / **800.682.AIAA** or **703.661.1595**, Dept. 415 • **Corporate Members** / Merrie Scott, ext. **7530*** • **International Affairs** / Betty Guillie, ext. **7573***; Emily Springer, ext. **7533*** • **Editorial, Books and Journals** / Heather Brennan, ext. **7568*** • **Honors and Awards** / Carol Stewart, ext. **7623*** • **Journal Subscriptions, Member** / **800.639.AIAA** • **Exhibits / Journal Subscriptions, Institutional / Online Archive Subscriptions** / Michele Dominiak, ext. **7531*** • **Continuing Education** / Chris Brown, ext. **7504*** • **Public Policy** / Steve Howell, ext. **7625*** • **Section Activities** / Chris Jessee, ext. **3848*** • **Standards, Domestic** / Amy Barrett, ext. **7546*** • **Standards, International** / Nick Tongson, ext. **7515*** • **Student Programs** / Stephen Brock, ext. **7536*** • **Technical Committees** / Betty Guillie, ext. **7573***

* Also accessible via Internet. Use the formula first name last initial@aiaa.org. Example: megans@aiaa.org.
† U.S. only. International callers should use 703/264-7500.

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

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

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2014			
15–16 Apr	**NASA MaterialsLAB Workshop**	Arlington, VA (Contact: D. Griffin, dennis.e.griffin@nasa.gov, http://www.cvent.com/events/nasa-materials-lab-workshop/event-summary-f0ee4d29123a453b94c511ab660b81fa.aspx	
29 Apr	**2014 AIAA Fellows Dinner 2014**	Crystal City, VA (http://www.aiaa.org/FellowsDinner2014/)	
30 Apr	**2014 Aerospace Spotlight Awards Gala**	Washington, DC	
5–9 May	**SpaceOps 2014: 13th International Conference on Space Operations**	Pasadena, CA	**5 Aug 13**
14–19 May†	**International Space Development Conference (ISDC)**	Los Angeles, CA (Contact: 202.429.1600, pat.montoure@nss.org, http://isdc.nss.org/2014)	
26–28 May	**21st St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia (Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru)	
26–29 May†	**6th International Conference on Research in Air Transportation (ICRAT 2014)**	Istanbul, Turkey (Contact: Andres Zellweger, 301.330.5514, dres.z@comcast.net, http://www.icrat.org/	
2–4 Jun†	**Global Space Applications Conference**	Paris, France (Contact: Lisa Antoniadis, +33 1 45 67 68 46, lisa.antoniadis@iafastro.org)	
5 Jun	**Aerospace Today ... and Tomorrow: An Executive Symposium**	Williamsburg, VA	
14–15 Jun	**Third AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III)**	Atlanta, GA	
14–15 Jun	**Business Management for Engineers**	Atlanta, GA	
14–15 Jun	**Optimal Design in Multidisciplinary Systems**	Atlanta, GA	
16–20 Jun	**AIAA AVIATION 2014** **(AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **20th AIAA/CEAS Aeroacoustics Conference** **30th AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **AIAA/3AF Aircraft Noise and Emissions Reduction Symposium** **32nd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **6th AIAA Atmospheric and Space Environments Conference** **14th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Flight Testing Conference** **7th AIAA Flow Control Conference** **44th AIAA Fluid Dynamics Conference** **19th AIAA International Space Planes and Hypersonic Systems and Technologies Conference** **11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference** **21st AIAA Lighter-Than-Air Systems Technology Conference** **15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **45th AIAA Plasmadynamics and Lasers Conference** **7th AIAA Theoretical Fluid Mechanics Conference**	Atlanta, GA	**14 Nov 13**
22–27 Jun†	**12th International Probabilistic Safety Assessment and Management Conference**	Honolulu, HI (Contact: Todd Paulos, 949.809.8283, secretariat@psam12.org, www.psam12.org)	
13–17 Jul†	**International Conference on Environmental Systems**	Tucson, AZ (Contact: Andrew Jackson, 806.742.2801 x230, Andrew.jackson@ttu.edu, http://www.depts.ttu.edu/ceweb/ices/)	
15–18 Jul†	**ICNPAA 2014 – Mathematical Problems in Engineering, Aerospace and Sciences**	Narvik University, Norway (Contact: Seenith Sivasundaram, 386.761.9829, seenithi@aol.com, www.icnpaa.com)	
28–30 Jul	**AIAA Propulsion and Energy 2014** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference** **12th International Energy Conversion Engineering Conference**	Cleveland, OH	**14 Jan 14**
31 Jul–1 Aug	**2nd AIAA Propulsion Aerodynamics Workshop**	Cleveland, OH	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
31 Jul–1 Aug	**Hybrid Rocket Propulsion**	Cleveland, OH	
31 Jul–1 Aug	**Missile Propulsion Design, Technologies, and System Engineering**	Cleveland, OH	
31 Jul–1 Aug	**Application of Green Propulsion for Future Space**	Cleveland, OH	
2–10 Aug†	**40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events**	Moscow, Russia http://cospar2014moscow.com/	**14 Feb 14**
3–4 Aug	**Decision Analysis**	San Diego, CA	
4–7 Aug	**AIAA SPACE 2014 (AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA/AAS Astrodynamics Specialist Conference** **AIAA Complex Aerospace Systems Exchange** **32nd AIAA International Communications Satellite Systems Conference** **AIAA SPACE Conference**	San Diego, CA	**21 Jan 14**
7–12 Sept†	**29th Congress of the International Council of the Aeronautical Sciences (ICAS)**	St. Petersburg, Russia (Contact: www.icas2014.com)	**15 Jul 13**
29 Sep–3 Oct†	**65th International Astronautical Congress**	Toronto, Canada (Contact: http://www.iac2014.org/)	
3–6 Nov†	**28th Space Simulation Conference**	Baltimore, MD (Contact: Andrew Webb, 443.778.5115, Andrew.webb@jhuapl.edu, http://spacesimcon.org/)	
2015			
5–9 Jan	**AIAA SciTech 2015 (AIAA Science and Technology Forum and Exposition 2015)** **Featuring:** **23rd AIAA/ASME/AHS Adaptive Structures Conference** **53rd AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Infotech@Aerospace Conference** **AIAA Spacecraft Structures Conference (formerly the AIAA Gossamer Systems Forum)** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **17th AIAA Non-Deterministic Approaches Conference** **56th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **8th Symposium on Space Resource Utilization** **33rd ASME Wind Energy Symposium**	Kissimmee, FL	
7–14 Mar†	**2015 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
25–27 Mar†	**3rd Int. Conference on Buckling and Postbuckling Behaviour of Composite Laminated Shell Structures with DESICOS Workshop**	Braunschweig, Germany (Contact: Richard Degenhardt, +49 531 295 3059, Richard.degenhardt@dlr.de, www.desicos.eu	
30 Mar–2 Apr	**23rd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar**	Daytona Beach, FL	**30 Sep 14**
25–27 May†	**22nd St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia, (Contact: Prof. V. G. Peshekhonov, 7 812 238 8210, icins@eprib.ru, www. Elektropribor.spb.ru)	
22–26 Jun	**AIAA AVIATION 2015 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **21st AIAA/CEAS Aeroacoustics Conference** **31st AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **33rd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **7th AIAA Atmospheric and Space Environments Conference** **15th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference**	Dallas, TX	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
	45th AIAA Fluid Dynamics Conference **22nd AIAA Lighter-Than-Air Systems Technology Conference** **16th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **46th AIAA Plasmadynamics and Lasers Conference** **8th AIAA Theoretical Fluid Mechanics Conference** **45th AIAA Thermophysics Conference**		
27–29 Jul	**AIAA Propulsion and Energy 2015** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **51st AIAA/ASME/SAE/ASEE Joint Propulsion Conference** **13th International Energy Conversion Engineering Conference**	Orlando, FL	
31 Aug–2 Sep	**AIAA SPACE 2015** **(AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA SPACE Conference**	Pasadena, CA	

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

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

AIAA Continuing Education courses.

From the Corner Office

ENDINGS AND BEGINNINGS

Michael Griffin, AIAA President

Last month, Klaus used this space to talk about "timely endings," referring to his pending retirement after many years of service on the AIAA staff, which itself followed a long prior career in industry during which he always found time for service to AIAA in many different volunteer roles. I am very pleased to be able to use a few column-inches of my own Corner Office space to thank Klaus publicly for his contributions to our Institute; very few have done more to support and advance AIAA and the aerospace profession. Thank you, Klaus!

My own friendship with Klaus goes back to 1978 when, as a fresh young supervisor of the Control Systems Design Group at NASA-JPL, I was accepted for membership on the Guidance & Control Technical Committee. I was 29 years old, and somewhat young for the role even then, when we had plenty of young members; attracting and keeping them was not a concern that anyone in that era's AIAA leadership then envisioned. By accepting my application for membership on his TC, Klaus enabled my first formal involvement in Institute affairs. This led directly to membership on two successor Technical Committees, chairmanship of more technical conference panels than I can possibly remember, the General Chairmanship of our first AIAA Space Systems Conference, two terms on the Honors & Awards Committee, two terms as Director-at-Large, two terms as President-Elect, and then to the first two-year term as President. It has been my pleasure and my goal to do the very best I could for our Institute in any role that I have held, but I frankly doubt that any of it would have happened if, 36 years ago, Klaus had been unwilling to bring an untried young member onto his TC. Thank you again, Klaus.

As Klaus is retiring, so too comes my own "timely ending." At this year's AIAA Awards Gala, I will be stepping down from my term as AIAA president, and Jim Albaugh will begin his term. Jim's record of accomplishment in our industry and service to AIAA is so well known to most of you that I need say little more about him, other than to recall how pleased I was when he accepted the invitation of our Nominations Committee to run for President. I look forward to helping him in any way that I can during my new two-year term as "past President," quite likely the last formal role I will ever fill within AIAA.

But enough of endings; in this final column I would like to return to the beginning of which I wrote about, when a young member was accepted for full-fledged participation on an AIAA TC, and the consequences that followed. Those of you who have heard me speak, or who have troubled to labor through what I have written, over the last three years cannot be in doubt about where I think the primary focus of our Institute must be as we go forward: attracting and retaining the young members of today's aerospace profession. And in what may be a verbal paradox, but must not become an intellectual paradox, to succeed in that goal we must focus on breadth. We must appear to be, and must actually be, an attractive home for today's aerospace professional, not just that subset of our profession that looks like it did when I joined AIAA in 1974. This, I think, is the crucial issue that we must address if we are to remain "the" American Institute of Aeronautics and Astronautics.

What were we like, and what was our profession like, back in 1974? Well, first, we were young, or if not actually young, then we were not all that old. The average aerospace professional then was in his (and, of course, emphatically "his") early or mid-thirties. Even our leaders, people like Benny Schriever, George Mueller, Chris Kraft, Bob Gilruth, or Wernher von Braun, who even then held legendary stature in our profession, were in their fifties or early sixties. Second, and even more importantly as it relates to AIAA, we were a pretty narrowly channeled group as it appears to me in hindsight. By and large, if we worked in space we were either Cold Warriors or we worked on NASA programs. Quite a few of us had feet in both camps at different periods in our careers. Or, if we worked in aeronautics, then it was either military airplanes or civil air transport, and again many of us did both at one time or another.

But while one set of actors quite often performed in secrecy and the other played on some of the most visible stages of our time, we had in common that we worked for critically important government agencies and laboratories, or for critically important companies that did the work commanded by those agencies. What we did mattered to the nation by the only standard that passes the test of time—money. Despite the fact that the 1970s were years of reduced budgets relative to the 1960s or 1980s, for most of us our formative years were a time in which a truly enormous amount of public monies were spent on what we did.

AIAA inexorably reflected this environment. If we had among our members and leaders those who worked in or led the important agencies and industrial entities of the Apollo and Cold War eras, and we did, then we had everyone who mattered. AIAA's membership largely included those who shaped the course of the aerospace profession of their time, at a critical time.

Not so today. I have written previously about the more diverse nature of the aerospace profession and its professionals today than in decades past, and will not repeat those observations here. I think it is obvious to most of us that no longer is our profession populated almost exclusively by middle-aged white males, no longer do we work so exclusively on government programs, no longer are all of our significant competitors to be found solely within our national borders, and, most significant of all—no longer are we as important in the national scheme of things as we once were.

Given all of this, the question for AIAA that remains unanswered as I leave office is this: what are we going to do about it? How are we going to change so that membership in AIAA, and participation in Institute activities, remains just as attractive to a young woman today who is working in commercial space or on an unmanned aerial system, and to the young entrepreneurs who run those companies, as it was to the Apollo veterans and Cold Warriors of forty years ago?

ANNUAL BUSINESS MEETING NOTICE

Notice is hereby given that the Annual Business Meeting of the American Institute of Aeronautics and Astronautics will be held at The Hyatt Regency Crystal City, Arlington, VA, on Thursday, 1 May 2014, at 12:00 PM.

William Seymore, AIAA Corporate Secretary/Treasurer

ARCS® FOUNDATION TO HONOR DR. WANDA AUSTIN

Dr. Wanda M Austin, President and CEO of The Aerospace Corporation, has been named the 2014 Eagle Award recipient by the Achievement Rewards for College Scientists Foundation (ARCS), Metropolitan Washington Chapter (MWC). The Eagle Award is presented to individuals who, through their personal and professional activities, have provided significant contributions to the advancement of STEM achievements. Dr. Austin will be recognized by the ARCS Chapter on 7 May 2014, at the "Promoting Partnerships to Advance Science in America" evening event in Washington DC.

With more than 25 years of experience in the aerospace industry, Dr. Austin has led The Aerospace Corporation since 2008. Prior to assuming the position as Chief Executive Officer, Dr. Austin was Senior Vice President, National Systems Group. She has also served as the company's Senior Vice President, Engineering and Technology Group.

Throughout her career, Dr. Austin has been committed to STEM education and to inspiring the next generation of scientists and engineers. She is a prior member of ARCS/MWC, and remains a champion of the ARCS Foundation mission. Through her leadership, Aerospace has undertaken a number of significant initiatives, including MathCounts, US FIRST Robotics, and Change the Equation.

Dr. Austin earned a B.A. in Mathematics from Franklin & Marshall College, master's degrees in Systems Engineering and Mathematics from the University of Pittsburgh, and a Ph.D. in Systems Engineering from the University of Southern California. She is an AIAA Fellow and a member of the Defense Science Board, the National Academy of Engineering, the International Academy of Astronautics, and the American Academy of Arts and Sciences. Over the course of her career, she has received awards and recognition from many organizations, including the National Intelligence Medallion for Meritorious Service and the National Reconnaissance Office Gold Medal.

CALL FOR NOMINATIONS

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

Aerospace Design Engineering Award recognizes design engineers who have made outstanding technical, educational, or creative achievements that exemplifies the quality and elements of design engineering. (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 recognizes outstanding technical and/or management contributions to aeronautical or astronautical software engineering. (Presented odd years)

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

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

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

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)

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

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

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

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

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

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

Mechanics and Control of Flight Award is 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 is presented for an outstanding contribution or contributions to aeronautical and astronautical literature in the relatively recent past.

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

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

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

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

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

RICHARD BATTIN SPECIAL ISSUE OF THE *JOURNAL OF GUIDANCE, CONTROL, AND DYNAMICS*

We were deeply saddened recently by the announcement that Dick Battin passed away on 8 February 2014. Besides being a giant in the field of astrodynamics and an idol and inspiration to many, Dick was a gentleman. In his hometown of Lexington, Massachusetts, he and his wife, Margery, were well known for their contributions to the community. Dick was best known for his books, *An Introduction to the Mathematics and Methods of Astrodynamics* (1999), *Random Processes in Automatic Control* (1956), and *Astronautical Guidance* (1964), and his leadership in the development of the Apollo onboard navigation and guidance system. His AIAA von Kármán lecture "Some Funny Things Happened on the Way to the Moon," which has been given all over the world, is memorable.

The *Journal of Guidance, Control, and Dynamics* (*JGCD*) has decided to honor Dick and his contributions by dedicating a section of a journal issue to him. This dedicated section will consist of papers on Astrodynamics, Space Navigation and Guidance, Optimal Estimation, and Celestial Mechanics. The Guest Editors for this section will be Terry Alfriend, Donald Fraser, John Junkins, and George Schmidt. Those wishing to have their papers considered for publication in this dedicated issue need to do the following:

1. Submit an abstract to the Guest Editors at the addresses below with a copy to the *JGCD* Editor-in-Chief, Prof. Ping Lu, by **1 May 2014**. Authors will be notified within two weeks of the deadline of the acceptability of their topic for the special issue. This does not mean publication approval.
2. Following approval of the topic, authors will submit their papers to *JGCD* using the standard procedure by **1 August 2014**. In the submission, notify the Editor-in-Chief that the paper is being submitted for the Battin special section, and also notify the Guest Editors that the submission has been made.
3. The papers will then go through the usual review process.
4. For those authors who already have a paper under review and wish to have it considered for publication in the special section, please send an abstract to the Guest Editors notifying them of this desire and also notify the Editor-in-Chief, Prof. Ping Lu. Even if the paper is acceptable for publication, the Editors will have to agree that it is appropriate for the Battin issue.

Ping Lu, Editor-in-Chief	plu@iastate.edu
Kyle T. Alfriend	Alfriend@tamu.edu
Donald Fraser	donaldfras@gmail.com
John L. Junkins	junkins@tamu.edu
George Schmidt	gtschmidt@alum.mit.edu

CLAYFIELD HONORED WITH 2014 SPERRY AWARD

Dr. Kimberley Clayfield was the 2014 recipient of the Lawrence Sperry Award. She received the award for "significant and sustained contributions to the development of the Australian aerospace sector through national public policy, scientific leadership, and education activities." Dr. Clayfield is the executive manager of Space Sciences and Technology at Australia's CSIRO (Commonwealth Scientific and Industrial Research Organization).

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

Can you give us a bit of background about yourself? What led you into engineering?

I was fascinated by space from a young age and, while I loved science fiction novels and movies and studying astronomy in school, I didn't really know how to transfer this interest into a career until I heard about mechanical engineering. It struck me as a very broad discipline with potential application to a great range of space-related activities, as well as many other interesting applications. I ended up completing both a Bachelor degree and a Ph.D. in mechanical engineering at the University of Adelaide in South Australia. My Ph.D. research was in the area of fluid mechanics and combustion, and one of the highlights of my time as a researcher included contributing to the testing of the combustion system for the Sydney 2000 Olympic Torch, the design of which was undertaken by my research group. However, my main interest was always in aerospace applications.

What led you to become involved in space science and public policy? Were there any influential people who helped guide you into this field and mentored you?

I became more interested in space-related policy and law when I began my Ph.D. studies, and joined a group of university students from around Australia in organizing the SpaceFutures 2000 conference. This was the first space conference to be held in Australia specifically for students and young professionals, and it opened my eyes to the important role policy, law and politics plays in achieving engineering goals—a technically brilliant solution is not sufficient in and of itself: to be successful, it must be implemented within a wider framework that includes policy and regulation considerations.

My interest really blossomed when I was selected as a delegate to the Space Generation Summit held in conjunction with the World Space Congress in 2002. A few years later I was fortunate to receive a scholarship to attend the International Space University's (ISU) Space Studies Program, where I chose to join the Space Policy and Law department; the freedom to choose to major in a discipline in which you have no previous expertise is what I consider to be one of the great opportunities offered by this program (although choosing Policy and Law is apparently a rarity for someone with an engineering background!). The academics leading that department (Dr. Ray Williamson, now of Secure World Foundation, and Prof. John Logsdon, emeritus professor and former Director of the Space Policy Institute at The George Washington University) were inspiring, and I absolutely loved the program; interestingly, I found that an engineering problem-solving approach is well suited to tackling policy issues.

At the conclusion of my Ph.D. program, and with the added experience of the ISU program, I joined the Australian Government's Department of Industry, which is responsible for civil space policy and the regulation of space activities (through the Space Licensing and Safety Office) in Australia. There I found the combination of my engineering background and my more generalist training from the International Space University to be an excellent foundation for policy work relating to a technical field.

On 2 December 2013, AIAA Sydney Section Chair, Dr Michael West, presented Dr Kimberley Clayfield with AIAA's Lawerence Sperry Award during an AIAA event in Canberra.

Can you tell us a bit more about your areas of research/work?

For the past five years I have been Executive Manager of Space Sciences and Technology within Australia's national research agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO). In this position I have a broad overview of CSIRO's space-related activities and interests, and a wide variety of responsibilities supporting CSIRO management, which is great—there is always something new and interesting to be involved in. My responsibilities include providing space-related advice to senior executives, supporting the coordination of Earth observation-related capabilities across the organization (including the recent initiation and establishment of a new million-dollar capability development platform), representing CSIRO's space interests in Australian government forums, representing CSIRO in the International Astronautical Federation, exploring potential new space research activities for the organization, and supporting national space education, outreach and industry development activities. A particular highlight has been contributing over a period of several years to the development of Australia's Satellite Utilisation Policy, our first national space policy, which was released in April 2013 (available from **www.space.gov.au**).

Do you have any advice for other young professionals in the aerospace field?

Don't underestimate the value of continuing professional development (including further study in areas like business, economics and law that will complement your engineering skills), active involvement in professional associations (like AIAA), and volunteer work. All of these elements have been integral to my career development thus far.

How do you keep busy outside of work and AIAA?

I am passionate about science education and outreach, and for the last 14 years I have been part of a team of science and education professionals who operate two annual space schools for high school students (the South Australian Space School and the National Space Camp) on a volunteer basis. These three-day residential programs are a wonderful way of inspiring school students to continue studying STEM subjects by engaging them through space applications.

What role has AIAA played in your career?

Involvement in AIAA has been fundamental to my career progress to date. I became a member in 1999, while I was still at university, and that year founded the University of Adelaide AIAA Student Branch; at the time, it was only the second Student Branch to be established outside of the USA. I have also served as the Chair of the AIAA Sydney Section, and as Deputy Director, Young Professionals for Region VII (International). Active involvement in AIAA has afforded me leadership opportunities, responsibilities, and experience that I may not otherwise have had the opportunity to take on through my regular jobs. It has also provided the opportunity to meet many professionals (local and international) with similar interests, both through Section activities and through AIAA conference attendance, and build my professional network.

I have always been, and continue to be, impressed by AIAA's support of its volunteer office bearers, who are responsible for providing many of the professional development and social engagement opportunities that members enjoy at both local (Branches/Sections) and national/international (national committees, technical conferences, etc.) levels. I have found it extremely rewarding to be actively involved in the operations of AIAA at these levels, and I would highly recommend it to other young professionals.

In my experience, AIAA membership can be a powerful tool in creating opportunities for professional development and building a successful career in the aerospace profession.

What is your perception of AIAA's engagement of younger members?

I have been proactively engaged with AIAA from my first year of membership throughout my time as a young professional, and I am testament to the fact that you don't need to be a senior member with many years of professional experience under your belt to be actively involved in and appreciated by the organization, including in leadership positions. Furthermore, there are many opportunities available for younger members to access support and recognition from AIAA (such as scholarships, awards, and grants), which can be of great benefit to the career development of students and young professionals.

Is there anything else you'd like to add?

It's an absolute honor and a privilege to have my contributions to the Australian space sector recognized by AIAA, and to join the Lawrence Sperry Award honor roll alongside inspiring luminaries like Gene Kranz, Sheila Widnall, David Thompson, and Robert Braun. Thank you!

SUMMARY OF THE JOINT STRIKE FIGHTER JAMBOREE

On 12 February, at the University of Florida REEF Auditorium, AIAA's Northwest Florida Section held "The Joint Strike Fighter Jamboree," an outreach, recruitment, and membership support event. Dr. Paul Bevilaqua, AIAA Distinguished Lecturer and inventor of the Joint Strike Fighter (JSF) STOVL system, gave a seminar on "Inventing the Joint Strike Fighter," which was followed by guided tours of the JSF.

Invitations were widely distributed to Florida State University (FSU) through their student chapter, scientists and engineers at Eglin AFB, local ASME members through the ASME chapter president, and all AIAA members. The response was massive. Within one day, a diverse group of over 40 individuals registered for the event. The final registration count reached 110 attendees, composed of 26 FSU students (at least half potential AIAA recruits), 51 professionals, and 33 military personnel. The event yielded an impressive 87% turnout, almost filling the REEF auditorium.

The first 30 minutes of the event was a "Meet and Greet" with coffee and other refreshments. An AIAA membership table was setup with an attendant to distribute literature and answer questions of all interested parties. Dr. Ben Dickinson, AIAA Northwest Florida Section Chair, introduced the AIAA organization and explained the benefits of membership and highlighted the importance of aerospace to our nation. He then introduced Dr. Bevilaqua and upon handing over the stage, the crowd responded with a tremendous applause. Dr. Bevilaqua delivered a fascinating, inspirational, and humorous seminar filled with great stories and just enough technical jargon. His talk was concluded with a standing ovation. Attendees proceeded back to the lobby to feast on Hungry Howie's pizza and chat amongst themselves and with the speaker. Following lunch, JSF tours were held on base and attendees proceeded to the JSF hangar in two separate groups to experience firsthand what had just heard about from Dr. Bevilaqua's fascinating talk.

Although numerous photos were taken during the Meet n' Greet as well as the seminar, photography was strictly prohibited at the hanger so that even away from the aircraft, no group photos were allowed.

Dr. Ben Dickinson advocates for AIAA membership, aerospace, and introduces Dr. Paul Bevilaqua (photo by Don McMann)

A packed house! (photo by DonMcMann)

Dr. Paul Bevilaqua delivers his talk, "Inventing the Joint Strike Fighter." (photo by Will Clements)

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.

Important Announcement: New Editor-in-Chief Sought for the *Journal of Thermophysics and Heat Transfer*

AIAA is seeking an outstanding candidate with an international reputation for this position to assume the responsibilities of Editor-in-Chief of the *Journal of Thermophysics and Heat Transfer*. The chosen candidate will assume the editorship at an exciting time as new features and functionality intended to enhance journal content are added to Aerospace Research Central, AIAA's platform for electronic publications.

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

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

Heather Brennan, Director, Publications
American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
Fax: 703/264-7551
E-mail: heatherb@aiaa.org

A minimum of two letters of recommendation also are required. The recommendations should be sent by the parties writing the letters directly to Ms. Brennan at the above address, fax number, or e-mail. **To receive full consideration, applications and all required materials must be received at AIAA Headquarters by 15 May 2014, but applications will be accepted until the position is filled.**

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

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OBITUARIES

AIAA Fellow Stalker Died in February

Dr. Raymond J. Stalker, retired Professor of Space Engineering at the University of Queensland, Australia, died on 9 February 2014, at age 83.

He was widely recognized for development of the free piston driven shock tube, known as the "Stalker Tube," as well as for his many contributions to the fields of hypersonics and scramjet technology. He built three progressively larger free piston shock tunnels while teaching at the Australian National University in Canberra. He then accepted an appointment to the University of Queensland in Brisbane where he built a still larger and more powerful shock tunnel, which was followed by a large free piston driven expansion tunnel that provides unique gas dynamic conditions to super-orbital speeds. Dr. Stalker also spent time working in Canada, England, Sweden, Switzerland, and the United States, where he developed close ties with the Hypersonic Air-Breathing Propulsion Branch at NASA Langley.

Although he officially retired 20 years ago, he continued to be an active mentor to the hypersonics group that he started at The University of Queensland. His colleagues in that group initiated the HyShot Program that successfully launched a series of scramjet flight tests and established Australia as an international center for hypersonic propulsion development. Dr. Stalker was the recipient of the AIAA's Ground Test Award in 1993 and was elected an AIAA Fellow in 2001. He became a member of the HyTASP Committee at its formation.

He was given the International Collaboration Award of the International Society for Air Breathing Engines in 1995. He was also a Fellow of the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering, and the Australian Institute of Engineers. In 2013 he was awarded an honorary fellowship of the Royal Aeronautical Society (UK), the society's highest honor. He earned his BSc, BE, MEngSc and PhD degrees from the University of Sydney. He will be remembered warmly by his many students and colleagues.

AIAA Associate Fellow Geisler Died in February

Robert Lee "Bob" Geisler, 78, passed away on 20 February.

Mr. Geisler graduated from the University of Cincinnati with a Bachelor's degree in Chemical Engineering in 1957. He moved to California in July 1959 when the Air Force Rocket Propulsion Laboratory (AFRPL) was relocated to Edwards Air Force Base from Wright-Patterson Air Force Base in Dayton OH.

Mr. Geisler had a lifelong love for his profession as a rocket scientist and continued consulting on rockets after his retirement from the AFRPL in 1990. He developed a broad spectrum of advanced solid rocket propellant ingredients and established an Air Force in-house capability at the AFRPL for precision performance measurement and prediction for advanced solid propellants. A recognized Air Force propulsion motor failure forensics expert, Mr. Geisler served as the key Air Force member of Navy/Strategic Systems Project Office Trident I/C4 detonation failure investigation and recovery program and the Air Force Titan 34D9 failure investigation.

He had numerous publications in professional journals and many patents related to solid rocket propulsion. Mr. Geisler was a member of AIAA since 1958 and an AIAA Associate Fellow. He had been active in the Solid Rockets Technical Committee and the Hybrid Rockets Technical Committee.

AIAA KEY ISSUES: POLICY ISSUES FOR ALL SEASONS

Each year, the AIAA Public Policy Committee, with input and guidance from the Technical Activities Committee, develops public policy key issues for the Institute's use in engaging lawmakers and the public about the importance of aerospace. Reviewed and approved each year by the AIAA Board of Directors, the issues become the focal points of the Institute's engagement with congressional decision makers, the administration, and state and local officials.

The key issues also form the supporting pillars of AIAA's Congressional Visits Day (CVD) program that brings over a hundred aerospace engineers and scientists to Washington, DC, each year for a day of meetings and advocacy on behalf of aerospace engineering and science with lawmakers on Capitol Hill. Participants in the CVD program nearly universally report that having a slate of key issues makes their time on the Hill more productive, and helps them focus their advocacy on issues that truly support our community.

Throughout the years, the Institute's key issues have encompassed a wide range of the Institute's focal points, always examining the top issues facing aerospace each year, identifying areas of concern, and proposing policy solutions to fix the weak areas in policy that cause those concerns. While the issues change each year to meet the current needs of the community, traditionally they include items from space policy, aeronautics research, education, and workforce issues. However, as technology and science change, the Institute has expanded the scope of the issues in recent years to include new areas of concern posed by the challenges of unmanned aerial vehicles and emerging cybersecurity threats to aerospace's infrastructure.

"Congressional Visits Day 2014 was a huge success," said AIAA Executive Director Sandra Magnus. "Over 100 members descended on Washington DC, scheduling 191 meetings with their representatives to discuss the importance of Aerospace for the country. CVD is just the first step in establishing relationships with policy makers. I look forward to hearing from everyone about the follow-on activities that will be undertaken locally!"

Besides being the key part of the CVD program, AIAA's key issues support the formation of panel discussions at AIAA forums, provide talking points for media engagement, and allow the Institute to demonstrate the value of aerospace to the American public by allowing the public to learn a little about the policy needs of the community.

For more information on the key issues process, please contact Steve Howell, AIAA Public Policy, at steveh@aiaa.org or at 703.264.7625.

This year, the Institute went to Capitol Hill with seven key issues; they were:

Long-Term Investment in Technology Development and Transition

Background: In 2005 HR 2862 called for the creation of a national aeronautics policy and a national R&D infrastructure plan that would address, among other issues, the extent to which federal laboratories should focus on long-term, high-risk research. The policy was issued in December 2006 and was followed by the National Aeronautics R&D Plan in December 2007 and the National Aeronautics R&D Infrastructure Plan in December 2008. While the policy calls for the advancement of U.S. technological leadership in aeronautics, neither plan addresses the high-risk research, critical research infrastructure, and long-term financial commitments required to demonstrate effectively the stated goals and objectives for NASA and other federal agencies as stated in the legislation. With mounting national debt and decreasing R&D budgets, our federal laboratories have become increasingly focused on short-term research investments have become more risk-averse. Willingness to accept failure is a normal, accepted, and necessary part of understanding the capability potential and limits of a technology, and is vital to the successful demonstration of technology readiness. The effective transition of aeronautics-related technologies from federal laboratories to civil and military aircraft systems hinges on successful demonstration of the technology readiness level (TRL) required to enable and expedite timely system development and acquisition. Since technology readiness is highly dependent on anticipated operational environments, demonstration in such environments is vital to successful technology transition. A disciplined assessment methodology must be employed at critical milestones throughout the technology and system development processes to validate technology readiness and uncover capability shortfalls that can have detrimental impacts on program cost, risk, and/or schedule.

Aeronautics expertise is critical to U.S. understanding of the potential and limits of revolutionary new aeronautics technologies. However, aeronautics technology development and demonstration programs are becoming increasingly more short-term focused and risk-averse, which impacts U.S. defense capabilities and economic competitiveness. A 2013 report by the Science & Technology Policy Institute (STPI) concluded that "complacency and risk aversion has cost the United States its global leadership more than once since its invention of flight." The report identified almost 70 barriers to effective technology transition.

Fundamental changes must be made in how civil aeronautics technologies are matured and transitioned from federal laboratories to civil aircraft development programs. To meet the goals of the National Aeronautics Plan and to transition new technology to industry end users effectively, the nation must make a commitment to long-term investment in R&D and the requisite critical infrastructure.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress support technology investments that specifically include a balanced risk portfolio of aeronautics research with demonstration "off-ramps" for technology transition that can be infused into new fielded systems.
- Congress and the Administration support "X-plane"–style competitions and capability demonstrations to enhance technology transition and inspire the next-generation workforce.
- The Administration requires programs to include frequent demonstration through simulations, ground tests, and flight tests that provide adequate validation of new technologies.

Assuring the Viability of the U.S. Aerospace and Defense Industrial Base

Background: Continued stability of the U.S. aerospace and defense (A&D) industrial base is critical to our economy, national security, infrastructure, and future workforce. The A&D industry is facing one of its greatest challenges in history as Congress and the Administration deal with mounting national debt and the need to balance the federal budget. All federal agencies face significant budget reductions, with the Department of Defense (DoD) potentially bearing the biggest burden. While all areas must be examined to identify unnecessary spending that can be reduced or eliminated, we must make sure that the nation's future is not mortgaged to address today's crisis.

The A&D industry is the nation's largest manufacturing exporter and contributes 2.23% of the Gross Domestic Product. A&D small business generates almost half of private sector jobs, 64% of net new private sector jobs, 43% of high-tech employment, and is responsible for 33% of exports.* The industry's workforce is highly skilled and leads our nation in global competitiveness, providing current and future opportunities for young people to have high-paying careers that will keep the industry strong for the future while advancing our national and economic security.

In 2011, as part of the deal that allowed for the increase in the national debt ceiling while recognizing the unsustainability of the national debt, Congress passed the "Budget Control Act of 2011". The act included automatic triggers that mandate across-the-board spending cuts. Legislative proposals to allow for more flexibility among the agencies have been met with mixed outcomes. In April 2013, when faced with the growing reality of widespread flight delays caused by sequestration-related Federal Aviation Administration (FAA) staffing shortages, Congress acted swiftly to provide flexibility within the FAA to continue core operations while shifting sequestration impacts to lower priorities within the agency. However, other agencies have been prevented from employing the same priority-based shifting, and have continued to cut operations and programs across the board indiscriminately.

The A&D industrial base possesses unique capabilities and expertise required to address the unique and diverse missions required by their civil and military customers. However, future U.S. space operational capabilities face industrial base challenges, both from reduced production capability and loss of supporting human expertise. Small business is the backbone of the American economy and technology innovation. The domino effect of reduced federal budgets will undoubtedly force some companies out of business and still others to scale back significantly, resulting in single-source suppliers or even no domestic supplier for items on the critical development path. If those capabilities are allowed to erode in this lean budget environment, this nation could become technologically bankrupt and unable to address future threats to our national security or economic stability.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress and the Administration carefully consider the impact of budget cuts on the continued viability of the aerospace and defense industrial base as well as their impact on U.S. national and economic security in their budget reduction deliberations.
- Congress and the Administration must address the impending threat of sequestration by eliminating the automatic "across-the-board" defense budget reductions that will severely impact research, development, testing, evaluation, and acquisitions programs; allow agencies the flexibility of discretion to prioritize programs, capabilities, and functionality when determining where statutory cuts should be made; and provide assurances of continuity and sustainability to federal contractors, the small businesses that support these programs, and university and federal laboratories that provide national security RDT&E.
- Congress should reform federal acquisitions and procurement and associated program processes to allow for multi-year appropriations for complex systems similar to DoD contracts for shipbuilding and fleet acquisitions.
- Congress must meet constitutional budget obligations to return program stability and economic certainty to the development of complex systems.

*AIA Second to None, 9/19/12

Developing a Seamless National Cybersecurity Policy

Background: Cybersecurity continues to be a continually and rapidly evolving arena where our policy decisions have significant implications in both the commercial and military world. Beyond economic losses attributed to stolen Personally Identifiable Information (PII), the risks associated with loss of Intellectual Property (IP), especially from the aerospace and defense industry, pose a national security risk. The risks become even greater when cyber attacks target critical infrastructure, including air traffic management (ATM) and space-based assets, such as GPS, weather monitoring, and even the International Space Station (ISS). The presence of ground-based systems in the communication path adds additional portals for access that must also be protected. The risk to the system, both space and ground based, is amplified when the introduction of malicious hardware and code through the supply chain is also considered.

Cybersecurity presents a significant challenge to the "business as usual" approach when it comes to not only Con Ops (concept of operations) of our systems, but also the ways in which we design, build, and acquire them. The rapid growth in cybersecurity service companies also presents a new area of concern relative to ITAR issues: transfer of technology and "know how" to other nation-states and parties that may be using that same technology and capability against the United States and its interests. Additionally, the move to mobile and portable platforms with a rapidly growing catalog of "apps" (applications) that users can install on their devices and inadvertently provide backdoor access to networks and databases introduces another possible breach point.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress should require the Administration to assess vulnerabilities throughout the supply chain relative to space-based and ground-based equipment, especially considering recent relaxing of ITAR restrictions in the area of satellites.
- Congress should require the Administration to develop a roadmap for protection of critical space-based and related ground-based assets that are vital from both a national security and critical infrastructure perspective.
  — This roadmap should include a review and propose guidelines related to cybersecurity skills, software, and hardware provided to companies and nation-states that could be used against the United States and our interests here and abroad.
  — Specific protocol for protecting GPS and other vital hardware should be included as part of the roadmap.
- Congress should increase the emphasis of STEM initiatives for the purpose of developing a "cyber cadre" that can address skill shortages and the growing need for cyber-capable individuals. Considering the sensitive nature of the work, this must be done in a manner that reflects the need for proper background assessment protocols and provides standardized training requirements.
- Congress should develop policies that encourage public/private cooperation to forge viable strategies that address the multiple areas of cybersecurity that ensure the integrity of global positioning systems technology and other space-based assets, national air traffic management systems, supply chain, etc.

Access for Unmanned Aerial Vehicles in the National Aerospace System

Background: The FAA Modernization and Reform Act of 2012 directed the FAA to address the rapidly evolving issue of accommodating UAVs (Unmanned Aerial Vehicles, i.e., drones) in the national airspace. The recent (Fall 2013) publication of its "Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap" attempted to lay out its systematic approach to what is an admittedly challenging issue from both a technical and policy perspective.

While the roadmap is successful in capturing the complexity of the task in front of the FAA and other involved groups/agencies, the broad timelines included indicate a system that is literally decades away from maturity. Recent efforts by the FAA to solicit proposals for and selection of six (6) test sites for UAV testing (a key early step) were delayed beyond the originally announced milestone date. Additionally, political issues, namely the recent government shutdown, have halted work and remain before the FAA as possible future impediments to integration efforts.

Beyond impacts from external forces, the report itself indicates concerns over the FAA's ability to meet the milestones and dates it has set out for itself in its own roadmap. In Appendix C (page 50), the report states "Some of the target dates are aggressive and will require additional industry or government resources if they are to be met." Considering that the roadmap contains both serial and parallel efforts relative to its phased approach to "accommodate, integrate, and evolve" UAVs into the NAS, there is significant risk to the overall roadmap. And while some aspects of the roadmap may be implemented, the FAA's stated focus that it must be done "…without reducing existing capacity, decreasing safety, negatively impacting current operators, or increasing the risk to airspace users..." leaves little doubt that even a small delay in an integration task could have significant ripples throughout the overall effort.

The rapid growth of the UAV industry, the limited ability to operate commercially under the current system (Certification of Authorization, or COA), and the ambiguity that currently exists as to what the final FAA oversight will look like and what restrictions it will pose on developers and users of UAVs will all need to be considered.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress should direct the Federal Aviation Administration to shorten its "mid-term" and "long-term" task period of performance from "5–10 years" and "2022–2026", respectively, to timelines that reflect the importance of the crossroads that the UAV/UAS industry is at within the United States. Significant technical and business implications could result from decisions by the FAA and other regulatory bodies and there is significant risk that companies/investors will choose to NOT enter the UAV/UAS market while ambiguity could possibly exist for another decade.
  — The FAA and its UAS Technical Community Representative Group (TCRG) should accelerate the effort to define the required sensors and approved approach (ABSSA, GBSSA, etc.) that will allow for safe vehicle operation within the NAS. The roadmap indicates an expectation of no major progress until the mid-term timeframe, between 5 and 10 years. This timeline could hamper efforts for vehicle development as FAA-mandated technology could impact vehicle design and costs downstream of decisions made 5–10 years out.
- Congress require the FAA to review and issue a report, within 180 days, addressing the planning and progress on NextGen being able to accommodate UAV/UAS, specifically its ability to deal with the required secure Control and Communications (C2).
- Congress should identify areas of concern that risk delays because of either insufficient federal funding or resources and work to create public/private partnerships that can be leveraged to minimize impacts to the overall integration effort.
- The FAA should look to international examples of functioning UAV/UAS integration (Israel, Canada, etc.) to leverage both their Lessons Learned and to avoid U.S. regulations being overly burdensome on U.S. manufacturers and thereby impede their ability to compete for international business (this requires a balance between safety and competitiveness).

Ensuring a Robust U.S. Human Spaceflight Program

Background: Since the U.S. human spaceflight program was initiated in the early 1960s, the country has benefitted from the global space leadership, diplomatic opportunities, and inspiration that result from success in difficult human endeavors. The technologies that have been developed to enable human space exploration have resulted in great leaps in Earth-bound technological fields such as health care, communications, navigation, and environmental management.

The current Administration and Congress are in agreement that the ultimate destination for humans in space within the next 20–30 years is Mars. Currently, human space exploration is limited to travel to and from the International Space Station (ISS), located in low Earth orbit (LEO) approximately 250 miles above Earth. There is also strong agreement between the policymakers and the technical community that a stepping stone approach to human space exploration is necessary to demonstrate the human-rated spacecraft and critical technologies necessary to transport humans safely to and from Mars. NASA and its industry partners are developing a highly capable heavy lift launch vehicle and spacecraft that will enable deep-space human exploration to multiple destinations, and NASA and other international space agencies are jointly assessing options for milestone missions with the ultimate goal of landing humans on Mars. NASA is advancing the maturity of key technologies that will be necessary for future deep-space exploration, including such areas as in-space propulsion, in-space power generation and storage, cryogenic fuel management, crew health and safety, human-robotic systems, and other technologies crucial to deep-space human exploration.

Development of the Space Launch System (SLS) is also well underway. NASA and the agency's industry partners are maturing a design that maximizes the use of existing systems to reduce the launch vehicle cost and minimize schedule and technical risk. Currently the program is operating five months ahead of schedule. The initial test flight of the SLS integrated with the Orion spacecraft is scheduled for 2017.

The technologies and capabilities developed in support of human spaceflight also benefit other critical U.S. programs such as space science, Earth observation, weather forecasting, and national security space programs. Technologies developed to support astronauts in the constrained environment of space travel have been leveraged to improve methods for water filtration, agriculture, food storage, material manufacturing, communications, and energy management. Human spaceflight has the potential to provide economic opportunity as government and the private sector each contribute in unique ways.

A strong government human spaceflight program beyond Earth orbit inspires young people to join the scientific and technical workforce. The expanding human spaceflight industry is enabling the transport of humans, scientific instruments, and cargo to low Earth orbit, further enhancing educational, workforce, and commercial opportunities. Human exploration beyond Earth orbit also provides a platform for the U.S. to strengthen international relationships via collaboration. Historically the U.S. has been seen by other countries as the leader in human spaceflight, providing an opportunity to make the geopolitical links that will facilitate strong trade and security cooperation with established and emerging space-faring nations.

Recommendations: To ensure U.S. leadership in space and enable a robust human spaceflight program, the American Institute of Aeronautics & Astronautics recommends:

- Congress should adopt a NASA-endorsed roadmap of missions and milestones that leads to a human mission to Mars in the early 2030s.
- Congress should enable stable long-term funding for NASA to complete development of the SLS and Orion and to develop other systems necessary to execute a sustainable exploration roadmap, in conjunction with international partners.
- Congress and the Administration should provide for the uninterrupted development of NASA-defined technologies that are necessary to execute the exploration roadmap.
- Congress and the Administration should state clear priorities for linking NASA Human Spaceflight activity to national goals related to foreign relations, economic growth, education, and technological achievement.

Addressing the Growing Threat of Orbital Debris

Background: The tracking, prevention, and removal of orbiting debris is necessary to ensure that our nation's commercial, civil, and defense space assets achieve mission success throughout the originally designed mission lifetime. The largest population of debris in low Earth orbit (LEO) consists of 300,000 to 1 million objects between 0.1 cm and 10 cm. This debris is difficult to identify and track and poses a significant threat to space operations. Despite policy efforts to mitigate future space debris, there will continue to be on-orbit incidents that create small- to medium-sized debris in critical orbits. The Chinese anti-satellite test of 2007 and the Iridium 33/Cosmos 2251 collision in 2009 are examples of situations that are likely to recur. These two events alone likely doubled the amount of debris in critical sizes in orbit. While some debris naturally de-orbits over time, models indicate that we already have an unstable situation where debris is created faster than it naturally de-orbits, with an increasing collision frequency. Models indicate that even if all launch activity stopped, satellite collisions with existing debris would continue, with the debris population growing exponentially. Modeling studies indicate that removal of at least 5 large space objects per year in key orbits would be required to stabilize debris growth.

Current tracking systems primarily identify objects bigger than 10 cm. Active spacecraft with propellant reserves can maneuver away from threatening objects given sufficient warning, but collisions with objects smaller than 10 cm are difficult to avoid. Without debris mitigation and remediation, spacecraft life would be adversely affected and replacement costs will rise significantly. Furthermore, because LEO spans all geographic boundaries, debris is also an international legal challenge. There are no international regulations that limit actions that create debris; retired spacecraft and resulting debris remain the sovereign property of the nations that launched the spacecraft; and no means currently exist to raise the long-term funding required to develop and implement methods of debris mitigation. International and national laws are vague and still in their infancy, with many legal and technical hurdles that prevent active debris removal.

Recommendations: To address the threat of orbital debris, the American Institute of Aeronautics & Astronautics recommends the following actions should be taken by the Congress and the Administration:

- Sponsor development of space situational awareness (SSA) methods on a global cooperative basis to identify, track, and maintain a catalog of LEO debris objects down to 1 cm.
- Develop a clearinghouse of "best practices" for satellite and launch vehicle upper stage designers that limit debris generation and minimize orbital loiter after booster and satellite end of life. Provide international access with all space-faring nations to share these best practices.
- Establish international agreements that prevent intentional creation of hazardous debris.
- Continue to work through UNCOPUOS to develop international agreements to limit orbital debris, including transparency and confidence-building measures.
- Develop and demonstrate cost-effective technologies for debris remediation, and promote the resolution of legal issues of liability and other legal hurdles related to debris removal.

Building Our Competitive Foundation: Supporting K–12 STEM Education

Background: Science, Technology, Engineering, and Mathematics (STEM) education in our nation's classrooms provides the critical foundation needed for our future national security and economic competitiveness. Students need adequate preparation at the primary and secondary education levels if they are to advance to university study of STEM and onto careers in STEM fields. However, inadequate emphasis, funding, communication of resources, and teacher training has been provided, particularly for the critical technology and engineering (T&E) components of STEM, thus eroding this foundation. Additionally, a 2011 White House report on federally sponsored STEM programs suggests there may be significant overlap. If the nation is to reap fully the intended benefits of STEM education and its investment therein, we must remedy our current deficiencies in emphasis, funding, communication of resources, and teacher training in STEM areas.

Recommendations: To remain globally competitive, the American Institute of Aeronautics & Astronautics recommends that the U.S. must increase its emphasis, funding, and teacher training in STEM subjects at the primary and secondary education levels. Several policies and actions would make significant progress on this objective.

- Congress should provide incentives for states to adopt the new Next Generation Science Standards being developed by a multi-agency working group lead by the National Research Council. Incentives might include curriculum development grants, teacher training grants, or materials grants.
- Congress should provide direct funds specifically to support teacher training programs in technology and engineering areas. Engineering and technology-related learning opportunities are compounded exponentially for each teacher who is effectively trained.
- The Administration should pursue a research-based evaluation of existing teacher training programs in technology and engineering subjects to determine which training approaches are most successful and then deploy those approaches nationwide.
- Congress should create a centralized national STEM resource center/network that identifies, publicizes, coordinates with, and connects educators to STEM support opportunities throughout all federal government agencies.
- Congress should recommend language to the Federal Acquisition Regulations that requires private companies to perform a minimum amount of STEM outreach activities for all federally funded technical contracts. Research has shown that the most effective method of encouraging students to enter a STEM field is through local scientists and engineers volunteering in a classroom.
  — Reduces costs by eliminating, at a minimum, overhead of managing federal STEM funding for local STEM programs.
  — Encourages greater participation in STEM activities by private industry, which are the most effective at encouraging students.
  — Generates local community involvement.

AIAA Propulsion and Energy Forum and Exposition

Leveraging Aerospace and Energy Technology Synergies to Address Future Challenges

28–30 July 2014
Cleveland Medical Mart & Convention Center
Cleveland, Ohio

Featuring:
50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference
12th International Energy Conversion Engineering Conference

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Current Exhibitors

Aerojet Rocketdyne
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The Boeing Company
Cobham
Desktop Aeronautics
Dunmore Corporation
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L-3 Electron Technologies, Inc.
Marotta Controls, Inc.
Metal Technology (EB)
Moog, Inc.
National Aeronautics and Space Administration (NASA)
National Technical Services (NTS)
Pointwise, Inc. (EB)
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Vacco Industries
Worthington Industries (SCI)
Wyle

AIAA Programs

Conference Overview

At the AIAA Propulsion and Energy Forum and Exposition (AIAA Propulsion and Energy 2014), the energy and excitement will result as much from the networking opportunities and plenary discussions as from the technical sessions. 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, and most of these come from the researchers and engineers who will come together at this forum.

Join us in Cleveland, 28–30 July 2014, as we roll up our sleeves to help answer the questions of:

- How do we Define Propulsion and Energy System Architectures that are Safe, Clean, and Economical?
- How do we Develop High Energy and Power Density Technologies for Clean, Sustainable Energy Production, Power Generation, and Propulsion?
- How do we Implement Advanced Manufacturing Solutions for Propulsion and Energy Systems?

NEW for 2014: Rising Leaders Program

The innovative and in-demand Rising Leaders Program is coming to Propulsion and Energy 2014 and featuring two special sessions. These sessions are geared toward our young professionals and students but can be just as educational for all forum attendees.

Monday, 28 July 2014, 1930–2130 hrs
Town Hall Discussion to help answer the question: Where is MY Apollo Vision for the Future?

Tuesday, 29 July 2014, 1900–2100 hrs
Join us as Brad Owen, CEO, Creavos, discusses how to “Brand Yourself.” In today’s world, an engineer’s brand is both virtual and in person. Brad will discuss how to develop and manage your brand.

Speakers

Speakers for AIAA Propulsion and Energy 2014 will be announced on the forum website, **www.aiaa-propulsionenergy.org**, as they are confirmed. Check back for updates.

Technical Program

A strong technical program, will keep you at the cutting edge of new thinking, best practices, and stimulating idea exchanges within the Propulsion & Energy Industries. Make plans to be a part of these discussions. With over 850 abstract submitted there will be a diverse collection of papers presented on topics such as:

- Advanced Manufacturing
- Advanced Seal Technology
- Advanced Topics in High-Speed Propulsion
- Aircraft Electrical Power Systems
- Centaur Upper Stage
- Combustion and Acoustic Instabilities
- Combustion Modeling and Simulation
- Combustors
- Cryogenic Propellant Storage and Transfer
- Distributed Engine Controls
- Effects of Ground Test Facilities on Electric Propulsion Thrusters
- Energy Harvesting, Renewable Energy, and Photovoltaic Systems
- Energy Policy
- Experimental Investigations in High-Speed Propulsion
- Green Propellant Infusion Mission
- Hall Thrusters
- Heat Transfer in Aerospace Power and Propulsion Systems
- Hypersonics
- Internal Ballistics of Hybrid Rocket Motors
- Micro-Thrusters
- New Hybrid Motor Concepts
- Non-Toxic Propellants
- Nozzles
- Nuclear Thermal Propulsion
- Orion Launch Abort System
- Propellant Feed Systems
- Propellers, Small Engines & Alternative Fuels
- Propulsion Education
- Radioisotope and Fission Power Systems
- Regression Rate Studies in Hybrid Rockets
- SEP Technology Demonstration Missions
- Solid Rocket Motors
- Spacecraft and Lunar/Mars/Venus Surface Thermal Management
- Stirling Analysis, Simulation and Testing
- Supersonic Combustion Simulation
- The Next Ion Thruster
- Thermoelectric Conversion Systems
- Vacuum Facility Effects
- Wave Rotors and Pulse Combustors for Gas Turbine Engines

And many more...

For a complete listing of the technical papers and sessions occurring at the forum, please visit **www.aiaa-propulsionenergy.org**.

Recognition

Join us in Cleveland as we recognize the very best in our industry: those individuals and teams who have taken aerospace technology to the next level … who have advanced the quality and depth of the aerospace profession … who have leveraged their aerospace knowledge for the benefit of society. Their achievements have inspired us to dream and to explore new frontiers. The AIAA Propulsion and Energy 2014 will present 15 best papers awards and the following technical awards:

- AIAA Aerospace Power Systems Award
- AIAA Air Breathing Propulsion Award
- AIAA Energy Systems Award
- AIAA Propellants and Combustion Award
- AIAA Wyld Propulsion Award

Continuing Education

Stay at the top of your game with the following courses held 31 July– 1 August:

Missile Propulsion Design, Technologies, and System Engineering

This course is oriented toward the needs of missile engineers, system engineers, system analysts, marketing personnel, program managers, university professors, and others working in the area of missile propulsion systems and missile propulsion technology development. Attendees will gain an understanding of missile propulsion design, missile propulsion technologies, launch platform integration, missile propulsion system measures of merit, and missile propulsion system development process.

Hybrid Rocket Propulsion

This short course is aimed at bringing together professionals with mutual interest in chemical combustion and propulsion, including modern techniques for measuring hybrid rocket performance, flame and flow field modeling, testing, and stability analysis. The purpose is to present and discuss fundamental theory alongside research findings with emphasis on unsolved problems, open questions, and benchmark tests. The course will provide a platform for learning and exchanging hybrid rocket experiences in the hope of stimulating further interactions and future collaborations.

Application of Green Propulsion for Future Space

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

2nd AIAA Propulsion Aerodynamics Workshop

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

Networking

AIAA Propulsion and Energy 2014 is expected to draw more than 1000 participants from across all facets of the aerospace enterprise who are shaping the future of flight. Whether it's breakfast or lunch in the exhibit hall, evening receptions, B2B matchmaking, awards ceremonies, lectureships, or simply talking with the person next to you at a technical paper presentation, you'll find many opportunities to meet new colleagues and build new relationships.

Business-to-Business (B2B) Speed Networking

Want to find out how to do business with commercial, governmental, and aerospace research entities like the small business programs offices of DARPA, NASA, Lockheed Martin, Boeing, and SPAWAR? Find out how your capabilities match with the needs of major government R&D agencies and aerospace corporations. This B2B event will help both our prime and our small business members of the space supply chain to learn about the latest technology opportunities, to form new alliances and partnerships, and to maximize business resources. After companies outline what they are looking for in partnerships, there will be one-on-one matchmaking and detailed discussions about programs and opportunities. Registration is required for this event, and is complimentary for AIAA corporate members.

Sponsorship and Exposition

In today's dynamic business environment, effective outreach and customer interface are vital to successfully capturing new partnership opportunities. AIAA's sponsorship and exhibits programs can help you achieve your objectives. Contact Merrie Scott, merries@aiaa.org to secure your sponsorship, and Christopher Grady at chrisg@aiaa.org to book your exhibit space today.

Hotel Information

AIAA has made arrangements for a block of rooms at the hotels listed below. Rooms will be held until **8 July 2014** or until the room block is full, then released for use by the general public.

Cleveland Marriott Downtown at Key Center

127 Public Square, Cleveland, OH 44114
Call in for Reservations: 216.696.9200
Room rates are $164 for a standard room (single or double occupancy). Applicable taxes will apply.

Renaissance Cleveland Hotel

24 Public Square, Cleveland, Ohio 44113
Call in for Reservations: 1.800.HOTELS 1
Room rates are $169 for a standard room plus applicable taxes (single or double occupancy). There are a limited number of rooms available at the prevailing government per diem. Proper government ID is required.

Westin Cleveland Downtown

777 St. Claire Avenue, NE, Cleveland, OH 44114
Room rates are $159 for a standard room plus applicable taxes (single or double occupancy). There are a limited number of rooms available at the prevailing government per diem. Proper government ID is required.

Registration

Register and sign up for email alerts at **www.aiaa-PropulsionEnergy.org**.

23rd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar

30 March–2 April 2015
Hilton Daytona Beach Oceanfront Resort
Daytona Beach, Florida

Abstract Deadline: 30 September 2014

The 23rd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar provides the world's leading scientists, engineers, researchers, and managers, as well as promising students within the field of parachute and aerodynamic decelerator systems, an opportunity to present recent advances before a knowledgeable international audience. Topics include, but are not limited to, the following:

- *Modeling and Simulation*: Advances in applied computational fluid dynamics (CFD) methodology, applications, and techniques; structural modeling techniques; progress in fluid structure interaction capabilities; simulation environments; studies combining experimental, analytical, and/or numerical techniques; CFD/FSI verification and validation; atmospheric modeling; and prediction techniques.
- *System Applications and Operations*: Decelerator systems for personnel, cargo, aircraft escape, spacecraft reentry, ordnance retardation, and unmanned aerial vehicles; logistics; environmental effects that affect system life cycle, aging, damage, maintenance, and repair; life-cycle extension programs; system studies; definition of new decelerator applications; visual training simulations and training; airdrop/aerial delivery planning methods; and wind field and environmental data processing techniques.
- *Testing*: Ground and flight testing of systems and components; instrumentation; advanced data acquisition techniques; data processing methods; low-cost airborne measurement methods to estimate trajectory and dynamics; miniaturized sensor technologies; remote sensing technologies; in-flight measurement techniques used at ground test facilities; and atmospheric measurement techniques.
- *Materials and Manufacturing*: New materials; weaving; material forming methods; sewing; bonding; fabrication methods; automation and inspection techniques; quality assurance; statistical process control; production cost reduction processes; material specifications; and material science.
- *Design and Development*: Precision aerial delivery programs; development of ballistic parachutes, gliding parachutes, parachute clusters, paragliders, and inflatable structures; packing methods; deployment and extraction systems; reefing and staging methods; parachute system components and hardware, including attachment structures, release and dis-reef devices, mortar systems, ejection seats, composites, and airbags; updates on the development programs of aerodynamic decelerator systems, including new programs, completed programs, and lessons learned; and guidance, navigation, and control paradigms development.
- *Other*: Decelerator system and components aerodynamics; structural analysis; drag characteristics and stability; scaling; flow field and wake characteristics; pressure distributions; databases, storage and retrieval; technology transfer; education; and historical aspects.

Important Dates
Abstract Deadline: 30 September 2014
Author Notification: 25 November 2014
Final Manuscript Deadline: 10 March 2015

To submit an abstract, and to view abstract submission requirements and instructions, go to the conference website, **www.aiaa.org/ads2015**.

Questions should be referred to the Technical Program Chair:

Oleg Yakimenko
oayakime@nps.edu
Naval Postgraduate School

Student Paper Competition

The AIAA Aerodynamic Decelerator Systems (ADS) Technical Committee is sponsoring a Best Student Paper Competition at the 2015 AIAA ADS Technology Conference and Seminar in Daytona Beach, FL. Papers are sought from students on all research topics related to aerodynamic decelerators. Draft manuscripts should be submitted, which include a brief assessment of prior work by others, an explanation of the paper's main contributions, and appropriate figures. The draft manuscript must include sufficient detail to allow an informed evaluation of the paper. Up to five finalists will be selected for presentation at the AIAA ADS conference.

Finalists will present their papers at the beginning of the conference for judging so that the award may be presented at the awards dinner. Finalists will receive a complimentary ticket to the awards dinner where they will be recognized. All finalists will receive a $1,250 award (to offset travel expenses, lodging, and registration) after attending and presenting their papers. An overall best paper and presentation will be selected from the Student Paper Competition finalists, and this winner will be presented with an additional $1,250 prize. All prizes are provided by the ADS TC.

To be eligible for this award, the student must be the primary author of the paper and the work must have been performed while the author was a student. The student author must also: 1) be currently enrolled in January 2015; 2) be a member of AIAA; 3) present the paper at the conference; and 4) along with the final paper, include a cover letter from his/her advisor stating that the student did the majority or a significant amount of the research in question.

Students should submit their abstract by **30 September 2014** according to the regular conference rules and indicate "Student Paper" at the time of electronic submittal. All student authors will be notified of their status on or about **25 November 2014**. An electronic copy of the final paper must be submitted to the competition chair Nathan Slegers, slegers@mae.uah.edu, for scoring by **5 February 2015**. The final manuscript must also be electronically submitted to the regular conference technical session by **10 March 2015**. Note that the deadline for submittal to the competition chair is earlier than the conference final manuscript deadline. Scoring for the award will be equally based on written paper content and audio presentation.

Important Competition Dates
Abstract Deadline: 30 September 2014
Author Notification: 25 November 2014
Final Manuscript Submission to Competition Chair: 5 February 2015
Final Manuscript Conference Deadline: 10 March 2015

Questions should be referred to the Student Paper Competition Chair:

Nathan Slegers
slegers@mae.uah.edu
University of Alabama in Huntsville

Upcoming AIAA Continuing Education Courses

AIAA now offers live and on-demand Continuing Education webinars.
Viewers enjoy excellent tutorials for effective online learning at home or in the office.
For more information please visit https://www.aiaa.org/webinars.

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

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

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

Business Management for Engineers (Instructor: Alan Tribble)

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

Key topics
To develop an understanding of the basic principles of:

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

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

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

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

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

2nd AIAA Propulsion Aerodynamics Workshop

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

Hybrid Rocket Propulsion (Instructor: Joe Majdalani)

This short course is essential 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 ultimate goal to promote the science of hybrid rocketry that 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.

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

Who Should Attend

This short-course is aimed at bringing together professionals with mutual interest in chemical combustion and propulsion, including modern techniques for measuring hybrid rocket performance, flame and flow field modeling, testing, and stability analysis. The purpose is to present and discuss fundamental theory alongside research findings with emphasis on unsolved problems, open questions, and benchmark tests. The course will provide a platform for learning and exchanging hybrid rocket experiences in the hope of stimulating further interactions and future collaborations.

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

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

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

Application of Green Propulsion for Future Space

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

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

Decision Analysis (Instructor: John Hsu)

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

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