June 2013

AEROSPACE AMERICA

Stealth sneaks into UCAVs

A conversation with Michael Gazarik

Expanding customer base for space payloads

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

AEROSPACE AMERICA

June 2013

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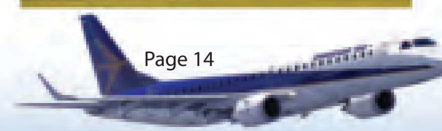
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COVER
An X-47B is transported on an aircraft elevator aboard the aircraft carrier Harry S. Truman. To learn more about the new UCAVs, turn to page 28. USN photo courtesy of Northrop Grumman by Alan Radecki.

Aerospace America (ISSN 0740-722X) is published monthly, except August, by the American Institute of Aeronautics and Astronautics, Inc. at 1801 Alexander Bell Drive, Reston, Va. 20191-4344 [703/264-7500]. Subscription rate is 50% of dues for AIAA members (and is not deductible therefrom). Nonmember subscription price: U.S. and Canada, $163, foreign, $200. Single copies $20 each. **Postmaster: Send address changes and subscription orders to address above, attention AIAA Customer Service, 703/264-7500.** Periodical postage paid at Herndon, VA, and at additional mailing offices. 40,000 copies of this issue printed. This is Volume 51, No. 6.


49th AIAA/ASME/SAE/ASEE
Joint Propulsion Conference and Exhibit (JPC)
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13-0137-1

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is a publication of the American Institute of Aeronautics and Astronautics

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June 2013, Vol. 51, No. 6

AIAA
American Institute of Aeronautics and Astronautics

Editorial

Time to roll up our sleeves

It's getting crowded up there.

After several generations spent polluting our oceans and streams and fouling the air, we inhabitants of the planet finally took a long, hard look around and collectively began taking better care of our home. Individually, we started using more nature-friendly products and processes and began monitoring our activities more closely with regard to their possible future environmental impact. More broadly, socially conscious industries began to seek processes that would leave a smaller manufacturing footprint. For those less inclined to follow suit, social and ultimately economic pressures were often brought to bear.

We also began to recognize that we were creating huge piles of trash while finding fewer and fewer places to dump it. Once again, we began searching for solutions, using more recyclables and materials that can be disposed of with little or no negative impact.

There is still a long way to go, and no one nation can do it alone, but it's a good start in reversing the mess we were making of Earth.

Now it is time to turn our attention further skyward. More nations every year are joining the space community, and low Earth orbit is a popular destination for constellations of communications and remote sensing spacecraft. It is also the home of the international space station.

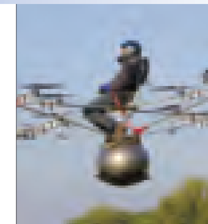
But even as we launch increasing numbers of satellites, so do many of them pass their useful life. Every year, the orbital debris map gets denser. LEO is strewn with spent rocket upper stages; dead satellites in decaying orbits are sharing space with new arrivals just beginning their productive lives. All of this material will stay in orbit long after their missions end.

Many space agencies have informally adopted a best practice that is commonly called the '25-year rule,' a time limit for the removal of their equipment from orbit once it has completed its mission. More often than not, however, the rule is met with a wink and a nod, as launches continue and retrieval and deorbit are almost nonexistent.

According to some estimates, there are at least 21,000 particles in orbit exceeding 10 cm in size, big enough to cause a good bit of damage. Harmful impacts with otherwise viable spacecraft or with the space station now seem to be a question of when, not if. We compound this problem by activities like the 2007 Chinese ASAT test. Debris from that test later damaged an orbiting Russian satellite.

Not long ago, space, even just low Earth orbit, seemed infinite; the notion that we might one day create an environment that might be so crowded as to be hazardous to newcomers seemed unthinkable. Yet here it is. But this orbiting junkyard was the creation of many nations, and so must be the effort to clean it up. Space agencies around the world must come together to develop plans for deorbit and retrieval, as well as truly committing themselves to honoring the 25-year rule. Just as we got in this mess together, collectively, we can find ways to make it right.

Elaine Camhi
Editor-in-Chief



Europe goes full tilt for electric helicopters

AGUSTAWESTLAND'S PROJECT ZERO, an all-electric tilt-rotor technology demonstrator, was unveiled for the first time in March. It is the latest in a line of European advanced programs that researchers hope will one day lead to a technically and economically competitive all-electric rotorcraft.

Designed to hover like a helicopter and convert to a fixed-wing aircraft in forward flight, Project Zero features two integrated rotors that can be tilted through more than 90 degrees. The aircraft's electric motors are powered by rechargeable batteries. Its tilt-rotors can be angled forward into wind when the Zero is on the ground, allowing them to 'windmill' and recharge the batteries.

The demonstrator performed its first unmanned tethered flight in June of 2011 at AgustaWestland's research center Cascina Costa in Italy and has since performed several more untethered hovering flights. According to the company, "Future hybrid solutions have also been investigated using a diesel engine to drive a generator. All of the aircraft control systems, flight control, and landing gear actuators are electrically powered....During cruise, the wings will provide most of the lift, with the blended fuselage and shroud also making a contribution."

Project Zero features detachable outer wings for missions that will be performed primarily in helicopter mode. Elevons enable pitch and roll control in forward flight, while the V-tail provides longitudinal stability. The electrical drive system design eliminates the need for the complex and heavy transmission system required by conventional rotorcraft.

The project's main industrial partners are based in Europe but receive support from other partners in the U.S. and Japan. The proof-of-concept vehicle is one of several 'top-down' all-electric or 'more electric' technology demonstrators under development in Europe, pioneered by the major European helicopter manufacturers.

Eurocopter turbos

In October 2011 Eurocopter revealed it was working on a turboshaft/electric concept for its light, single-engined AS350. This approach uses "the supplemental electric system to increase maneuverability of a single-engine helicopter during an autorotation landing....In the event of an engine failure, the electric motor provides power to the rotor, allowing a pilot to control the helicopter easily during the

Zero

descent to a safe touchdown," according to the company.

During 2012 Eurocopter worked on maturing the basic technology and evaluating its implementation on the company's current series production helicopters. The critical design challenge has been to develop an electric power source that is light and powerful enough not to penalize the payload performance of the single-engine aircraft fleet in normal operations. The work was still proceeding at the start of this year, and no announcement on progress was forthcoming. The AS350 hybrid demonstrator features a compact electric motor and a lithium ion polymer battery installed in the center area of the helicopter.

eCO_2 Avia-Hybrid

Hybrid approaches

Meanwhile, in February, the EADS Innovation Works (EADS is Eurocopter's parent corporation) published further outline details on its long-running concept study of a diesel-electric hybrid propulsion system they call the eCO_2 Avia-Hybrid helicopter.

The aim of the study is to determine which mix of diesel engines, generators, batteries, and electric motors would best enable, by the end of this decade, the development of a helicopter with fuel consumption around half that of today's models. The company is examining various configurations, including combinations of two and three diesel engines powering batteries via electric generators, with the electric motors driving the rotors.

As always with designing electrical power generation, weight is a key challenge, and one option being considered is to remove more standard components. These might include the main gearbox, which will be unnecessary with a direct electric drive, or the heavy traditional tail rotor shaft, which can be replaced by an electric drive system.

In this configuration, says the company, "Electrical rotor drives of the main and tail rotors allow for flexible, power-optimized rotor speed settings while further reducing fuel consumption. Tilting of the main rotor during the cruise phase enables the hybrid helicopter to retain optimum aerodynamics during cruise, reducing the power demand and the fuel consumption. Takeoffs and landings are possible with electrical power only, resulting in lower noise levels and improved flight safety."

This is an area of considerable research activity by EADS Innovation Works. At the September 2012 Berlin Air Show the company also released the first details of a hybrid power system concept for the Tanan, a tactical remotely piloted air system (RPAS) under development by EADS' Cassidian division. This hybrid approach combines a heavy-fuel-powered Wankel SuperTec rotary engine with a shaft-coupled electric generator; electric motor drives for the main and tail rotors; a power train control unit for electric power management; and a battery providing energy for the aircraft's electric propulsion system and on-board systems.

Green Rotorcraft plan

Both AgustaWestland and Eurocopter are also lead partners in the EC/industry-funded 'Green Rotorcraft' integrated technology demonstrator (ITD) program. The plan is to produce by 2020 mature technologies that reduce carbon dioxide emissions over current levels by 25-40% per mission (for rotorcraft powered respectively by turboshaft or diesel engines), and to reduce noise sensed on the ground by 10 EPNdB (effective perceived noise in decibels) or halving the noise footprint area by 50%, while protecting human health and the environment

Project Zero industrial partners

- *Carbon graphite aircraft exterior surface: Lola Composites (U.K.).*
- *Flight control system and rotor design: Sistemi Dinamici and IDS (Italy).*
- *High-integrity flight control computer and actuator control unit: Selex (Italy), with software provided by Wind River (U.S.).*
- *Motor inverter and motor control algorithm: Ansaldo Breda (Italy).*
- *Axial flux permanent magnet electric motors: Lucchi R. Elettromeccanica (Italy).*
- *Rotor blade aerodynamics: AgustaWestland (Italy/U.K.) and Rotor Systems Research (U.S.).*
- *Composite structure for the blades, shrouds, and spokes: Advanced Concepts Group and AgustaWestland (Italy), Japan Asia Technology Center (Japan); fabricated by Uchida (Japan).*
- *High bandwidth electromechanical actuators: Microtecnica (Italy).*
- *Motor cooling system: MB Motorsport, Aerosviluppi (Italy).*
- *Wiring harness and retractable landing gears: Marc-Ingegno (Italy).*
- *Diesel engine alternate electric-hybrid propulsion: Oral Engineering (Italy).*

from harmful chemical substances.

One strategic research area within the ITD is the development of new architectures 'for more electrical helicopters.' These include new concepts such as an electric tail rotor, a brushless starter generator, electromechanical actuators, electric taxiing, an electric regenerative rotor brake, and management of energy recovery.

For the past four years, the Green Rotorcraft program has focused on selecting key research areas and partners to perform specific research tasks. This year tests on a variety of components will use several testbeds, integrating complete subsystems and evaluating them on large test rigs during 2014 and 2015. The Copper Bird Test Rig, under construction by Hispano-Suiza in France, "aims to validate the integration of electrical systems and equipment, the quality of the energy generated, the stability of the electrical network and, more generally, demonstrate the maturity of technologies and systems needed for 'more electric' aircraft," according to the company. The rig has been upgraded as part of the EU's Clean Sky research program to simulate the entire electrical network architecture on helicopters and small regional aircraft.

"The technologies are changing radically with super-capacitors potentially replacing or partly replacing batteries, plus new power components, motors, a wide variety of range extenders including fuel cells and multiple energy harvesting," according to Peter Harrop, author of *Manned Electric Aircraft 2013-2023: Trends, Projects, Forecasts,* published by IDTechEx in the U.K. "But at the current rate of progress we don't see pure electric helicopters becoming available for the leisure market for at least another 10-15 years."

Other efforts

Complementing these 'top-down' approaches by major European manufacturers are 'bottom-up' programs of small all-electric rotorcraft, under development in Germany, France, and throughout the continent.

In August 2011 in Venelles, France, French aerospace engineer Pascal Chretien made the first recorded flight of an all-electric helicopter. He flew a prototype untethered electric-powered manned helicopter featuring counter-rotating rotors, each driven by a brushed DC motor with lithium-ion batteries mounted under the pilot's seat. It hovered about 50 cm above the ground for just over 2 minutes. A French automotive research company, Solution F, sponsored the program.

Green Rotorcraft: Integration of innovative electrical systems technology streams

•Electrical system architecture, electrical network, power management
Required functions and load profiles are established at a vehicle level for different helicopter classes. The corresponding electrical networks are selected according to performance metrics such as balancing weight and engine power performance.

•Brushless starter/generator (S/G) for a turboshaft engine
Current S/Gs feature poor energy efficiency and require substantial maintenance, so a prototype brushless machine with the converter to match a high-voltage network for helicopters is now under development and test.

•Energy recovery, conversion, and storage systems
Prototype systems allowing waste energy recovery from several sources are under development in areas such as heat recovery from engine nozzles and energy storage systems. These will be tested on ground rigs.

•Electromechanical actuation for landing gear
This research will provide an alternative solution for taxiing a helicopter without rotor spinning (safety, fuel saving) and without hydraulic power.

•Electromechanical actuation for primary flight control
The eventual removal of hydraulic systems requires replacement of rotor boosters with all-electric actuators. Two actuators are under development with different specifications: one for the light helicopter segment, the other for the heavy/medium. The first one will be tested on a helicopter on ground, the second one with an 'iron bird' testbed.

•Power supply
The development of flightworthy and compact supply equipment aims at enabling the use of future active control systems.

•Electric tail rotor
This will replace mechanical tail rotor drive shafts, gearboxes, and couplings. Key potential advantages include reduced drive train vibration, fatigue, and noise, overall weight savings, and improved through-life maintenance. A motor for a conventional tail rotor is under development for ground demonstration.

Source: Clean Sky.

One myCopter notion

Then, in October 2011, a Karlsruhe-based German company, E-volo, flew its VC1 for the first time. This electrically powered proof-of-concept vehicle features 16 small propellers (see http://www.youtube.com/watch?v=L75ESD9PBOw). The effort is partly funded with a $2-million grant from the German ministry of economics.

Later this year E-volo plans to have a provisional airworthiness certificate for its all-electric twin-seat Volocopter V200, a commercial development of the VC1. The V200 will have a speed of over 54 kt, a takeoff weight of 450 kg, and an endurance of more than 1 hr flight time.

Also in 2011 work began on the myCopter research program, a long-term project to develop a rotor-based all-electric personal air transport system (PATS), as part of the EC's seventh framework research program. The effort focuses on three major research areas: user-centered human machine interface and training; automation; and a sociotechnological assessment of implementing all-electric PATS technologies. Using RPAS platforms for incremental developments of automation, and three flight simulators—one airborne, two ground-based—the results of the work will be integrated within the German Aerospace Center's Flying Helicopter Simulator.

Air vehicles are also now included in the research agenda of the EC's Innovative Transport SME (small and medium-sized enterprises) Support Action effort, which seeks to improve access by SMEs to research work on future low-carbon road and air transport systems.

✈✈✈

Although there are clear differences of approach between the major European manufacturers wishing to develop more-electric helicopter systems, this is one key area of aviation technology in which Europe seeks to gain some kind of global dominance. Ultimately the speed with which 'more electrical' and 'all-electric' concepts find their way on board rotorcraft will depend mainly on the performance improvements of batteries and supercapacitors. But it is likely that Europe's helicopter sector will be in a prime position for industrially exploiting any gains in electrical storage and charging efficiencies.

Philip Butterworth-Hayes
phayes@mistral.co.uk

Events Calendar

JUNE 6

Aerospace Today…and Tomorrow: Disruptive Innovation, A Value Proposition. Williamsburg, Virginia.
Contact: Merrie Scott, merries@aiaa.org

JUNE 12-14

Sixth International Conference on Recent Advances in Space Technologies. Istanbul, Turkey.
Contact: Suleyman Basturk, rast2013@rast.org.tr

JUNE 17-19

2013 American Control Conference. Washington, D.C.
Contact: Santosh Devasia, devasia@u.washington.edu

JUNE 24-27

Forty-third AIAA Fluid Dynamics Conference and Exhibit. Forty-fourth AIAA Plasmadynamics and Lasers Conference. Forty-fourth AIAA Thermophysics Conference. Thirty-first AIAA Applied Aerodynamics Conference. Twenty-first AIAA Computational Fluid Dynamics Conference. Fifth AIAA Atmospheric and Space Environments Conference. AIAA Ground Testing Conference. San Diego, California.
Contact: 703/264-7500

JULY 14-18

Forty-third International Conference on Environmental Systems. Vail, Colorado.
Contact: 703/264-7500

JULY 15-17

Forty-ninth AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit. Eleventh International Energy Conversion Engineering Conference. San Jose, California.
Contact: 703/264-7500

AUG. 11-15

AAS/AIAA Astrodynamics Specialist Conference. Hilton Head Island, South Carolina.
Contact: Kathleen Howell, 765/494-5786; howell@purdue.edu; ww.space-flight.org/docs/2013_astro/2013_astro.html

AUG. 12-14

AIAA Aviation 2013: Charting the Future of Flight (Continuing the Legacy of the AIAA Aviation Technology, Integration, and Operations Conference. 2013 International Powered Lift Conference and the 2013 Complex Aerospace Systems Exchange).Los Angeles, California.
Contact: 703/264-7500

Washington and the sequester

In Washington, America's leaders continue to be at loggerheads over the size and shape of the federal budget. Democrats and Republicans remain in gridlock over debt and deficit issues, making it difficult for federal agencies to conduct any long-term planning.

The government is operating under a continuing resolution until FY13 ends on September 30 and is likely too dysfunctional to return to a traditional budget thereafter. The White House, House of Representatives, and Senate have each crafted separate budget proposals for FY13, but none of the three is similar to the others—or likely to be enacted.

The process called sequestration, under which funding is automatically reduced for future government operations, is in effect and is not going away.

Secretary of the Air Force Michael Donley, in an unusually candid breakfast talk with defense writers, said ongoing deliberations about budget and strategy are "two separate discussions trucking along in parallel." The secretary has announced that he will be retiring this month.

Donley said that sequestration and strategy are out of sync. Acknowledging that the problem is, in effect, above his pay grade, the secretary said, "It's up to the national leadership, I think, to figure out when those streams cross and how to make the right judgments on a budget plan that fits strategic realities."

Air Force Secretary Michael Donley

Many in Washington would say that instead of two separate dialogues about budget and strategy, the nation's capital is discussing only half of the problem. Everybody in Washington is debating sequestration. Even though major policy reviews are due soon in several key cabinet departments, almost no one in the capital seems to be talking strategy.

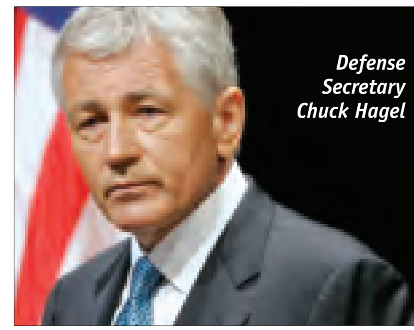
An anonymous blogger suggested that Washington is reacting to sequestration using the Kubler-Ross model, which lists five stages of grief following a trauma—denial, anger, bargaining, depression, and, finally, acceptance. In early May it appeared that agency heads had progressed from denial to anger, with acceptance nowhere in sight.

Budget proposal

The executive branch proposal calls for $3.77 trillion in spending to run government during FY14, which will begin October 1. The plan does not allow for sequestration, even though the sequester is very real. The plan would give a modest 1% pay increase to government workers and military members but retains a pay freeze on senior political officials.

The plan involves small spending increases for some agencies involved in science and research and small cuts for others. NASA would get $17.7 billion, a reduction of 0.3% or about $50 million from the FY12 spending level. The plan for NASA includes full funding for the Space Launch System and Orion crew capsule. The goal is still an Orion test flight next year and a first flight of SLS in 2017, the White House says.

The NASA proposal includes $78 million to study "a robotic mission to rendezvous with a small asteroid—one that would be harmless to Earth—and move it to a stable location outside the Moon's orbit." Many in the space community feel this does not go far enough to scrutinize a situation that could one day involve a genuine threat.



Defense Secretary Chuck Hagel

The defense portion of the budget proposal, released on April 10, also ignores sequestration. Defense Secretary Chuck Hagel testified on Capitol Hill on April 17 and was criticized for this omission. Sen. John McCain (R-Ariz.) told Hagel the administration "put together a budget that ignores the realities of the law today."

Hagel acknowledged that the $526-billion Pentagon budget plan exceeds the law's current spending cap by about $52 billion, or 10%. He said DOD strategists and money managers are now looking at how sequestration will affect funding and that he had ordered "a strategic choices and management review" that will take sequestration into account and may result in a revised spending plan.

Furloughs and less friendly skies

In mid-April, the Federal Aviation Administration responded to sequestration by furloughing employees, one working day out of every 10. This included air traffic controllers at 149 major airports.

FAA Administrator Michael Huerta and his staff understood that by imposing furloughs they were inviting a reaction from lawmakers. However, they may not have anticipated the pushback they got.

The remarkably safe U.S. airways handle 23,000 aircraft every day, according to the Associated Press. On the first day of furloughs, April 15, some 1,200 airline flights were delayed because 1,500 fewer air traffic controllers staffed the system.

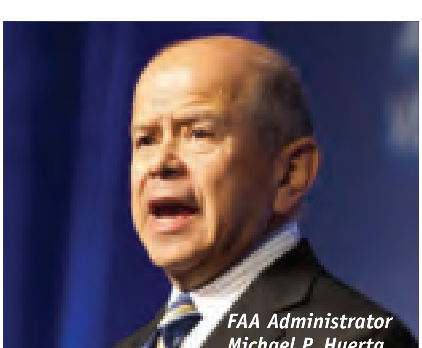
"This is a manufactured crisis," said Sen. Susan Collins (R-Maine). "I would add 'phony and contrived'," Sen. John Cornyn (R-Texas) told the *Washington Post*'s Ashley Halsey III.

Sens. John D. Rockefeller IV (D-W.Va.) and Jon Thune (R-S.D.) sent Transportation Secretary Ray LaHood and Huerta a letter demanding to know how much it would cost to end the controller furloughs. Sen. Harry Reid (D-Nev.) entered the dialogue with a bill that would defer sequestration cuts—a measure seen as purely symbolic. And the National Air Traffic Controllers Association said in a statement that some controllers are being paid overtime so others can be given unpaid days off.

By the end of April, the Senate had enacted legislation that would transfer up to $230+ million from other sectors of the DOT to the FAA. That would be enough to stop further furloughs and keep the air traffic control system operating at a normal pace through FY13. House endorsement (with many members already out of town) followed shortly thereafter, and the president signed off.

LaHood had announced his retirement in January, pending confirmation of his replacement. Obama has nominated Anthony Foxx, mayor of Charlotte, N.C., to be the next secretary.

Few in Washington had expected the FAA furloughs to last, but other sequestration cuts were evident everywhere. At least two dozen air shows that rely on military participation have been canceled around the country. Performances by the Navy's Blue Angels and the Air Force's Thunderbirds flight demonstration teams have been halted. The Air Force has postponed a long-planned move of an F-22 Raptor squadron—24 aircraft, 1,200 airmen and 500 civilians—from New Mexico to Florida. Navy fleet operations have been reduced. As noted last month, the Navy has one aircraft carrier strike group in the Persian Gulf region rather than two as planned.


FAA Administrator Michael P. Huerta

Almost every government agency has its own sequestration story. One State Department officer, referring to an ice cream retailer, said, "If the government were running Baskin-Robbins, it would offer only one flavor." Several polls show Americans have moved past denial—to anger—over the inability of government to fulfill its basic responsibilities.

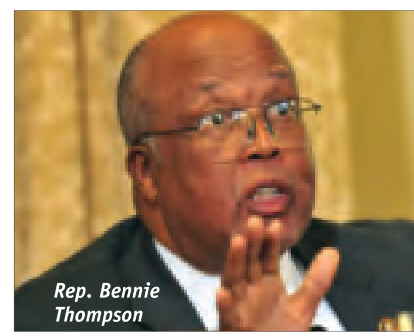
For many in Washington, however, duty still beckons. Hard-working people in industry, government, and the military continue to cope with aerospace issues that resemble the 'old normal' more than the 'new normal.'

Getting the knife

The Transportation Security Administration, the agency everybody loves to hate, said on April 22 that it would postpone changing its list of prohibited items on airplanes. The TSA drew disbelief and anger from pilots, flight attendants, and other aviation professionals when it said in March that small pocketknives, as well as sporting goods like golf clubs and hockey sticks, would be allowed on airliners for the first time since the agency was created in the aftermath of the Sept. 11, 2001, attacks. There was also some negative reaction to the idea from the flying public, though not a lot. With the TSA, the public, it might be said, long ago made the leap from anger to acceptance.

The TSA brouhaha revived the ages-old conflict between citizens wanting to be secure and wanting to be free. "They'll pick 'secure' every time," an airline pilot with libertarian leanings observed. "They've forgotten all about their civil liberties. They forget that we got by for years without having a TSA at all."

Rep. Bennie Thompson (D-Miss.) reflected the opposite, and more popular pro-security view, when he said that a prohibition on items that can be used as weapons is "absolutely essential." After no fewer than 133 lawmakers objected to the planned relaxation of the rules, TSA boss John Pistole


Rep. Bennie Thompson

arranged for Thompson to announce the decision to postpone—and few in Washington believe the postponement is anything other than a full-fledged cancellation.

Text 'no' to texting

The National Transportation Safety Board, a government agency almost everyone likes, reported that the pilot of a medical helicopter that crashed in Mosby, Missouri, in 2011 was distracted by text messages while at the controls. CNN reported that, "to the amazement of safety officials [the pilot] evidently sent several text messages with one hand while piloting the aircraft with the other."

The NTSB reported that James Freudenberg "was distracted by sending and receiving over 10 text messages when he should have been conducting preflight checks." The board said that because the pilot did not perform his preflight properly, he apparently did not know the Eurocopter AS350 B2 was low on fuel. In addition

(Continued on page 17)

Michael Gazarik

Tell us about your vision and plans for your NASA directorate. Why was it formed? What are its goals?

The Space Technology Mission Directorate was established a few months ago. It is focused on developing and demonstrating the technology to enable NASA to go above and beyond low Earth orbit. To explore farther than we ever have, NASA needs a heavy launch rocket and a human-rated capsule, and they are in development. And NASA also needs new technology across a variety of fronts to enable us to explore space, to move in space, to store energy and propulsion power, and to do all the things we need to do to explore on long-distance trips in space.

Give us a sense of the history of your directorate.

We were in formulation and execution for about two years as NASA's Space Technology Program, getting organized, prior to becoming a mission directorate. We're already building, flying, and testing hardware for NASA and for our country—to help the U.S. maintain and improve its technological edge and also to invest in the innovation economy.

Investing in technology and creating high-paying jobs, and helping small businesses and universities that do this kind of work, is a good way to meet some of the economic challenges we have. Creating our directorate gives space technology sharper focus and greater visibility on equal footing with the other three mission directorates that manage human exploration, science missions, and aeronautics. And we have solid backing in Congress and the administration.

Tell us more about working with the universities.

NASA's science mission directorate has a great relationship with a number of universities in projects addressing key challenges the agency faces. My directorate is reemphasizing this relationship. We have formal programs to reengage our universities, letting them know we need their help, their ideas. We now have 350 activities with over 100 universities across the country. We are increasing the number of fellowships. We reach out to the universities in all of our projects.

Does the establishment of your directorate signal a shift in NASA's emphasis and direction?

NASA completed 30 years of operation with the shuttle—a magnificent vehicle—and built and began operating the international space station, and that took much effort and willingness to accept risk. Where NASA is now, though, is back to doing things that we haven't done before, moving beyond low Earth orbit, and to do that, we need new technology and we have to get back into the nation's laboratories in order to get there, and that's what my directorate is all about.

What we're seeing from the work force in NASA's 10 research centers is great excitement, trying to do new things, build new things, making progress. We are at the cutting edge, and excitement is high. The mindset for building and operating the shuttle is different from the mindset for developing and testing new technologies for space exploration, and that's the shift we're making.

So yours is anything but a risk-averse directorate, I take it.

It is not. We push the envelope as far as we can. It is not a good sign if everything always works right. We have to push the envelope. We're like DARPA in some respects, and, if you go back in history, like Bell Labs and other laboratories, for example. They all worked on really tough problems that they weren't sure

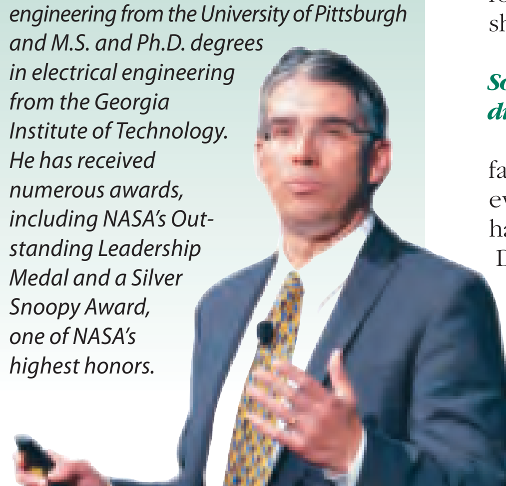
Michael Gazarik is associate administrator of NASA's Space Technology Mission Directorate. He manages and executes the agency's space technology programs, focusing on infusing them into NASA's exploration and science mission needs.

Prior to this appointment, Gazarik was deputy chief technologist and director for space technology. He has more than 25 years' experience in the design, development, and deployment of spaceflight systems, and has contributed to the development of technology with application to NASA's Exploration Systems, Space Operations, and Science missions.

At NASA Langley, Gazarik served as deputy director for programs in the Engineering Directorate. He led the formulation of a variety of programs in aeronautics, exploration, and science.

Prior to joining NASA, Gazarik served as project manager for the Geosynchronous Imaging Fourier Transform Spectrometer project at MIT's Lincoln Laboratory. He led the development of the Airborne Sounder Testbed-Interferometer, an instrument that helps scientists understand temperature and water vapor profiles of Earth's atmosphere, and worked in the private sector on software and firmware development for commercial and government applications.

Gazarik earned a B.S. degree in electrical engineering from the University of Pittsburgh and M.S. and Ph.D. degrees in electrical engineering from the Georgia Institute of Technology. He has received numerous awards, including NASA's Outstanding Leadership Medal and a Silver Snoopy Award, one of NASA's highest honors.



Interview by James W. Canan

how to solve, and they came up with some great breakthrough ideas such as the laser and the transistor. There was a community of organizations and people working on tough problems. What we're trying to do is develop the same kind of community, get them communicating and sharing with each other. When that happens, that's when you get breakthrough ideas.

There are some problems associated with space exploration, like radiation exposure, that require new technologies to overcome, aren't there?

That's right. One of the top needs is radiation protection for humans. Another is a reliable, long-lasting, low-mass propulsion system that will give us the ability to move about in space quickly and efficiently. That ties into solving the radiation problem. The quicker we can get where we're going, the better. So we need technology for propulsion and navigation, including a better clock. That is why we're working on an atomic clock. Those are just some of the problems, and they've been known for a long time.

"We push the envelope as far as we can. It is not a good sign if everything always works right."

How many, and how long?

We have a stack of about 40 reports over the past three decades that have identified the challenges and the technologies that are needed to meet them. We have a lot of reports but not a whole lot of progress. So now our emphasis is on hardware, not on reports. We have nine programs in the technology misson directorate now, and they are all focused on getting hardware built, designed, and tested in the lab and in space. We're getting more and more people back into the labs now, after 30 years in the shuttle program, working on new technology, designing, building, testing, flying, seeing if it all works. That's what we're all about.

How important is the space station in all that?

It is very important. We have a number of projects that are using and will use the international space station. For example, we want to learn and understand what long exposure to the space environment does to materials, and the space station is a great platform for that. One of our newer programs called NICER [Neutron-star Interior Composition Explorer] is exploring how to use X-ray sources for spacecraft navigation.

We're also using the space station to learn more about robotics—about robots working side by side with humans in space. Robonaut 2, a humanoid robot, has been aboard the space station for well over a year, doing maintenance tasks. Robonaut 2 does not have legs, though, and we're developing its legs and will fly them up to the station this fall.

Is private industry heavily involved in your programs, your plans?

Very much so. For example, we are in partnership with General Motors in the robotics program, learning how robots can safely work with crew members on the station and automotive workers in factories here on Earth.

Crews will begin making longer duration flights aboard the ISS in 2015. Will that benefit your directorate?

Yes. The extension of space station flights is an agency-wide decision, and we will take advantage of it to develop and demonstrate our technology. We have to be able to show that our technology really works in space so that the potential users can be comfortable with it and trust it. So demonstrating new technology in space is key for us, and the ISS provides a great platform to do that.

Give us a sense of your timetable for programs.

We've been at this for a little over two years, getting programs established, and now we have a number of challenging and interesting problems to work on, a number of incredible things coming up. As we go to building hardware and demonstrating in space over the next couple of years, some of our demonstrations will begin to take place. One of our most fascinating programs is the solar sail.

Tell us more about that.

It will be the world's largest solar sail, a new way to move about in space without the need of a chemical propellant. We will use the Sun's energy in the form of photons. To get enough force from them, we will need a big sail, and we will be flying one that's over 100 ft by 100 ft—a huge sail.

Why do you want to do this?

For NASA's next mission in heliophysics, which is the study of the Sun. If we can control and maneuver a spacecraft with a solar sail precisely as required, we will be better able to monitor the Sun and look at and predict the space weather generated by the Sun. We will send spacecraft out to L1—Lagrangian Point 1, where the forces of gravity balance out and the spacecraft stays in roughly the same position relative to Earth—and keep it pointed at and around the Sun precisely where we want it to point. The [NASA] Science Directorate's technical survey on heliophysics calls the solar sail a great way to do this.

You mean you will be able to fine-tune the navigation of an object in space with a solar sail based on its interaction with photons?

Yes. It sounds incredible, but it

"It sounds incredible, but it will be just like pitching a sail to control a sailboat on the Chesapeake."

will be just like pitching a sail to control a sailboat on the Chesapeake. We can stationkeep our spacecraft in position by managing the momentum of photons. The company that's doing this for us is L'Garde in Tustin, California, working with Dupont. It won the NASA competition for the solar sail contract. All of our programs have a competitive element. Our solar sail demonstration in space is scheduled for 2014.

Earlier this year the Obama administration announced its plan to have NASA go out into space and capture an asteroid. What is your directorate's role in the asteroid mission?

We move it. The mission leverages a lot of what our directorate has been doing. We've been working on developing solar-electric propulsion, and this mission will be a great way for us to demonstrate it. Solar energy will power the spacecraft out to capture the asteroid and bring it back.

Why solar electric propulsion?

It is the most efficient way to get to the asteroid. The spacecraft could not carry enough chemical propellant to do that; the propellant would be too massive. Solar electric power has been used on many spacecraft, but we need it to produce a much higher level of power. The state of the art today for spacecraft is a total 25 watts of solar power. To get more power, we need bigger solar arrays. The arrays we have today can't collect enough of the Sun's energy.

Solar cell efficiencies aren't what they need to be. So we need a bigger, better structure and we need to learn and understand how we're going to deploy those big solar arrays. They may be more than 100 ft in length. And we have to learn and understand how to manage them structurally and thermally.

How long have you been working on solar-electric technology?

We've focused on high-powered SEP for over a year, and that early investment allows NASA to go do the asteroid mission. So we are working closely with the human spaceflight team and the science mission team on how to do the mission, and my Space Technology Mission Directorate is going to develop the solar propulsion system that will get us there and back.

Is cutting the weight of propellants and the cost of propulsion important in your technology development?

Absolutely. It's very expensive for NASA to get off the surface of the planet, and that's a big challenge from a chemical propulsion perspective. One of the advantages of solar electric propulsion is that it's very mass-efficient. You don't need a lot of mass to move. Now the solar-electric thrusters don't generate a lot of force, but it's enough to provide constant acceleration. One of the problems is that the highly charged particles that come out of the back end erode the walls of the thrusters, and over time you lose thrust as your walls erode. So one of the advances we've been working on is to develop a magnetic control shield that basically prevents the erosion. This great work is being done by Glenn and by JPL.

What else does your directorate have in store?

Another project, called lasercomm, we're working on at Goddard. The Mars rovers take great images of the planet but most of them remain on Mars because we cannot get them back. So we're exploring laser communications—using optical communications and lasers to send data back and forth from Earth to space.

The Europeans have made some progress with using lasers for communications between low Earth orbit and geosynchronous orbit, and we're tied into that. But the harder job is going from space to ground, because we have to get the laser cleanly through the atmosphere, which has a distortion effect. We think that's solvable, using adaptive optics. We will test it on our LADEE [lunar atmosphere and dust environment explorer] mission with a satellite that has a laser optical terminal.

Do you have any other propulsion projects in mind besides solar sail?

Yes, and a demonstration will take place in 2015, a demo of the technology of a new, green propellant for maneuverability in space. Spacecraft typically use hydrazine for maneuverability, a chemical that's been in existence for years. Hydrazine is high performing, works very well, but is very toxic to humans, so when you load a spacecraft with hydrazine on the ground, you have to take a lot of precautions. So we are trying to develop an alternative propellant that is much greener and safer.

I take it that going green is not your main goal in this endeavor.

That's right. We're not doing it primarily to get a green propellant, we're doing it to try to get a replacement for hydrazine. We have a competitively selected project led by Ball Aerospace and Aerojet to demonstrate this new alternative propellant. We think it will have a big effect. We want to show that it performs just as well as, or better than, hydrazine. It works in a larger temperature range, and it's more dense than hydrazine, so we can carry and use less of it. And it's less toxic, so we can easily load spacecraft with it on the ground. But we still have to prove to the world that it's going to work.

How will you test it?

We're going to build a spacecraft, a whole new system, with new thrusters made by Aerojet. We have to show the spacecraft builders in the aerospace community that they can have confidence in the whole system, so it's got to be a system demonstration in space under a variety of condi-

"We are customer-focused, we are going to solve problems, and that's our real push."

tions to show that it works safely and reliably, that the performance is there.

This is a great role for my directorate; we're leveraging what's already out there. It would be hard for private industry to take the risk and spend the money to do this. Propellant alternatives have been developed for years, but no one has been able to pick up the ball and spend enough money to demonstrate them in space, and this is where the government comes in, and it's a great role for us.

So NASA believes that this will induce the companies to spend money themselves on developing and utilizing non-hydrazene alternatives?

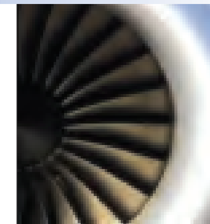
That's right, and we think we can leverage a larger part of the whole aerospace industry by working on the tough problems, attacking them, and by taking risks where it would be hard for private companies, for the industry, to do so. That's a key role for us in the Space Technology Mission Directorate. We are customer-focused, we are going to solve problems, and that's our real push.

Are you working with other government agencies?

We are working closely with the [White House] Office of Science and Technology Policy and the Office of Management and Budget. OSTP was a big architect and proponent of our program, especially in its early days, in setting it up and focusing on the types of problems we would be facing. We work with them on a number of national initiatives, including one on advanced manufacturing—a multi-agency initiative—that President Obama mentioned in his State of the Union message this year.

As you point out, a lot of this work has been going on for some time. So is it fair to say that the creation of your directorate is NASA's way of bringing it all together and highlighting the need and the enthusiasm for new space exploration technology?

Yes, and I think there was recognition by [NASA Administrator] Charlie Bolden and others within the agency that we needed an organization to go do this, and by [mission directors] Bill Gerstenmaier and John Grunsfeld that they want to do more missions and more capable missions, and that the Space Technology Mission Directorate can help with all that. We're going to do things that haven't been done before, and in a new way.



Regional jets: Running to stay in place

THE REGIONAL JET MARKET IS FLAT, but has attracted many new industry entrants. The arrival of new-generation engines has enabled one next-player to gain some traction on the market, although some others face uncertain prospects.

This new entrant challenge has induced very different reactions by the two legacy regional jet market leaders. One is reinventing itself to survive, while the other seems content to gradually fade away.

A flat market

There is little about the regional jet market that inspires hope. It was the only segment of the aviation industry that did not grow during the great 2003-2008 boom market. Large commercial jetliner deliveries grew at a 7.4% annual growth rate in that period, and continued growing at a 12.4% rate in 2008-2012. Yet regional aircraft grew at a mere 4.4% rate in 2003-2008, and even this was completely due to turboprop deliveries growth (regional jets stayed flat). Worse, in 2009 the regional sector declined by 13.1%, and all told fell by 34% in 2008-2012. Between 2009 and 2010 Embraer, the largest regional player, saw its backlog drop from 375 jets to 229.

In 1989, regional aircraft deliveries were 15% of the total world transport market by value. In 2012, they were 6.4%. High regional jet seat-mile costs (worsened by high fuel prices), persistent airline pilot scope clauses (agreements between pilots' unions and airline management that limit how many large regional jets an airline can fly), and problematic relations between major and regional carriers all portend continued market flatness in real terms, and shrinkage in relative terms.

Not only is this market flat, it is also heavily concentrated. The 2,000 jets based in North America represent about 60% of the world's fleet. Asia, which has become the biggest single market for large jetliners, has a mere 230 regional jets, or 7% of the fleet. The importance of penetrating the North American market has greatly complicated the efforts of new market entrants.

Enter the new generation

Despite the challenges associated with entering this market, three new regional jet producers have thrown their hats in the ring. The biggest success, and a major surprise, has been the Mitsubishi Regional Jet (MRJ), powered by Pratt & Whitney's PurePower PW-1000G geared turbofan (GTF).

In October 2009 the MRJ scored a notable breakthrough with a tentative order for 50 firm and 50 option planes from Trans States Holdings, the parent company of Trans States Airlines and GoJet Airlines. A firm contract was expected by the end of the year, but did not arrive until February 2011. In July 2012 SkyWest announced a tentative commitment for 100 MRJ90s. This order, for 100 firm and 100 option craft, was firmed up in December 2012.

The Mitsubishi Regional Jet has been the surprise success as a new enrant in the regional jet market.

The once and future king

In 2006, two years after it began deliveries of its E-Jet series, Embraer surpassed Bombardier as regional jet market leader. This successful program has since allowed Embraer to maintain its top position. However, the company continued to delay any kind of reengining upgrade, even as it became clear that the market preferred products with the new engines.

Finally, in January of this year the company announced that it too was adapting Pratt's GTF, specifically going with the 15,000-22,000 lbt PW1700G and PW1900G. The new family will enter service in 2018. However, since January, no launch customer has been announced, and no timing has been provided as to when such an event might occur.

Going with Pratt's GTF offers the safest path to compete with the MRJ, and the Pratt engine offers impressive new technology. However, moving away from a General Electric powerplant means Embraer can no longer count on GE's GECAS leasing unit for orders. GECAS has provided about 50 orders for the current E-Jet series.

Pratt & Whitneys' PurePower is becoming the go-to engine for many regional jet builders.

Embraer's experience with offering a reengined E-Jet series echoes similar episodes in the industry, particularly Airbus with its A320neo (New Engine Option) series and Boeing with its 737 MAX. Any airframer announcing a new engine program runs the risk of watching orders for its current generation of jets dry up, as customers elect to wait for the new model. This means they can face a few years of declining production rates, or, alternatively, declining profits as they are forced to discount prices on current-generation jets in order to keep sales up.

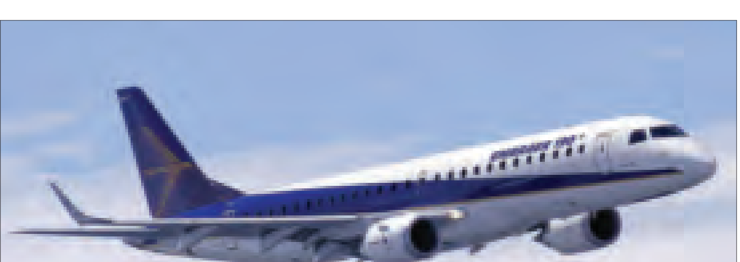
While unpalatable, this reengining decision is necessary if a new or current competitor has an advantage. Airbus was forced to launch the neo in response to Bombardier's CSeries, which uses the GTF; Boeing had to launch the 737 MAX to respond to Airbus's neo.

In short, Embraer quickly found out that the only thing worse than cannibalizing your own backlog is to have competitors do it for you.

Bombardier's difficult options

Now that the regional jet battle revolves around new engines, former market leader Bombardier risks being left behind. After building more than 1,600 CRJ series regional jets, deliveries have trailed off markedly, with just seven -900s and seven -1000s delivered in 2012.

As of the start of the year, there were 107 CRJs on backlog, compared with 185 E-Jet series jets. This isn't a disaster, especially since a few months earlier the CRJ backlog was down to just around 50 planes. However, the CRJ backlog was increased last year by 40 -900s for Delta. This order competition victory resulted from a unique Bombardier advantage with this customer: Delta has the largest CRJ-200 fleet by far, and wanted to return many of them. This allowed Bombardier to offer generous trade-in terms, an advantage that likely will not be repeated in many more competitions. The advantages of going with a new engine (on an MRJ or ERJ) will weigh against Bombardier in the future, particularly as fuel prices stay high.



Embraer has sat atop the leader board since its entry into the regional jet market.

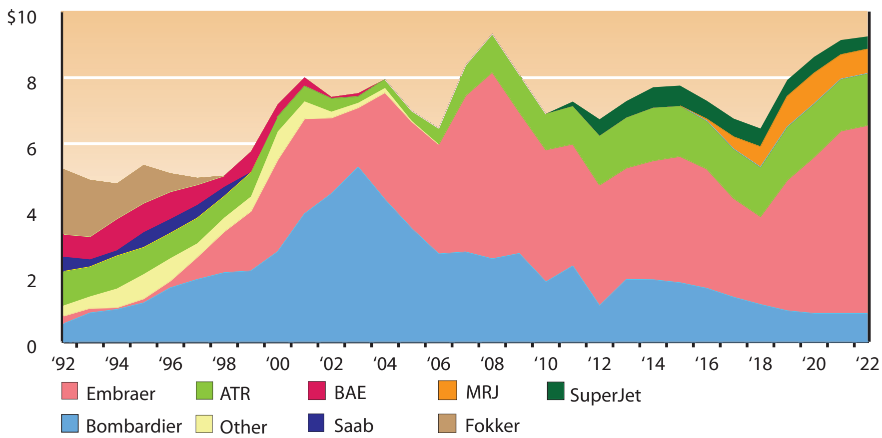
Also, Bombardier, unlike Embraer, has no plans to upgrade the basic CRJ design. Given the massive corporate challenge of bringing the CSeries jetliner to market, along with other challenges such as developing the Lear 85 and Global 7000/8000 business jets, Bombardier is unlikely to find the resources necessary to do anything more than a superficial refresh to the series. Given the CRJ's smaller and older airframe, it is possible that introducing newer engines would be technically difficult.

In addition, given Bombardier's focus on the CSeries, it is clear that the company wishes to focus on the larger mainline jet market, taking advantage of that segment's larger size and faster growth rates. It is quite likely that the company views regional jets as a mere legacy, and a distraction moving forward. The CSeries, of course, is generally too large and heavy to compete effectively in the regional market, although it does offer some appeal against smaller versions of Airbus's and Boeing's single-aisle families.

Delta is a mainstay customer for the CRJ.

Still, an intriguing possibility presents itself. General Electric's Passport engine (formerly NG34) might provide the basis for a major CRJ upgrade, if GE provides the resources. The 16,500-lb Passport 20 has been selected to power Bombardier's Global 7000/8000 business jets, and will enter flight testing in 2014. However, this new engine series has not been selected for any kind of regional jet application. While the CF34 also powers COMAC's ARJ 21, that aircraft's likely death eliminates that prospect of another General Electric platform. The MRJ's arrival,

REGIONAL MARKET DELIVERY SHARES BY MANUFACTURER
(Value of deliveries in 2013 $billions)



and the E-Jet reengining decision, means GE will go from overwhelming market dominance (the CF34 series powers both the CRJ family and the E-Jet family) to exactly zero new-build market presence.

GE is therefore a wild card in this market. If the engine maker pays for some or all of a reengined CRJ's development and certification bill, and adds the weight of GECAS's market clout (perhaps even providing launch orders too), the CRJ could be rejuvenated. Bombardier, and General Electric, would be able to maintain a position in the regional jet market longer than currently anticipated.

Bombardier, in short, offers a superb illustration of regional jet market dynamics. Given a flat market and the threat posed by new competitors, legacy manufacturers need to keep running just to stay in place. Embraer did not want to run, but decided it had no choice. Bombardier seems to have decided not to run. And unless General Electric provides direct support, Bombardier will gradually leave the regional jet race.

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(Continued from page 9)

to the pilot, the crash killed flight nurse Randy Bever, paramedic Chris Frakes, and patient Terry Tacoronte.

The AP reported that the helicopter tragedy underscored the NTSB's worries that "distractions from electronic devices are a growing factor in incidents across all modes of transportation—planes, trains, cars, trucks, and even ships."

The news of the distracted pilot came just after the bipartisan Ralston Institute issued a report citing texting as a greater danger on the nation's highways than drinking. Moreover, the report concludes, the nation is becoming increasingly aware of the problem and taking it more seriously—witness the murder charge filed against a Utah woman for hitting two pedestrians, killing one, while simultaneously driving and using a hand-held device.

No U.S. airline crashes have been linked to the use of electronic devices, but the FAA—which often acts on recommendations by the NTSB—in January proposed regulations prohibiting flight crews from using cellphones and other wireless devices while a plane is in operation. The regulations are required under a law passed last year by Congress in response to an October 2010 incident in which two Northwest Airlines pilots overflew their destination of Minneapolis-St. Paul International Airport by 100 miles while they were engrossed in working on their laptops.

No drone medal

On April 15 Secretary Hagel scrapped a new medal for unmanned aerial vehicle pilots and cyber specialists. Hagel's decision to abandon the Distinguished Warfare Medal, which had been unveiled by predecessor Leon Panetta just weeks earlier, was a surprise even though the medal drew strong criticism from Capitol Hill.

Most in Washington had expected Hagel to defend the new form of recognition for Americans engaged in a new kind of warfare that uses remote technology. The medal would have recognized specific acts—such as a critically timed UAV aerial strike that neutralizes an important target—rather

Rep. Duncan D. Hunter

than constituting recognition merely for being on duty. Hagel's action took place before the medal was awarded to anyone.

One highly visible opponent of the award was Rep. Duncan D. Hunter (R-Calif.), who served as a Marine in Iraq and Afghanistan (and is the son of the congressman he replaced in 2009, also named Duncan Hunter). "I wasn't as concerned about the medal as about where they placed it in the order of things," Hunter said in a statement. Until Hagel killed it, the medal was rated above the Bronze Star and Purple Heart in the hierarchy of awards.

Hagel indicated the DOD would find a different way to recognize UAV and cyber duty. USAF Lt. Col. Matt J. Martin covered the dichotomy of this form of military service in the book *Predator*. He wrote of flying at 10,000 feet over Baghdad, pinpointing insurgents with a laser, and guiding an AC-130U Spooky gunship to unleash a barrage of weapons fire that killed dozens of the enemy. "Then," Martin wrote, "I remembered that Trish had asked me to pick up a gallon of milk on the way home."

The operators of UAVs work in Nevada, California, and Arizona and live in everyday American communities even though their MQ-1B Predator and MQ-9 Reaper drones fly combat missions in overseas war zones. (The discussion and the medal apply to military members; CIA operators, who handle drones outside the war zones in places like Pakistan, would not have been eligible for the medal). Even though they commute to work and live with their families, many in the UAV community experience post-traumatic stress disorder according to Patience Mason, an author and authority on PTSD. "It's very real," Mason said in an interview. "In my opinion, killing people is a traumatic stressor.

"In the original list of traumatic stressors, because everyone, veterans and mental health providers, believed killing other people was a manly thing and wouldn't be traumatic, it was not listed," Mason said. "What was considered traumatic was when someone tried to kill you, your friends, or even people you didn't know. When drone operators started having PTSD, it was no surprise to me. They see the people they kill up close and personal, see the body parts and wounded and dead afterwards. That is traumatic."

The question of how to recognize the service of drone operators and cyber warriors, like so many questions lingering in the summertime air in the nation's capital, now awaits an answer at some future date.

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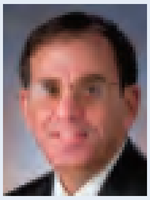

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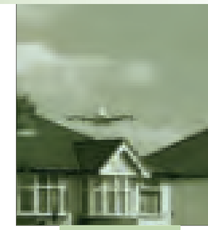
ERA Phase 2: A descending hush



UNDER NASA'S FIXED WING AND ENvironmentally Responsible Aviation (ERA) projects, finding a way to reduce airframe noise during an aircraft's landing approach has remained an important area of research.

During both takeoff and landing, the engines of modern commercial planes are much quieter than those of previous aircraft generations. This is helping to reduce the noise burden on communities in and around airports. But reductions in airframe noise have not kept pace. Today, it is well known in the industry that airframe noise is comparable to or even louder than engine noise during aircraft approaches to landing. As a result, communities under the glidepaths to runways at major airports must still endure noise levels much higher than they—and NASA—would like.

Now, under ERA Phase 2, eight integrated technology demonstration (ITD) areas have been selected to move toward flight demonstration by 2015. One of these is a 'flap and landing-gear noise reduction flight experiment.' Based on work in ERA Phase 1, NASA felt that flaps (including leading-edge slats) and landing gears might offer particular promise in terms of reducing airframe noise. Throughout the ERA project, the agency has partnered with Gulfstream Aerospace on airframe noise research.

For Phase 2 of NASA's ERA project, Mehdi Khorrami's team is testing flap and landing gear noise-reduction technologies using a half-span, 18%-scale model of a Gulfstream G550 installed in Langley's 22x14-ft wind tunnel.

Mehdi Khorrami, a NASA Langley scientist who is ITD lead for the flap and landing-gear experiment, says these components are major sources of airframe noise. Slats are another prominent source and are being addressed under the Fixed Wing project.

ERA Phase 1 research, Khorrami recalls, started with high-fidelity numerical modeling of airflows over various reduced-noise flap and landing-gear design concepts. The modeling used CFD simulations and analysis run both by NASA in-house software and third-party software developed by Exa.

"One of the unique things about our noise-reduction concepts is that they are not just based on cut-and-tried models, but are significantly based on computational simulations," Khorrami says. NASA tested multiple iterations of its design concepts in virtual space, and only after refining them until it felt they were optimal did the team build physical scale models and test them.

Research challenges

Especially challenging for Langley was that it could not just design a new noise-reducing flap in isolation and pair it with a noise-reducing landing-gear fairing without accounting for their mutual interactions. (Although landing-gear fairings are included in the research, Khorrami says, NASA is going through the patent application process for some of the concepts, so he is constrained from describing them further.) The new landing-gear and flap configuration concepts effectively had to be weight- and fuel-efficiency neutral in order not to affect ERA's integrated technology goals.

In addition, NASA had to be careful that smoothing the airflow around a landing-gear unit did not worsen the noise source mechanisms associated with the airflow hitting another part of the airframe. "You also want [the airframe] more 'draggy' for landing—the ideal-case scenario is that you want 'silent' drag," says Khorrami.

Small-scale models of landing-gear units and other reduced-noise components were tested in Virginia Tech's wind tunnel, although the tests did not involve integrated sets of such parts. Khorrami notes also that small-scale testing can go only so far. "The ultimate test is in the real environment—with a smaller scale model, you cannot maintain the geometries accurately. Noise sources are notorious in that every little detail matters."

Gulfstream model testing

As part of ERA Phase 2, NASA is continuing to partner with Gulfstream Aerospace and has created an 18%, half-span model of a Gulfstream G550 executive jet. The team is testing integrated combinations of its concepts in the 14x22-ft subsonic wind tunnel at Langley. The model is mounted vertically in the wind tunnel and its design modified very slightly compared with the real aircraft to mitigate boundary-layer effects within the tunnel. This ensures that the model's aerodynamic properties are the same as those of the G550.

To measure the airframe noise generated by the model and its noise-reducing flap and gear modifications, 97 microphones are mounted on a round traversing array inside the wind tunnel. The array can be moved along the flow direction, allowing it to obtain the same kind of data it would obtain if an aircraft were passing by. (The model in the tunnel is in a fixed position.)

"Certification only calls for noise measurement in the vicinity of the

In Langley's 14x22-ft wind tunnel, the team uses a round traversing array with 97 microphones mounted on it to measure the airframe noise generated by the half-span Gulfstream G550 model and its noise-reducing flap and gear modifications.

overhead direction, but NASA is all about proving there is significant noise reduction in every relevant direction for community noise," explains Khorrami. His team has tested five or six different landing-gear modifications and seven or eight different flap designs; in all, he says, the team has tried well over 30 different variations and permutations of different concepts.

Gulfstream Aerospace has performed flight tests using a G550 fitted with pressure ports and other sensors at the same relative locations as the sensors fitted to the half-span model in the Langley wind tunnel. This is to measure in a real aircraft the aerodynamic sources of airframe noise. Thus the company has acquired data on pressures on landing-gear units and flaps in a flying aircraft while its partner NASA has been obtaining data on the effects of noise-reduction modifications from the model in the wind tunnel. According to Khorrami, a preliminary look at its data by Gulfstream Aerospace indicates "very good" agreement between the flight test data and NASA's model-derived data.

Lowering landing-gear noise

While Khorrami cannot talk in detail yet about NASA's landing-gear noise-reduction concepts, he does say one promising idea involves using separate fairings for each landing-gear unit's upper struts and another for its wheels. The fairings must be designed so that the landing-gear unit remains retractable and stowable. Whatever fairing concepts are chosen for flight test, they will have to be designed to prevent water from gathering in the landing-gear units and to allow mechanics easy access to the landing gear for inspection and repair.

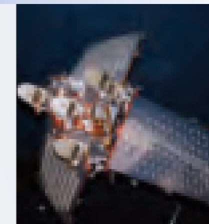
NASA Langley has based these landing-gear efforts on two-wheel bogies, but Khorrami is "very confident" that concepts to suit four- or six-wheel versions can be developed using high-fidelity simulation. "There is a lot of interaction between the various components of the landing gear—this is where we did the very high-fidelity simulations—but the design procedure can be extended to any landing gear with any number of wheels," he says. 'Very high fidelity' in this context means that every brake piston, hydraulic line, and fastener is simulated in very fine detail, Khorrami adds.

Because NASA has already patented some of its flap noise reduction concepts, Khorrami can be more forthcoming about them. He says Langley's research has focused on flap tips, since this small area, where minitornados develop as a byproduct of lift, is the source of much of the flap noise. Back in 2004, NASA Langley experimented with a design concept called a continuous mold line (CML), which kept the flap tip attached to the wing so that there was no flap-tip area when the flap was extended and hence the noise sources became much weaker. However, the CML design involved a large flap area and was not ideal for structural reasons.

FLEXSEL, ROLD, and FENoRFins

Khorrami says NASA Langley is now focusing much of its noise-reduction attention on a patented design called a 'flexible side edge link' (FLEXSEL). This relies on an elastomeric material

(Continued on page 25)



Expanding customer base for space payloads

If you look back at the number of space payloads launched (successfully or not) to Earth orbit during the past decade, the low point was in 2004, when the total was only 76. Note that by 'payloads,' we refer to any satellites or capsules. We also mean any distinct piece of hardware or equipment carried to the ISS during its assembly period.

There were only 55 launches attempted in 2004, and four of those missions were failures—the launch of the Telstar 8 commercial communications satellite by a Zenit 3SL rocket, the Offeq 6 military spy satellite by a Shavit 1, the Demosat instrumented dummy satellite and two military technology satellites (Ralphie and Sparky) by a Delta IV-Heavy, and the Sich-1M and Mikron civil Earth observation satellites by a Tsyklon 3.

That leaves 69 payloads that actually made it to orbit in 2004: 25 civil payloads, 22 military, 19 commercial, two university, and one nonprofit. Of those, 63 were satellites and six were capsules carrying supplies or crews to the ISS. (Technically, anything that goes into an orbit is a satellite, but we prefer to differentiate between these two types of payloads.)

Nearly 60% of the payloads were small (100-1,500 kg) or medium-sized (1,500-4,000 kg); 26% were large (4,000-5,500 kg), extra-large (5,500-6,500 kg), or heavy (over 6,500 kg). The remaining 14% were nano/pico-sized (20 kg or less) or micro-sized (20-100 kg). Sixty-one percent of the payloads were launched to LEO, 23% to geostationary (GEO), 9% to medium Earth orbit (MEO), 4% to elliptical, and 3% to deep space.

The payloads were launched using 23 different types of rockets: Europe's Ariane 5G; the U.S. Atlas IIAS, Atlas IIIA, Atlas V, Delta II, Taurus XL, and Titan 4B; Russia's Cosmos 3M, Dnepr 1, Molniya M, Proton K, Proton M, Soyuz 2.1a, Soyuz FG, Soyuz U, Tsyklon 2, Zenit 2, and Zenit 3SL; India's GSLV 1; and China's Long March 2A, 2B, 2C, and 4B.

The payloads belonged to government agencies, companies, universities, or organizations from 15 different countries or regions: Argentina, 2; Canada, 2; China, 10; Europe, 2; France, 7; India, 1; Italy, 1; Japan, 2; Russia, 20; Saudi Arabia, 3; Spain, 2; Taiwan, 1; Netherlands, 4; U.K., 1; and U.S., 11.

Market snapshot

The space market, which is driven primarily by the payloads market, appeared completely stagnant in 2004. Not many new satellites or capsules were being ordered. Nor were many new launch contracts awarded. In fact, in 2005, the number of launches attempted (55) was the same. Three ended in failure, leaving a total of, again, 69 payloads (62 satellites and seven capsules) sent to orbit. Clearly there was a sense of being stuck.

Not only was there little in the way of new contract work; there also were relatively few new payloads being proposed for manufacture and launch over the short (2-3 years), medium (4-6 years), or long term (7-10 years).

At the Berlin Air Show in early 2004, we released our Worldwide Mission Model: 2004-2013, listing planned payloads for that 10-year span. We were able to identify only 1,209 payloads—a drop of 14% from our model in 2003, which had counted 1,410 payloads. Our 2003 model, in turn, had diminished in number from the previous year, which had listed 1,547 payloads.

As this column noted in 2004, "We peaked in 2001 when we identified 2,160 payloads proposed for launch during 2001-2010….There are just not enough new commercial satellites being proposed to make up for all those commercial satellite programs that have died of attrition during the past few years."

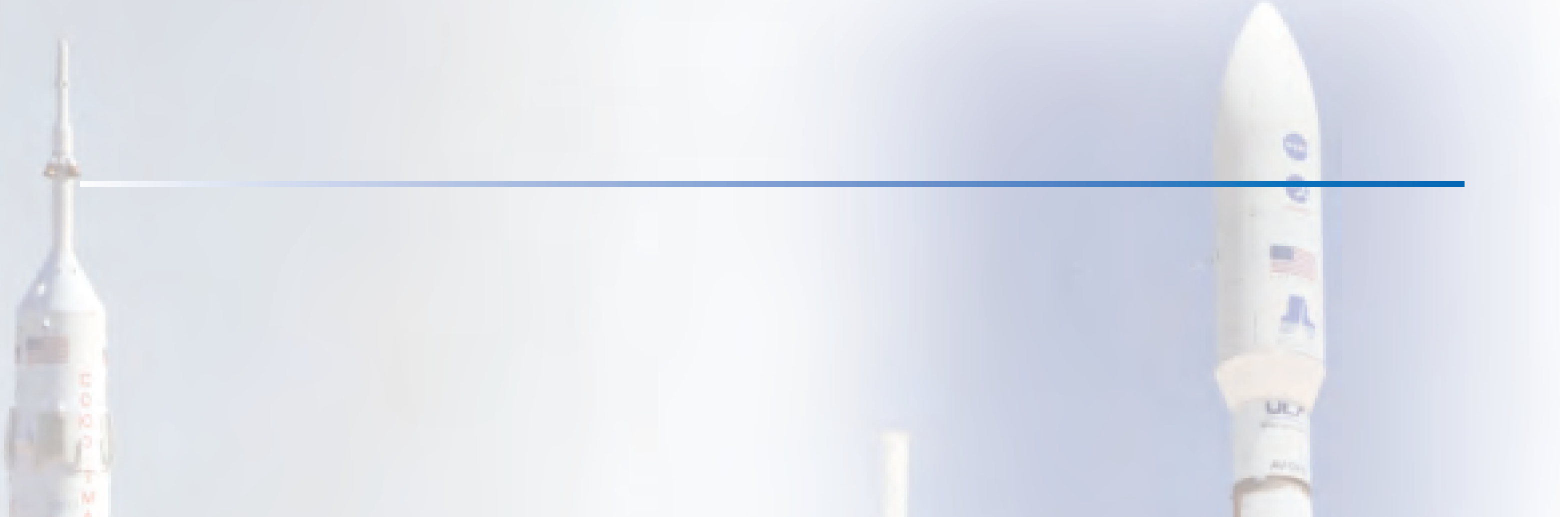
From 2001 through 2004, hundreds of payloads that governments and companies had been envisioning simply dropped off the radar. There was no development work or financing activity of any consequence within these programs, so we opted not to factor them into either our model or our forecasts.

Uninterrupted growth

However, in 2005, we did notice that things were starting to change a little in the market—more contracts, and particularly more talk about new programs. In our model that year for the period 2005-2014, we counted 1,297 payloads—a 7 % increase from the pre-

NUMBER OF PAYLOADS BY MARKET

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Civil	74	205	156	62	38	56	39	40	36	39	**745**
Commercial	54	142	141	130	35	32	31	43	38	43	**689**
Military	36	68	94	80	54	48	24	21	16	16	**457**
University and nonprofit	53	60	63	27	23	10	8	5	9	6	**264**
Total	**217**	**475**	**454**	**299**	**150**	**146**	**102**	**109**	**99**	**104**	**2,155**



NUMBER OF PAYLOADS BY ORBIT

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
LEO	170	317	341	233	109	98	63	62	65	78	1,536
GEO	23	80	66	31	26	31	22	22	21	15	337
MEO	16	27	16	21	9	7	14	19	7	5	141
Deep space	4	34	21	8	6	9	3	6	3	4	98
Elliptical	4	17	10	6	0	1	0	0	3	2	43
Total	**217**	**475**	**454**	**299**	**150**	**146**	**102**	**109**	**99**	**104**	**2,155**

vious year. This was followed by a 10.5% increase in our model for 2006-2015, which included 1,450 payloads.

The number of payloads proposed around the world has continued to grow without interruption ever since. Our latest model has 2,155 payloads for 2013-2022. Moreover, the number of payloads launched annually since 2006 has remained above 100. It has surpassed 110 each year, except in 2008 (105). The number of launches has been above 60 every year since 2006, and over 70 annually since 2009.

So the space market has recovered since its low point in 2004, and it also has stabilized. It is not what we would characterize as a 'booming' market. But looking at what has occurred during the past three years, we feel there is much reason for enthusiasm and hope. For example, there are far more payload customers from many more countries than ever before.

In 2010, payloads were launched for agencies, companies, universities, and organizations from 21 countries. Unsurprisingly, the numbers for the U.S. (52), Russia (29), China (18), and European nations (19) were strong. But countries such as Egypt and the Ivory Coast also launched payloads, as did about 43 different customers from these and other nations.

In 2011, the number of countries launching payloads rose to 25. Among the most active were the U.S. (48), Russia (25), China (19), Europe (13), and India. Others included Chile, Iran, Kazakhstan, Mexico, Nigeria, Pakistan, Singapore, South Africa, Turkey, the United Arab Emirates, and Ukraine. About 57 different customers from these and other countries launched payloads.

In 2012, the number of countries launching payloads rose again, to 28. Europe (29), U.S. (22), Russia (22), China (21), and Japan (7) led the way, but others were also active, including Belarus, Brazil, Indonesia, Iran, Mexico, North Korea, South Korea, Turkey, UAE, Venezuela, and Vietnam. Some 62 customers launched payloads.

The number of government agencies, companies, universities, and organizations that are becoming players in the buying and operating of space payloads is consistently growing, as is the number of countries. In 2004, 15 countries launched payloads. Last year it was 28. In 2004, there were 32 customers that launched. Last year, there were 62.

Future implications

These are extremely positive trends that bode well for the industry's future. While the number of payloads being launched each year (and their total dollar value) may not be nearly as high as what many in the 1990s had expected it to be by now, there are a lot more players in the market, and they will be buying more and more payloads every year.

During the past 10 years, for example, about 225 agencies, companies, universities, and organizations in 55 countries have launched payloads to orbit. By comparison, we estimate there will be more than 350 payload customers from nearly 100 countries over the next 10 years. Our Worldwide

NUMBER OF PAYLOADS BY MASS

Mass, kg	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
<20	88	62	86	63	44	13	15	9	14	13	407
20>100	10	53	51	45	13	14	3	3	0	4	196
100>1,500	65	231	211	129	45	54	45	52	41	52	925
1,500>4,000	20	62	46	26	19	29	10	9	11	9	241
4,000>5,500	8	23	16	10	8	15	10	13	6	10	119
5,500>6,500	10	16	24	11	8	6	7	8	14	3	107
6,500>	16	28	20	15	13	15	12	15	13	13	160
Total	**217**	**475**	**454**	**299**	**150**	**146**	**102**	**109**	**99**	**104**	**2,155**

NUMBER OF PAYLOADS BY CUSTOMER REGION

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
North America	102	183	183	141	64	56	25	30	31	38	853
Russia & CIS	35	48	76	42	29	30	31	21	26	24	362
Europe	42	121	94	71	28	31	15	23	14	9	448
Asia and Pacific Rim	29	77	72	30	22	21	23	27	20	25	346
Latin America and Caribbean	7	24	18	14	5	5	6	5	4	7	95
Africa and Middle East	2	22	11	1	2	3	2	3	4	1	51
Total	**217**	**475**	**454**	**299**	**150**	**146**	**102**	**109**	**99**	**104**	**2,155**

Mission Model for the period 2013-2022 specifically identifies 320 of these customers and 70 of these countries, and it names the 2,155 payloads that they are proposing either to build or to buy and launch.

Thirty-five percent of the payloads are civil—meaning government nonmilitary. Thirty-two percent are commercial, 21% military, 12% university or nonprofit. Of the roughly 1,109 payloads launched during 2003-2012, 40% were civil, 26% commercial, 26% military, and 8% university or nonprofit. We do believe that the growth trends favor commercial and university/nonprofit payloads.

In the next two or three years alone, there will be dozens of Globalstar, Iridium, and Orbcomm mobile communications replacement satellites launched to LEO, along with some 30 Galileo navigation, 20 O3b broadband communications satellites headed for MEO, and perhaps others less certain, such as the 24 Cicero meteorological satellites for LEO. There are potentially hundreds of pico-, nano-, and microsatellites from hundreds of universities—many of which are just waiting for affordable launchers. We have identified more than 200 university satellites proposed for launch in the next five years alone. We anticipate a lot more of them 5-10 years out.

Civil vs. military payloads

Civil payloads will not dominate quite so much as in past years because of public funding constraints in the U.S. and Europe. However, because of expanding national programs in China and India, payloads from countries recently entering the space market, and the increasing use of picosats, nanosats, and microsats by governments, civil payloads should make up at least one-third of the total.

We foresee military payloads comprising less than 20% of the market. The U.S. and Russia will continue to build and launch the vast majority of military payloads, and the U.S. in particular will increasingly employ picosats, nanosats, and microsats for imaging, communications, and technology development missions. A noteworthy program in this category is Colony 1, which calls for a constellation of 50 3-kg technology CubeSats built by Boeing Phantom Works for surveillance and reconnaissance. Another is the Kestrel Eye system, which would consist of six 15-kg nanosats built by Andrews Space for the Army Space and Missile Defense Command (SMDC). These are also technology development imaging satellites.

Another nanosat program for the U.S. military is ONE (Operational Nanosatellite Effect), which calls for at least 10 3-kg technology satellites for communications. These will be built by Miltec Missiles and Space for SMDC as well. DARPA is working on a system called SeeMe (Space Enabled Effects for Military Engagements), which envisions six prototype and 24 operational 40-kg technology microsats for surveillance. Millennium Space Systems has been contracted on this program.

Thus, while the Pentagon will perhaps be building and launching many more payloads than ever before, many of these will be very small technology satellites built to increase understanding of how they can support U.S. warfighting and logistical requirements. These picosats, nanosats, and microsats may eventually find useful applications, but probably not until 10-20 years from now.

We do not see other countries building and launching many dedicated military payloads. This is partly because of cost considerations and partly because of the trend toward sharing platforms with commercial and civil payloads. Another major reason is that so many military imaging and communications requirements can now be fulfilled by commercial payloads. Leasing or purchasing simply makes more sense than owning.

This is certainly the case within the civil payloads market, notably with regard to cargo resupply and crew transport services to the ISS. If you consider solely the payloads that could go up in the next four years as a result of NASA's Commercial Orbital Transportation Services program, there are about 16, split evenly between SpaceX with its Dragon capsules and Orbital Sciences with its Cygnus capsules.

Meanwhile, NASA will continue to lease seats for its astronauts aboard Russian Soyuz crew capsules, until a human-rated U.S. capsule—as part of NASA's Commercial Crew Integrated Capability—is ready to take over. That could be as early as 2015, but more likely will be closer to 2018-2020.

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(Continued from page 21)

that is attached to the end of the flap and stretches to keep the flap tip continuous with the wing when the flap is deployed.

Unlike CML, which constituted 35-40% of total flap area, the elastomeric material used by FLEXSEL represents less than 5% of the total flap area and so is potentially easier to implement structurally. To make the concept practical, Langley is still experimenting with a variety of different elastomeric materials to find one that is not affected by altitude and will be structurally strong enough to keep working over the long term.

Langley has also filed patents on two other flap noise-reduction concepts. One, called a 'reactive orthotropic lattice diffuser,' or ROLD, uses what Khorrami calls "a very elaborate set of interconnected holes" at the flap tip. The lattice in this design weakens noise-producing flow structures by interacting with the airflow.

The other NASA-patented concept, called 'flap edge noise reduction fins' (FENoRFins), involves using a "tight bunch" of small fins that extend from the flap tips into the passing airflow. Their spacing is key, and while the fins must be small, Khorrami says they cannot be too small, because they must be structurally strong. The FENoRFins approach is similar to the use of fine brush bristles extending from the flap tip, a concept that was investigated by European researchers but found to produce a small degradation in aerodynamic performance, he says.

For ERA Phase 2, the NASA-Gulfstream partnership is expected to downselect "three or four" of its best-performing flap noise-reduction concepts and "maybe two or three" of its best landing-gear ideas by this spring. Khorrami notes that all those chosen will "have to be practical, real-world concepts." While those selected for further experimentation will have to incur virtually no penalties in weight and aerodynamic performance, they will also need to be maintainable and suitable for certification.

For the downselection process, NASA would have to compare all its own computer simulations and wind tunnel data at length with the flight test data gathered by Gulfstream Aerospace using the G550 flying testbed.

Khorrami says that NASA wants "to flight test, at a bare minimum, from two to four concepts, no later than the fall of 2014." The agency actually is aiming to get its favored concepts into the air a little earlier than that; Khorrami says his team is "looking at mid-to-end summer 2014" for flight testing to begin. When it does, should the flight test aircraft pass overhead, you might be surprised at how quiet it is.

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(Continued from page 21)

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About the Location

National Harbor is just 15 minutes from the heart of Washington, D.C. So much of aerospace begins and ends in the Washington, D.C. area – beginning with Congress and ending at the Smithsonian National Air and Space Museums. The area is home to NASA Headquarters, NASA Goddard Space Flight Center, the National Oceanic and Atmospheric Administration, the Federal Aviation Administration, the U.S. Naval Research Laboratory, and the Pentagon, plus the headquarters of Lockheed Martin Corporation, Orbital Sciences Corporation, and Aurora Flight Sciences, along with scores of aerospace company branches. It's also home to some of the finest young minds in aerospace, at the University of Maryland, George Washington University, Catholic University, Howard University, Johns Hopkins University, and the U.S. Naval Academy. It's the perfect location to draw participants from all sectors of the aerospace field.

AIAA

Stealth sneaks into UCAVs

UAVs are now among the most heavily demanded aircraft types in military arsenals around the world. Predictably, interest in unmanned combat aerial vehicles (UCAVs) is also on the rise. In an increasingly dangerous threat environment, it is likely inevitable that stealth, a feature now widely used in manned combat aircraft, will find its way into UCAVs as well.

by J.R. Wilson
Contributing writer

When DARPA officials began looking into stealth technology in the mid-1970s, they did so without the support of the nation's military aviation leaders, who saw no value in a technology that might limit other design and capability factors they considered vital at the time.

That also was true with the agency's UAV research, which interested the services even less.

But when the F-117 Nighthawk entered service in the 1980s as the world's first stealth combat aircraft, the military view of that technology began to change. The subsequent development of the larger B-2 Spirit stealth bomber cemented the technology as a 'must have' for future aircraft. Indeed, it has become one of the defining elements of fifth-generation fighters, currently limited to the F-22 Raptor and F-35 Lightning II.

Born for combat

With the successful use of the U.S./Israeli-developed Pioneer UAV as an aerial spotter during Operation Desert Storm in 1991, UAVs—while still not universally supported by the DOD—began a new life as well. After September 11, 2001, the wars in Afghanistan and Iraq saw more advanced UAVs in widespread use as intelligence, surveillance, and reconnaissance (ISR) platforms. But in late 2001, their role in combat took a major leap with the introduction of an MQ-1 Predator armed with Hellfire missiles.

Since then UAVs have evolved into one of the most widely used and heavily demanded aircraft types in the U.S. arsenal—and in the militaries of more than 50 other nations. With that growth, a new concept has also gained support: the unmanned combat aerial vehicle (UCAV). Technically any weaponized UAV might be identified as a UCAV; however, the term generally means a next-generation platform, designed from the start to be armed and capable of performing all the missions of a manned jet fighter or bomber.

Both the Air Force and Navy have had research programs to build and test UCAV prototypes. Others focused on the concept of operations (CONOPs) for such aircraft,

An X-47B is hoisted aboard the carrier USS Harry S. Truman during carrier tests. Photo courtesy Northrop Grumman.

either removing pilots on extremely high-risk missions or flying UCAVs in concert with (and controlled from) manned aircraft. UCAVs, along with stealthy ISR platforms, also have found a key place in the Pentagon's new 'air/sea battle' concept, designed to improve joint operations in 'antiaccess/area-denial' (A2/AD) environments.

Changing requirements

With all legacy Air Force, Navy, and Marine Corps fighters being replaced by fifth-generation stealth aircraft—the USAF F-22 and multiservice/international F-35—it is only logical that future UCAVs be stealthy as well.

"It's a requirements issue," UAV analyst Steve Zaloga of The Teal Group tells *Aerospace America.* "The first-generation [aircraft] have been operating in a permissive air defense environment, but the services have to prepare in the future to deal with an enemy force with a more sophisticated capability. And in that case, the current systems would be inadequate….What the future battlespace will look like," he says, "is a judgment call at the highest level."

Col. Chris Coombs headed the Medium Altitude UAS Division at the USAF Aeronautical Systems Center before it was deactivated at Wright Patterson AFB in 2012. He agrees that while there were no stealth requirements on the Predator or Reaper UAVs used so heavily in southwest Asia, that is likely to change.

"It is definitely an area of consideration as you get out into the 2020 timeframe when looking at what kinds of targets you may have to address then," he says. "If you think about the kinds of missions manned aircraft have gone against previously—the F-117 and F-22—the reason for stealth is to get into high-value targets deep in enemy territory, typically protected by great radar

The successful use of Pioneers during Desert Storm set the stage for the use of UAVs to flourish. USN photo by Photographer's Mate 2nd Class Daniel J. McLain.


This U.S. Sentinel drone is seen operating from an unknown base.

systems. The same requirements that apply for manned also apply for UAVs or UCAVs for deep reconnaissance and deep strike.

"Right now, no defined CONOPs have been given to us to address SEAD [suppression of enemy air defenses] or manned aircraft accompaniment. However, the Air Force plan developed a couple of years ago talked about a future situation where UAVs accompany manned aircraft, providing the ability to carry additional weapons loads. Or stealth UAVs could go in for the initial deep strike and then report back to the manned aircraft to attack other targets or follow up. So in terms of where we want to go, it's considered, but not currently being implemented," says Coombs.

Whether stealth would be of greater value to future UAVs performing deep ISR or those tasked with strike missions is difficult to judge, based on current operations, he adds. This is because current Predators do both, sometimes switching from ISR to strike in midmission.

The Air Force has already used at least one stealthy UAV—the RQ-170 Sentinel, built by the Lockheed Martin Skunk Works. This large ISR platform, sometimes called the 'beast of Kandahar,' reportedly began flights in southwest Asia in 2011.

Range is key

Stealthy UAVs almost always come with a requirement for longer range capability than the manned aircraft whose missions, both ISR and attack, they are intended to perform. "A carrier-based UCAV with an unrefueled combat radius of 1,500 n.mi. or more and unconstrained by pilot physiology offers a significant boost in carrier combat capability," according to a 2008 study by the Center for Strategic and Budgetary Assessments (CSBA), a defense and national security think tank based in Washington, D.C.

What may have been considered a useful advantage in 2008, however, became a necessity by 2012, says CSBA analyst Mark Gunzinger, a retired Air Force colonel and former staff member of the National Security Council.

"We think the world is becoming increasingly nonpermissive for military operations—air, space, sea, undersea, and on the ground. If that trend continues, we're going to have to move toward capabilities that can operate in all those domains against those kinds of threats," Gunzinger says.

Those comments reinforced findings in his 2010 CSBA study, *Sustaining America's Strategic Advantage in Long-Range Strike*: "Antiaccess/area-denial networks like the one being developed by the PRC and other states with the resources to buy advanced military systems will likely pose unacceptably high risks to U.S. Navy surface forces and compel them to operate initially as far as 1,000 n.mi. or more from an adversary's coastline. This suggests the need for a carrier-based aircraft with a range that is at least two to three times that of the F/A-18E/F or F-35C if carriers are to contribute meaningful strike capacity at the outset of future operations.

"Moreover, land- and sea-based aircraft penetrating dense, sophisticated integrated air defenses will require all-aspect, broadband low-observable characteristics. Finally, hedging against the loss of vulnerable C4ISR battle networks will require strike platforms to be capable of operating effectively independent of these networks. Simply put, the combination of range, persistence, stealth and independence of action will likely be the sine qua non for effective strike operations over the coming decades."

But Chinese antiship missiles that could force even the Navy's new Ford-class aircraft carrier to remain outside manned aircraft range from an enemy coastline are not the only problem. Iranian cruise missiles, smart mines, and swarms of fast-attack boats also are threatening the fleet in the confines of the Persian Gulf and narrow Strait of Hormuz. Those, too, strengthen the concept of creating fleets of carrier-based long-range stealth UAVs and UCAVs, Gunzinger believes.

Navy and Air Force plans

Both the Navy and Air Force have had plans in motion for a stealth UCAV to meet those evolving demands. Although the Air Force canceled its X-45 UCAV as part of the Joint UCAS program in 2006, officially to concentrate on a long-range strike bomber, the general consensus is they actually moved it into the ‘black’ budget, where both the F-117 and B-2 were developed. The Navy, however, has stayed public with its X-47B, a Northrop Grumman-built ‘batwing’ UAV that was also part of J-UCAS, under a replacement UCAS-D (carrier demonstration) program.

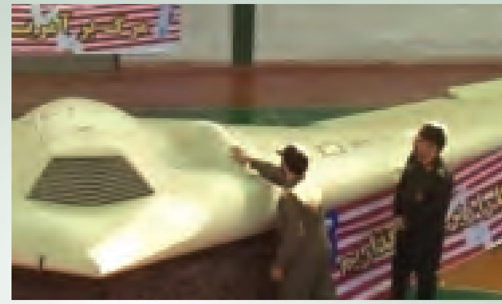
The X-47B completed carrier deck handling tests in late 2012 and is scheduled to make its first carrier launch and recovery at sea this year—the first by any UAV of its type—from the USS George H.W. Bush. Autonomous aerial refueling demonstrations are scheduled for 2014.

The Navy’s follow-up to UCAS-D is the unmanned carrier-launched airborne surveillance and strike (UCLASS) aircraft, a carrier-based stealth UAV capable of both persistent ISR and light strike. To combine the best evolving technologies with rapidly changing threat and mission requirements, says the Navy, the UCLASS will be developed using the ‘spiral’ concept. This approach entails implementing the system’s various capabilities in multiple steps rather than waiting to field a single version that delivers everything the service wants.

The Air Force has indicated it will base its own next-generation UCAV on the initial UCLASS capabilities document and has assigned an Air Force observer to the Navy program office. That would seem in keeping with the two services’ efforts to solidify the air/sea battle plan. However, even as the Navy vowed to issue a request for proposals to launch competition for the UCLASS this year, internal debate continues over design priorities—stealth, endurance, payload, maneuverability.

At a UAV conference held in February, Rear Adm. Mathias Winter, the Navy’s program executive officer for unmanned aviation and strike weapons, explained that UCLASS development will not include any new weapons. He indicated that talks are under way with both fleet commanders and defense contractors as to which strike weapons the aircraft should carry and how best to integrate those weapons with other systems and capabilities, presumably including stealth.

A captured beast



In December of 2011, Iran announced that a Sentinel the USAF said was patrolling the Afghan-Iranian border had been captured while violating Iranian airspace. After the aircraft was displayed on Iranian state television, the White House issued a formal request for its return. Iran refused, instead saying it would send President Obama a 1/80th pink scale model.

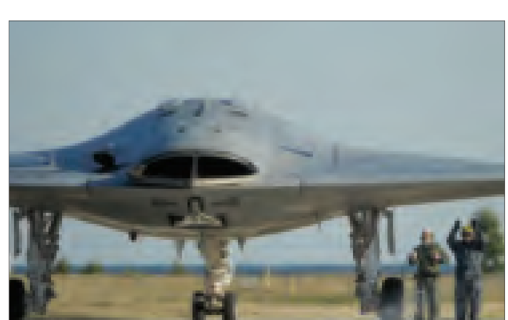
Although Iran claimed to have jammed the UAV’s GPS guidance system and taken control of the vehicle, U.S. experts dismissed that as an unlikely assertion, one that demonstrated a lack of knowledge of the platform’s actual operations. Tehran also claimed to have broken the UAV’s encryption codes, extracted information from its final surveillance mission, and reverse-engineered the aircraft to build its own line of stealth UAVs. However, the actual extent of Iran’s ability to replicate the UAV’s advanced technology—or produce any of the other next-generation platforms it has claimed to be developing—is debatable.

“There will be strike capability as part of this solicitation. The specifics will be in the trade space,” he told the Association for Unmanned Vehicle Systems International. “I will tell you that, from a munitions perspective, it will be something that’s already been certified…that is carried in our magazines on our aircraft carriers. There is no new weapons development program associated with UCLASS, and that strike capability will be organic to the UCLASS system.”

UCLASS candidates

At least four leading U.S. UAV builders—Lockheed Martin, Boeing, Northrop Grumman, and General Atomics—are expected to compete for the UCLASS contract.

Lockheed Martin says its preliminary concept, the Sea Ghost, “leverages [our] experience with the RQ-170 Sentinel unmanned aircraft system, the F-35C Joint Strike Fighter, and other Navy program technologies [to provide the Navy] with a versatile and supportable carrier-based unmanned aircraft solution with capability growth margins” to meet future threats.



The Navy and Northrop Grumman completed the first shore-based trials of a wireless, handheld controller for X-47B carrier deck operations.

A2/AD + Air/Sea Battle = QDR 2014 Overhaul?

On February 26, the House Armed Services Committee's oversight and investigations subcommittee heard testimony from CSBA vice president Jim Thomas, who served as a deputy assistant secretary of defense in both the Clinton and George W. Bush administrations. Thomas called for a reassessment of defense spending in the 2014 Quarterly Defense Review (QDR), based in part on the growing A2/AD threat.

"The key security challenges we face and the priority missions outlined in the 2012 Defense Strategic Guidance place a premium, in particular, on highly distributed, autonomous, and low-signature forces capable of operating independently, far forward in denied areas," he told the subcommittee.

"Such forces and capabilities will need to be far less dependent on vulnerable forward bases but vastly more effective operating in nonpermissive environments where adversaries will contest our air forces, jam our communications, and blind our sensors and command and control."

To ensure the nation's ability to project force into A2/AD areas, and to deal with future nonstate threats ranging from terrorists to pirates, DOD's highest capability priorities must include "land- and sea-based long-range, air-refuelable, unmanned stealth aircraft for surveillance, kinetic strike, and nonkinetic electronic attack," said Thomas.

"Combinations of such access-insensitive forces and capabilities are likely to be the spearhead of future campaigns against terrorists, WMD [weapons of mass destruction] powers, and adversaries possessing robust antiaccess networks," he testified, adding that those, along with enhanced special operations forces, "should become more central in the American military, especially in an era of declining resources."

Accomplishing that, Thomas said, will require that Defense Secretary Chuck Hagel and the Joint Chiefs agree on major trades up front, then address the most pressing security challenges—rather than trying to define a single defense strategy—and aggressively rebalance America's military capabilities portfolio, including an increased reliance on unmanned stealth.

"Given both the fiscal and external security challenges facing the nation, the upcoming QDR could be the most consequential of the last two decades. However, a 'business as usual' approach in the QDR is unlikely to lead to the major changes in our forces and capabilities that are needed," he concluded. The review "will need to prioritize those capabilities that perform best in contested operating environments, while divesting those that depend on relatively benign operating conditions.

"Finally," said Thomas, "it is worth bearing in mind that the upcoming QDR will have far less margin for error than previous reviews. Given the bleak fiscal outlook, we will likely be stuck with the force that results from the upcoming review for decades to come, for better or worse."

Northrop Grumman is expected to offer an enhanced version of its X-47B, which has drawn on lessons learned over the past year from its carrier landing and other flight tests. That test program, says the company, clearly indicates the Navy plans to have unmanned craft aboard carriers in the future.

General Atomics Aeronautical Systems' candidate is a version of the USAF Avenger (formerly Predator C). Drawing on nearly two decades of R&D, production, and operating experience with the Predator and Reaper, GA believes the Sea Avenger has demonstrated many of the Navy's requirements, although no previous version of the Predator included stealth.

The Sea Ghost would build upon lessons from the RQ-170.

Boeing is expected to offer a modified version of the X-45 Phantom Ray it designed for the UCAS-D competition (won by Northrop Grumman). Although drawing from previous designs, this will be a unique new platform, company officials indicate. They are strategically vague about details.

While the UCLASS—and, by extension, the Air Force adaptation—has slipped by about two years, the Navy has seemed confident it would begin moving forward this year. However, at an industry conference in December 2012, DOD's deputy director for unmanned warfare, Dyke Weatherington, said he expected procurement of new UAVs to be slowed in coming austerity budgets. "I do think the preponderance of what we see in the near future is improvements to current capabilities rather than a whole lot of new programs," he said.

Research and technology visions

Nonetheless, just as manned stealth aircraft and UAVs slowly evolved from uninteresting to indispensable, combining the two

Boeing may offer a modified version of its X-45A for the UCLASS competition.

technologies for the future military air fleet has developed a sense of inevitability.

The Office of Naval Research's current Naval Science and Technology Strategic Plan outlines both the strategic drivers and vision for the future of Navy UAVs and UCAVs—an integrated hybrid force of unmanned and manned systems with enhanced C4ISR capabilities.

"Increased proliferation of inexpensive lethal threats targeting individual warfighters and high-value assets, combined with continued rapid advances in computing, power and energy, robotics, sensors, and position guidance technologies drives the requirement to augment expensive manned systems with less expensive, unmanned, fully autonomous systems that can operate in all required domains," says the ONR plan.

"Central to achieving that vision is the development of a distributed system of heterogeneous unmanned systems relying on networkcentric, decentralized control that is flexible in its level of autonomy, with the ability to get the right level of information to the right echelon at the right time. This may include defeating asymmetric and emerging threats via persistent and stealthy distributed large-area presence, stimulation of suspect entities, and disruption and deception of potential hostiles."

In a *Foreign Policy* online article in March, Peter W. Singer, director of Brookings Institution's 21st-Century Defense Initiative, analyzed the global effort to bring stealth UCAVs into future air combat missions: "Consider Northrop Grumman's X-47 UCAS, a jet-powered, stealthy plane testing out in Maryland right now; or the Taranis, being tested in Australia by BAE; or the Blue Shark, rumored to be in development by the Chinese firm AVIC. In some ways, these unmanned combat planes represent traditional advances in weapons tech: They are designed to fly faster and farther than our current generation of strike drones and to better evade enemy defenses," he wrote.

"But these planes are also very different than their predecessors: They are smarter and more autonomous. They are designed to take off and land on their own, fly mission sets on their own, refuel in the air on their own, and penetrate enemy air defenses on their own. The Taranis even has modules designed to allow it to select its own targets."

Another March report on China's UAV programs by Project 2049 Institute, a Washington, D.C.-based think tank with an Asian focus, described the emphasis the People's Liberation Army (PLA) places on becoming a leading UAV power.

"UAV systems may emerge as the critical enabler for PLA long-range precision strike missions within a 3,000-km radius of Chinese shores. Emphasis on reducing the radar cross-section of new UAV designs indicates an intent to survive in contested or denied airspace," the institute noted. "The ultimate goal of combined UAV and missile campaigns would be to penetrate otherwise robust defense networks through tightly coordinated operations planned to optimize the probability of overwhelming targets."

In short, even as friends and foes challenge U.S. domination of 'traditional' UAVs, the rest of the world may be far closer when it comes to the next generation of unmanned stealth aircraft. This in turn puts even greater pressure on the DOD, Congress, and the administration to respond, even as defense budgets grow tighter.

Next year, in a dramatic flyoff at Marine Corps Base Quantico, two unmanned helicopters will demonstrate new navigation packages featuring advanced sensors, processors, and algorithms from two competing UAV manufacturers. These technologies may soon enable such aircraft to rescue troops from battle zones, or civilians from disaster areas, without putting pilots at risk.

Upgraded unmanned helicopters face off

The Navy conducted a successful five-day Quick Reaction Assessment in Arizona to prove the K-MAX helicopter's cargo-carrying capability in conditions similar to those it will experience in Afghanistan.

Most unmanned aircraft engineers cringe at the word 'drone.' It has political freight because of current missile strikes, and it also implies a lack of technical sophistication. The problem for critics is that it remains an apt term for how today's UAVs are operated. The Predators and Reapers flown over Afghanistan and Africa are controlled by joystick when the situation heats up, but most of the time they fly from one waypoint to the next while operators in ground control stations—often former fighter pilots—struggle not to yawn. The brains are not in the planes; they are on the ground.

Between now and February 2014, engineers at Aurora Flight Sciences in Manassas, Virginia, and Lockheed Martin in Owego, New York, will be preparing for a dramatic robotic helicopter flyoff that could soon make the word drone a misnomer.

Under an Office of Naval Research (ONR) program called AACUS (autonomous

Unmanned Little Bird successfully performed 14 autonomous takeoffs and landings from a ship during flight tests in July 2012.

aerial cargo utility system), Aurora and Lockheed are designing competing kits of sensors, processors, and algorithms for installation on existing optionally piloted helicopters. Weighing no more than 30 lb, the kits must sense obstacles, including power lines and towers, and figure out how to steer around them for a landing less than a meter from a predesignated landing spot.

Just in case things go badly, a safety pilot will be aboard each helicopter during the flyoff at Marine Corps Base Quantico, Virginia, where the power lines and towers are very real. Lots of VIPs will be on hand, and a Marine Corps general yet to be named will direct the helicopter using a tablet or smartphone.

"It promises to be the next-best thing to NASCAR," says Mary 'Missy' Cummings, an MIT professor and former Navy F-18 pilot who is on assignment to ONR as the program manager.

She is only half joking. Cummings, who has appeared on national TV shows, understands how to employ the media better than most program managers: She wants to have a live webcam stream from the cockpit so everyone can see that the safety pilot is not touching the controls.

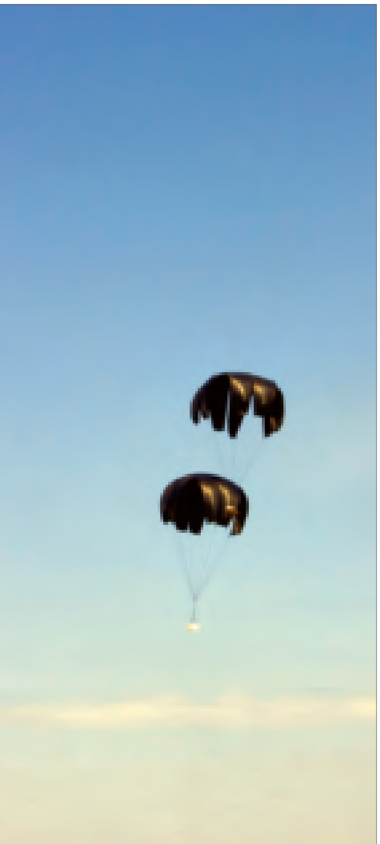
The race is on

The contractors are starting to assemble the mix of sensors, software, and algorithms they will need to install on their helicopters. They are still debating many key decisions, including which sensors are necessary for the flyoff and which can wait until later phases of the five-year, roughly $98-million program.

Arguably the biggest challenge is the software, which must interpret the sensor data and figure out how to react to dynamic situations. "Essentially, we're mimicking responses that typically an operator would have...and then embedding them in the code," says Jon McMillen, Lockheed Martin's business development manager for unmanned systems.

ONR has awarded $28 million in contracts for the flyoff phase. Aurora will receive $13.4 million, Lockheed $13.5 million.

by Ben Iannotta
Contributing writer



"Every time this aircraft delivers a payload, we're taking one more truck off the road," says Cpl. Ryan Venem, detachment aerial vehicle operator.

ONR also has small contracts with the Army Aeroflightdynamics Directorate at Ames and JPL to provide technical advice to the competitors. The winner will stay on to install its navigation package onto a completely different model of helicopter, a test version of the UH-60 Black Hawk called RASCAL (rotorcraft aircrew systems concepts airborne laboratory). That demo will happen in California, 11 months after the Quantico flyoff.

Eleven months, particularly for a risky R&D project, is a very short timeframe in which to provide essentially the same capability on a completely new aircraft, notes Cummings.

The Navy, which is leading this program on behalf of the Marine Corps, wants a modular system that can be installed on all sorts of vertical takeoff and landing planes, possibly including V-22 tilt-rotors. One task for the contractors will be to figure out where the sensors and processors should be installed on multiple aircraft.

Fly-by-app

If AACUS succeeds, a Marine without any aviation training could tap on a tablet or smartphone in the midst of a firefight and tell an autonomous helicopter to deliver ammunition or evacuate the wounded. There would be no one on the ground with a joystick, and no need to send other Marines scrambling over foot trails or onto roads that could be laced with improvised explosive devices.

"Whether it's a resupply mission or a casualty evacuation, we see a real game changer by having helicopters that go into settings that are very risky for humans," Cummings says. "The goal is to enable the sensing to do both obstacle avoidance and landing zone detection onboard the helicopter with no human in the loop."

The five-year program is meant to get the technology ready for the real world. An autonomous helicopter would have to figure out where to land amid boulders and moving objects like trucks and people. It might need to distinguish hard ground from soft marl that could swallow its skids or wheels and keep it from taking off again. It would need to see through dust kicked up by its rotor blades, and any rain or snow nature throws at it. Accomplishing all that will require a mix of electrooptical video cameras, radars, and lidars, plus onboard algorithms to turn those perceptions into wise autonomous decisions. The demo will be the first step toward figuring out what an operational version of the navigation system should include.

The helicopters

Lockheed plans to install its system onto a K-MAX helicopter, specifically the 1,800-lb optionally piloted variant created in the mid-2000s by Kaman Aerospace and Lockheed. Two of them are in Afghanistan delivering supplies to troops in the field. The goods are packed in cargo nets and dangled by long-line tethers—K-MAX does not have to land in difficult settings; it can just drop its cargo and return to base.

It has great payload lifting power, though. It can carry 6,000 lb at sea level, and 4,313 lb at a 15,000-ft density altitude; the latter is an aviation term describing the thinness of the air in high-altitude regions like Afghanistan, where flights just a few hundred feet above the ground mean flying thousands of feet above sea level. At some point, the air gets so thin that a helicopter with too heavy a load would have to turn its rotor blades impossibly fast to maintain lift. AACUS calls for an altitude density of 12,000 ft, which K-MAX easily meets.

K-MAX helicopters have flown many unmanned missions in Afghanistan since 2007. They perform well but do not yet have the computing power or autonomy ONR wants for the flyoff. They fly predetermined routes that are loaded into onboard computers ahead of time: "There's a certain flight path that you're going to fly. There's a certain landing zone, and everything is known throughout—what's going to happen, and how the system's going to react," says McMillen.

Lockheed calls its autonomous navigation package OPTIMUS (open-architecture planning and trajectory intelligence for managing unmanned systems). "We'll leverage everything we have from K-MAX, with the goal of having something built in an open-architecture way that can really be poured into many platforms," McMillen says.

Aurora Flight Sciences has no shortage of experience building unmanned aircraft, but most are fixed-wing planes: the optionally piloted Centaur, the experimental long-endurance Orion, and the hand-launched Skate. The company also made the composite airframe for Sikorsky's S-97 armed scout demonstrator helicopter.

Aurora chose to team with Boeing, maker of the H-6U Unmanned Little Bird helicopter. Little Birds were first designed in

1958 by Hughes Aircraft (now Boeing Rotorcraft Systems) as light reconnaissance vehicles. Despite the word 'Unmanned' in the newest version's name, it is actually an optionally piloted craft that can be flown by two pilots, one pilot, or a ground operator.

Unlike K-MAX, the Unmanned Little Bird has not seen much real-world action and often flies with a safety pilot. It made its maiden flight in 2004 and its first unmanned flight in 2006. It is used mainly to test unmanned aircraft concepts of operations, according to Boeing. Last year it took off and landed from a moving ship in a series of demonstrations.

Aurora exudes confidence about its choice, given the flyoff criteria listed in the broad agency announcement Cummings released back in November 2011: The aircraft must be able to carry 1,600-5,000 lb while traveling at speeds between 110 kt and 250 kt, in an altitude density of 12,000 ft.

"We went through a fairly involved source selection and evaluated a number of different aircraft from a [perspective of] feasibility, risk, performance, and the experience of whoever owned the airplane," says John Wissler, AACUS program manager at Aurora. "The Boeing Unmanned Little Bird was the one that fit what we're trying to do."

One of the goals is modularity, so both contractors will have to design their equipment to be compatible with multiple airframes. Aurora plans to tuck the processor behind the two pilot seats of the Little Bird. For other aircraft there are different possibilities; Cummings says one would be to attach the equipment to a strut. Lockheed has not said for sure where it will install its processor. The sensors would most likely be on the noses of Little Bird and K-MAX, because they need to have good views of the ground and the air ahead.

The big test will come in the Quantico flyoff.

Remember that Marine Corps general? Cummings wants him or her to have no aviation background. The person calling for the helicopter will use a 'telestrator' to trace where the aircraft should and should not fly, along with some preferred approaches.

The flight is meant to be challenging for the helicopters, not for the general. Both vehicles will do the calculating based on supervisory-level directions from the general.

"There's a big tower, actually several towers that they're going to have to avoid," says Cummings, plus the power lines and even some water. And, of course, a safety pilot ready to take control if necessary.

Having a nonexpert direct the aircraft introduces a variable that is absent from most demonstrations—especially one with millions of dollars in additional funding at stake. "That's just something we'll have to deal with, and it does interject an interesting element into the overall program; we're looking forward to it," says Wissler.

Boeing's Unmanned Little Bird will demonstrate Aurora's navigation package in the flyoff.

Inspired by Mars

The Marines are not the only government entity that operates in rugged, hostile terrain. JPL engineers are working to improve the precision of the next Mars landings or new missions to asteroids. The technologies overlap so much that ONR structured the program for each flyoff contractor to work with a separate team of JPL engineers. The JPL teams have been testing relative terrain navigation algorithms for rapidly crunching data into flight control decisions. Close to the ground, lidars would bounce lasers off the surface to find obstacles in three dimensions.

Cummings expects lidar to be among the core technologies in the AACUS sensor suites, too. Learning about the state of the art of lidars and their limits is a top goal.

"Some lidars do better at looking through dust," Cummings says. "One of the things that we're trying to assess is just how well can they—and I'm doing air quotes—see through dust and rain and weather."

She does not think lidar alone will be the answer, although settling that question will be saved for later phases of the program. "At some point it's likely we'll have to integrate some kind of millimeter wave radar to be able to see through dust or particulates," she says.

Figuring out the exact mix of sensors for an operational helicopter is not the goal of the flyoff phase. "The focus here for the first 18 months is really developing the enabling technologies," says McMillen. In fact, picking a technology too soon would be a big mistake, in his view. "As we get further down the path and later in the program, a lot of these technologies that we're looking at—sensors—will be smaller, with much better capability, so you hate to limit yourself to one form factor today," he says.

Long-term implications

The program's ultimate goal would be an autonomous casualty evacuation helicopter

K-MAX features Kaman's high-altitude, heavy-lift K-1200 airframe and Lockheed Martin's mission management and control systems.

that could be flown into battle zones or into civilian areas after earthquakes, tsunamis, or other disasters.

Aside from the technical challenges, these aircraft would test the human psyche. People instinctively want the person in charge of an aircraft to be physically present. Human factor experts call this shared fate. Attitudes toward robotic vehicles are evolving, however, and reactions can be surprising. Cummings says Marines generally feel okay about putting a wounded comrade on a robotic helicopter with no one else onboard if that's the only way to get them help within the golden hour. But if you suggest putting the wounded on a robotic helicopter occupied by a medic, some Marines back-pedal and feel uncomfortable, for reasons that are not entirely clear. This is not a problem for the Marines, because their casualty evacuation helicopters do not carry medics, Cummings notes. The bottom line is that attitudes are changing: "Lots of us have ridden a train with no engineer!," she adds by email.

When all this can happen is an open question. When ONR invited the industry to compete for AACUS in 2011, it described its goals in terms pulled directly from Marines' experience in Afghanistan. There was an urgent need to resupply remote combat outposts, and to reach out hundreds of miles from large forward operations bases, without risking ambushes or improvised explosive devices by taking land routes.

Cummings does not expect the AACUS technology will be ready in time to help in Afghanistan, given the U.S. plan to pull combat troops out by the end of 2014. The first spinoff probably will be the modular sensors and processors. Those could be added to existing, traditionally piloted airplanes to enable pilots to steer through extreme weather or dust—'degraded visual environments' (DVEs) in aviation parlance. Lidars and millimeter wave radars obviously can sense things humans cannot.

"The Marine Corps is losing $66 million a year in aircraft crashes in these DVE conditions, so we consider this an urgent, urgent need," Cummings says. "I would say that within a few years that could definitely make its way to some field. I'm not sure where we'll be in the next few years."

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Gaining

Environmentalists and others have raised concerns about contrails, the long emission traces formed in the wake of jet aircraft. Pollution effects are not the only issue; these benign-looking trails alert enemies to the presence of warplanes. Under NASA's ACCESS program, researchers are taking a closer look at these emissions and flight testing alternative fuels to minimize their adverse impacts.

For over half a century, the skies over the U.S., Europe, and much of the rest of the world have been crisscrossed daily by aircraft contrails—the white residue from military and commercial jet engine emissions.

Environmentalists view these seemingly benign lines as pollution of the atmosphere. Military planners see them as a potential danger that reveals to an enemy not just the presence but also the location of warplanes, from fighters to transports.

In March, three NASA centers—Langley in Virginia, Glenn in Ohio, and Dryden in California—moved research in this area another step forward with the first flight test segment of a project called ACCESS (alternative fuel effects on contrails and cruise

Exhaust contrails streaming from the engines of NASA's DC-8 flying laboratory are captured by an HU-25 Falcon flying in trail about 300 ft behind the DC-8. Instruments on the Falcon were measuring the chemical contents of the exhaust contrails at varying distances from the DC-8, which was using both standard JP-8 jet fuel and a mix of JP-8 and a plant-derived biofuel. NASA/Eddie Winstead.

emissions). These efforts built on ACCESS ground tests conducted in 2012, along with previous NASA emissions experiments.

"All of these, including the ground tests, have been very collaborative efforts," says Dan Bulzan, technical lead on the clean power subproject under which ACCESS is run within NASA's Fundamental Aeronautics Program. "In the ground testing, we sent researchers out to help perform some of the particle and gas phase measurements.

"We [Glenn] don't do flight testing, so our role at Dryden was a lot more limited, primarily making sure we purchased the right fuels, had [the fuel] properly blended and then sent out for analysis. All of the activities at Langley and Dryden are under the clean power subproject, which is part of the fixed wing project at Glenn."

Bruce Anderson, ACCESS project scientist at Langley, says that the specific roles and contributions of each NASA center in ACCESS 1 will continue in follow-up experiments. These cover a range of areas, from fuel blends used in the agency's DC-8 flying lab to its instrumented HU-25 Falcon chase aircraft.

"The fixed-wing [project] at Glenn is continuing lab tests on alternative fuels. My group at Langley looks at instruments and flight plans, and the Research Directorate, which operates the Falcon, does the aircraft modifications and certifications." He says that the latter area "was important, because we had to cut some holes in the airplane."

by J.R. Wilson
Contributing writer

The HU-25C Guardian Falcon arrives at NASA Langley in November 2011. Courtesy NASA/Sean Smith.

Dryden, he says, owns and operates the DC-8 and is responsible for the flight tests.

Emissions up close

ACCESS is the most in-depth study to date of how alternative jet fuels may affect engine emissions and the formation of contrails. "NASA has a program to assess alternative fuels, but there was very little information on the emissions from a jet engine—detailed information modelers need to predict local area impacts," Anderson says. "We had used the DC-8 on previous experiments, and when ACCESS came along, it was one of the few aircraft in the NASA fleet that had commercial links. So we used it in 2009 to study fuels made from coal, and another [made] from natural gas.

"But NASA really wants to study renewable fuels. Fischer-Tropsch (FT) fuels add to the CO_2 burden in the atmosphere, so the emphasis is on using feedstocks that can be grown and harvested. The experiment in 2011 focused on those fuels, using beef tallow. The most recent [ACCESS] tests used camelina oil."

The FT process was developed in Germany in the early 1900s as a way to produce liquid fuels, such as diesel, from coal. It uses a mixture of carbon monoxide and hydrogen as a synthesis gas that then is converted into hydrocarbons using a catalyst. The fuel used in ACCESS 1, however, comprised hydrotreated esters and fatty acids (HEFA) from the camelina plant—a member of the mustard family native to the Mediterranean—in a 50/50 blend with standard JP-8 jet fuel.

Staging from Dryden's Aircraft Operations Facility in Palmdale, the ACCESS flights took place in restricted airspace over colocated Edwards AFB. With its four CFM56 engines burning the camelina-based hybrid, the DC-8 flew a circular pattern at altitudes up to 40,000 ft while the Falcon trailed at distances from 300 ft to over 10 mi., its instruments 'sniffing' the larger jet's emissions, including its contrail.

"The overarching objective is to examine the effects of blended alternative fuels on aircraft emissions in flight. We've done a number of ground tests. We know burning pure alternative fuel results in a significant reduction in particle emissions, but only 50/50 blends have been approved for flight. That's primarily because the aircraft fuel systems will leak if we load pure alternative fuel on the aircraft," says Anderson. "In the long term, we hope [to have] these fuels in general use. The cost is coming down, and as petroleum sources become fewer and more expensive, these substitute fuels will become more important.

"We're just a small part of the big picture. A number of federal agencies are collaborating to promote the development of these alternative fuels, both to clean up the atmosphere and to make our country more energy independent. That includes looking at the different crops suitable for making fuels [and at] the impact on fresh water supplies and land usage. We know if we could switch to pure synthetic fuels, we would really have an impact on clean air."

ACCESS 1 began with 2012 ground tests at Dryden, with the DC-8 engines burning both blended and pure synthetic fuels while the aircraft remained on the ramp. Neither of those fuels contained the camelina oil synthetic used in the March flight tests, because it was not available in sufficient quantities at that time. The researchers gathered a great deal of emissions data from the ground tests, but early analysis of the results from those and the initial flight tests were inconclusive.

"During the ground tests, at medium to high power settings, we didn't see a lot of difference between burning the blended fuels and pure JP-8. And we didn't see much in the flight tests, either, although that is very preliminary at this point. We will be looking at those over a wider power range," Anderson says.

The March flights were interrupted by maintenance issues on the DC-8. The delay, say the researchers, may have been an advantage, giving them time to perform some preliminary analyses, make adjustments to plans for the remaining flights, and prepare to conduct the first ground tests of the camelina HEFA.

"We made a really good start at Dryden, getting about halfway through meeting our milestones and objectives before we had to stand down while they sorted out the aircraft issues," Anderson said in April. While the original plan was to resume ACCESS 1 flights in May, officials said in an April 25 briefing that they had cancelled any additional FY13 flights. The plan now is to resume flight tests at Dryden as part of ACCESS 2 some time in FY14, although no dates have yet been determined.

International efforts

Bulzan says the first results from that analysis will be presented at an international workshop this summer. Presentations by attendees from other countries on related research may include follow-up data from limited synfuel flight tests conducted by Canada and South Africa.

"The Canadians used a Falcon [similar to the NASA chase plane] as the emissions source and a smaller aircraft for chase. NASA's associate administrator has said there is truly worldwide interest in this, but no one else is actually doing these experiments; so there is great interest in getting the information we are developing," he adds. "On our last telecon, we had representatives from 10 or 12 other nations, and I suspect some of those would like to participate in future experiments if there is a way they can do that. That remains to be determined."

Future flight planning

Even as they prepared for the final ACCESS 1 flights and data analysis, the research team was starting to plan for ACCESS 2, currently scheduled for 2014, and similar experiments in the future.

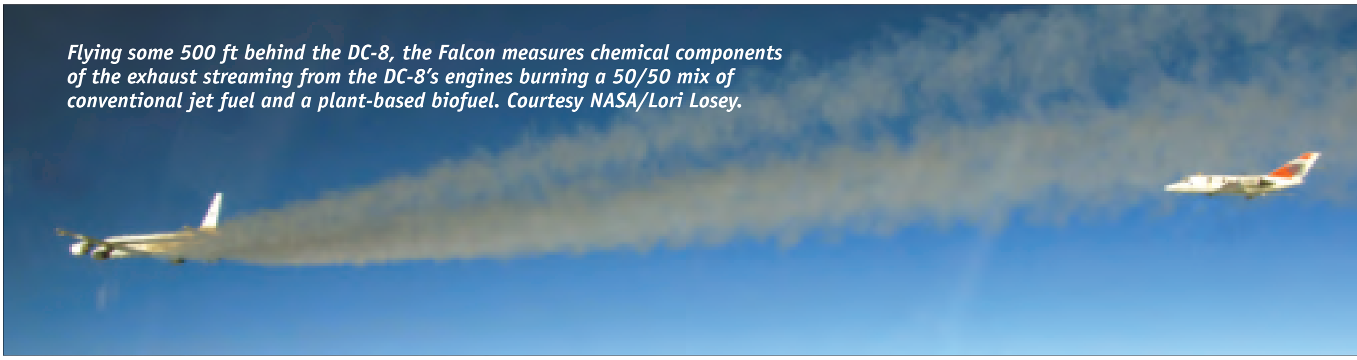
"The plan is to do a second, similar experiment, but the details will depend on the results we find from this one. We may want to expand the fuels; right now we're only using the 50/50 blend, but we may want to use a different fuel then," Bulzan says.

"The fuels must have certain properties—the major ones are sulfur content, hydrogen content, heat at combustion. We may want to investigate ways to take more of the sulfur out for the next round or reduce aromatics [polycyclic aromatic hydrocarbon emissions from the combustion of alternative fuels]. We're really just characterizing these fuels, not developing or producing them. We are looking at developing future combustors that reduce emissions and so have a strong interest in what effect these synfuels have on both current and future combustors."

Future tests, possibly including some to close out ACCESS 1, will look more closely at the formation and atmospheric impact of contrails. Plans include sending the Falcon out to gather data from modern commercial jetliners flying in the national airspace beyond Edwards AFB.

"We're waiting for some additional instruments and software the FAA requires in order to do that," Anderson says. "Then we can fly in the NAS [National Airspace System] above 28,000 ft." NASA has also obtained a Guardian jet from the Coast Guard and is modifying it to do atmospheric sampling. Part of that is a reduced vertical separation

Test instrumentation is set up behind the inboard engines of NASA's DC-8 during alternative fuels emissions and performance testing at the NASA Dryden Aircraft Operations Facility in Palmdale. Courtesy NASA Dryden/Tom Tschida.


Flying some 500 ft behind the DC-8, the Falcon measures chemical components of the exhaust streaming from the DC-8's engines burning a 50/50 mix of conventional jet fuel and a plant-based biofuel. Courtesy NASA/Lori Losey.

module; they used to space aircraft at 2,000 ft above 28,000, and now it's 1,000. So we have to get the aircraft certified for that." Some of the Guardian's equipment is different from that of the civilian Falcon on which it is based, he adds.

Balancing the heat budget

The team also hopes the combination of their own DC-8 flight tests and data obtained from trailing commercial air traffic will enable them to build on previous NASA studies and extensive modeling on how contrails affect the Earth's heat budget.

Certain constituents in the atmosphere trap heat, including long-lived greenhouse gases, of which water vapor is a major component; clouds formed by water vapor block incoming solar radiation, and temperatures drop. The Radiation Sciences Branch at NASA Langley measures both incoming and outgoing radiation to determine the atmospheric heat balance, or heat budget. If that balance is in equilibrium, then Earth is neither heating nor cooling.

"Contrails affect that balance, reflecting light and trapping heat. As other sources of pollution go away, [as a result of] using low-polluting technologies, the contrails of aircraft can have an impact on the Earth's heat budget. And where there is a substantial number of contrails, that impact is measurable," Anderson says. "There has been speculation that if you remove all particles from emissions, you can mitigate the creation of contrails. So part of our objective is to build links between particle emissions and the formation of contrails, making precise measurements.

"Soot typically warms the atmosphere; ice clouds typically reflect radiation back into space and so cool the atmosphere. But a lot also depends on the surface below—snow, forest, desert, ocean, etc. We're hoping to build on the current base of information on what conditions contrails form under and how they are related to soot emissions. Some people believe if there is no sulfur in the fuel, the black carbon particles would not be dense enough to form water and thus contrails. As we go along, maybe we can get fuels with very little sulfur."

The initial ACCESS flights did not seem to show any significant difference between contrails formed by pure jet fuel and those from engines burning a hybrid fuel.

"But that will take a great deal of statistical analysis, and we're just not there yet. This is something that takes extensive systematic study, which is something we hope to do in the coming year," he explains.

"We're learning a lot about how to sample emissions and what instruments are needed to really nail down the characteristics of the contrails. So we're in the process of building up and, as we go along, we'll have more data and statistics to pull out these more subtle effects. So from the Langley perspective, ACCESS has gone well."

Living with limitations

While any blend or even pure synthetic/alternative fuel can be used in ground tests, NASA is restricted to using FAA-certified fuels and blends for its flight tests.

"At the moment, only those two types [FT and HEFA] are certified for use with commercial aircraft, so we are pretty limited at the moment," Bulzan says. "However, a number of fuels are being looked at for certification, and that is something we might look into for ACCESS 2. The specifications say you can use up to a maximum 50/50 blend for the certified fuel. There are certain limits in the specs that the blended fuel has to meet, but even if a higher blend did meet all of those, you're not allowed to go beyond 50/50 for commercial flight.

"There are companies trying to develop pure drop-in biofuels that are not blended with JP-8. For now, those are not certified, but a South African company [Sasol] is trying to certify a pure Fischer-Tropsch fuel. For ACCESS 2, though, we may even try a fuel that is not certified, if it meets all the parameters and we can get approval from Dryden, which operates the aircraft. We're also limited to what NASA has [in its aviation fleet], but are in discussions with others on getting access to newer aircraft."

nized as an approved fuel by the international standards organization ASTM. Four aircraft—a Boeing 737-200 and three Hawker 4000s—conducted the first FSJF-fueled flights in September 2010, from Johannesburg to Cape Town.

"They landed and parked, then a few hours later flew back to Johannesburg on

The Falcon probes the exhaust contrails from the DC-8 as both aircraft enter a turn at about 35,000 ft during the first data-collection flight in the ACCESS biofuels flight test project in restricted test airspace over California's high desert. Courtesy NASA/Lori Losey.

Allowing NASA to use an uncertified fuel in future flight tests within restricted Air Force airspace would give the agency a jump on determining how such fuels may meet long-term emissions goals if and when they are certified.

"It's a long process to get new fuels certified. Pure synfuels don't meet jet fuel specs; they have issues with aromatic content and seals, which don't swell as much as they should. They typically are less dense than current specs [require], and there also are issues with conductivity, so gauges don't work right," he says.

"The goal is 'drop-in' fuels, so you can put them in anything and they will work just like petroleum-based fuels. After the ACCESS 1 news release went out, I was asked if we could use a new fuel that did not have to be blended with JP-8 in ACCESS 2. That's the fuel that was used by the Canadians. They called it 100% biofuel, but they may have added something to make it meet all jet fuel specs."

Sasol's fully synthetic jet fuel (FSJF) was approved as a Jet A-1 fuel under British military standards in 2008 and was later recognized

the same fuel. Totally uneventful, as expected," Bulzan recalls. "It has not gone into production, because the economics changed from the time of the beginning of the evaluation to approval."

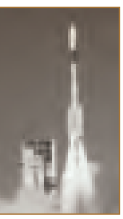
Remaining unknowns

Even with the current alternative fuel certifications and continuing ground and flight tests, some important considerations have been left out of the research programs. One is engine performance (the DC-8 is 1960s technology, so results would not be fully applicable to modern aircraft and engines); another consideration is how long-term use might affect maintenance requirements or engine life.

"I think it's too early to tell, because these [factors] have not been studied for long periods, but I have not heard any issues to date," Bulzan concludes. "Certification is a pretty stringent process, and it's unlikely anything would be certified that would incur significant changes. But, again, long-term use is required to fully determine that, and those are not something we are looking at in our program.

25 Years Ago, June 1988

June 9 The Kuiper Airborne Observatory, flying at 41,000 ft over the South Pacific, makes the first direct observation of an atmosphere on the planet Pluto. NASA, *Astronautics and Aeronautics, 1986-90*, p. 176.



June 15 The Ariane 4 rocket makes its maiden flight, a test mission. It carries PanAmSat 1 (PAS-1), the world's first private international geosynchronous satellite; the amateur radio spacecraft OSCAR 13; and a meteorological satellite. PAS-1 initiates the multibillion-dollar international commercial satellite services industry. Its owner, PanAmSat, was formed on April 23, 1984. PAS satellites are used for broadcasting, business communications, and, later, the Internet. NASA, *Astronautics and Aeronautics, 1986-90*, pp. 176-177.

50 Years Ago, June 1963

June 3-6 Sixteen NASA astronauts undergo jungle survival training at the USAF's Caribbean Air Command Tropic Survival School at Albrook AFB, Canal Zone. The training includes classroom instruction and a three-day field practice in a local jungle. NASA Marshall press release 63-96.

June 4 The California Institute of Technology announces the "first conclusive detection" of water vapor on Mars, based on findings made by the Mt. Wilson and Mt. Palomar observatories in California. The planet's water supply is found to be as small as half a cubic mile, compared with the millions of cubic miles on Earth. *New York Times*, June 5, 1963, p. 17.

June 8 The first of six Titan II ICBM squadrons based at Davis-Monthan AFB, Ariz., becomes operational. By December 31, the six squadrons' missiles total 357. The Titan II, with storable propellant, is fitted with a 9-megaton warhead and has a range of 9,325 mi. D. Baker, *Spaceflight and Rocketry*, pp. 152-153.

June 13 North American Aviation awards spacesuit manufacturing company David Clark a contract for Project Gemini suits, known as the G3C for intravehicular operations and the G4C extravehicular type, for 'space walks.' The G4C is to have added micrometeoroid and thermal protection. D. Baker, *Spaceflight and Rocketry*, p. 153.

June 14 The Vostok 5, carrying Soviet cosmonaut Valery F. Bykovsky, is launched and remains in orbit for four days 23 hr 6 min, still the longest solo spaceflight on record. D. Baker, *Spaceflight and Rocketry*, p. 153.

June 15 For the first time, six satellites are orbited in one launch, by a Thor-Agena D from Vandenberg AFB. The six are a classified 3,307-lb military satellite, the 57-lb Lofti 2A, the 86-lb Solrad 6, the 55-lb Radose, a 77-lb classified satellite, and the 7-lb Surcal 1C surveillance calibration satellite. D. Baker, *Spaceflight and Rocketry*, p. 153.

June 16 Soviet cosmonaut Valentina Tereshkova, age 26, becomes the first woman in space when her Vostok 6 is launched from the Tyuratam complex in the USSR. She is also the first civilian to fly in space, although she later joins the Soviet air force. She remains in orbit for almost three days. During the mission she comes within 3 mi. of the Vostok 5 in a 'tandem flight' and communicates by radio with its lone cosmonaut, Valery Bykovsky. Although Tereshkova has little formal technical training, she became interested in parachuting, was trained in skydiving, and made her first jump in 1959. Her expertise in skydiving led to her selection as a cosmonaut, but she also had some pilot training. She later reaches the rank of major general. D. Baker, *Spaceflight and Rocketry*, p. 153; Valentina Tereshkova file, NASM.

June 22 John C. 'Cliff' Garrett, founder of Garrett Corp. and a pioneer in the pressurization of aircraft and life-support systems, dies. In 1936 he founded a company that later was known as Garrett AiResearch, a manufacturer of turboprop engines and turbochargers. In 1939 he established a small research lab that conducted 'air research' in the development of pressurized flight for passenger aircraft. During WW II, Garrett developed and produced the cabin pressure system for the B-29, the first production bomber pressurized for high-altitude flying. From the 1960s, his AiResearch Environmental Control Systems developed life-support systems for Projects Mercury, Apollo, and Skylab spacecraft. *New York Times*, June 24, 1963, p. 27; John C. Garrett file, NASM.

June 27 Flown by Maj. Robert A. Rushworth, USAF, the X-15 rocket research aircraft penetrates space, climbing to 285,000 ft, or almost 54 mi. It also reaches a speed of Mach 4.89, or

Past

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

3,425 mph. Rushworth now qualifies for military 'astronaut wings.' D. Jenkins, *X-15: Extending the Frontiers of Flight*, pp. 408-410, 624, 630.

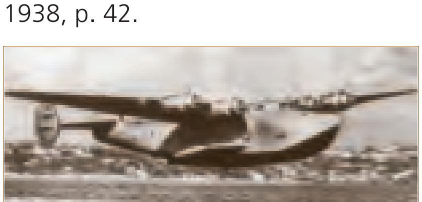
75 Years Ago, June 1938

June 1 Routine launching of balloon radiosondes begins at the Anacostia NAS in Washington, D.C. These craft, which carry radio meteorographs, will be in use in Navy fleet operations by year's end. E. Emme, ed., *Astronautics and Aeronautics 1915-60*, p. 36.

June 4 A new world record for altitude with a 5,000-kg payload is set by pilots Karlheinz Kindermann and Ruprecht Wendel, with Werner Hotopf. They ascend to 30,551 ft at Dessau, Germany, in a Junkers Ju 90. *Aircraft Year Book, 1939*, p. 466.

June 5 German pilot Maj. Gen. Ernst Udet breaks the world land-plane speed record over 100 km. He flies 394 mph from Rostok in a Heinkel He 112U (DB 601 engine), 50 mph faster than Italy's Furio Niclot Doglio. *Aero Digest,* July 1938, p. 38.

June 7 In the first test flight of the Boeing 314 flying boat, pilot Eddie Allen takes off from Puget Sound, circles over Seattle, and lands on Lake Washington. The 82,000-lb ship is the largest transport plane in the U.S. and accommodates 74 passengers. It has a maximum range of 2,400 mi. and features four 1,500-hp Wright Cyclone engines. *Aero Digest*, July 1938, p. 42.

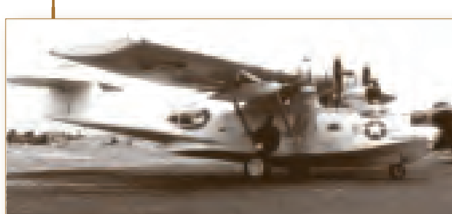


June 7 Douglas Aircraft's largest plane to date, the Douglas DC-4E, is test flown by Carl Cover in a 90-min flight. The 65,000-lb transport can carry 42 passengers and a crew of five. Powering the aircraft are four 1,400-hp Pratt & Whitney Twin Hornets. Hampered by complexity and mediocre performance, the plane never enters service; however, its failure results in an entirely new design, the DC-4/C-54, that later proves very successful. *Aero Digest*, July 1938, p. 43.

June 9 The British government announces it will purchase 400 U.S. planes, including 200 Lockheed Hudsons and 200 North American Harvard aircraft, for training by the RAF. The $28-million order is the largest ever received from abroad for U.S. aircraft. E. Emme, ed., *Astronautics and Aeronautics, 1915-60*, p. 36; *Aero Digest*, July 1938, pp. 18-19.

June 20 Karl Bode sets a world helicopter distance record of 143 mi., piloting an FW 61-VI from Fassberg to Rangsdorf, Germany. *Aircraft Year Book, 1939*, p. 467.

June 23 President Franklin D. Roosevelt signs the McCarran-Lea Civil Air Authority Act, abolishing the Bureau of Air Commerce and canceling jurisdiction over aviation matters by five other government agencies. Regulation of air commerce is now placed under a single agency called the Civil Aeronautics Authority. E. Emme, ed., *Astronautics and Aeronautics, 1915-60*, p. 36.



June 25 The Navy's most ambitious mass flight ends when 47 twin-engined Consolidated PBY-1 patrol bombers arrive at the Sand Point NAS in Seattle after a 1,100-mi. nonstop flight from San Diego. Approximately 300 officers and men are involved in the flights. *Aero Digest*, August 1938, p. 26.

100 Years Ago, June 1913

June 13 De Lloyd Thompson, the first man to loop-the-loop in the U.S., races in his plane against a racing car driven by Barney Oldfield at the Maywood Speedway in Chicago, before 20,000 spectators. *Aerial Age Weekly*, June 28, 1915, p. 344.

June 21 Georgia 'Tiny' Broadwick becomes the first woman to parachute from a plane when she jumps from an aircraft flown by Glenn L. Martin over Griffith Field in Los Angeles. F. Mason and M. Windrow, *Know Aviation*, p. 15.

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Meeting Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
2013				
6 Jun	**Aerospace Today ... and Tomorrow: Disruptive Innovation, A Value Proposition**	Williamsburg, VA (Contact: Merrie Scott: merries@aiaa.org)		
12–14 Jun†	**6th International Conference on Recent Advances in Space Technologies (RAST 2013)**	Istanbul, Turkey (Contact: Suleyman Basturk, rast2013@rast.org.tr, www.rast.org.tr)		
17–19 Jun†	**2013 American Control Conference**	Washington, DC (Contact: Santosh Devasia,devasia@u.washington.edu,http://a2c2.org/conferences/acc2013)		
24–27 Jun	**43rd AIAA Fluid Dynamics Conference and Exhibit** **44th AIAA Plasmadynamics and Lasers Conference** **44th AIAA Thermophysics Conference** **31st AIAA Applied Aerodynamics Conference** **21st AIAA Computational Fluid Dynamics Conference** **5th AIAA Atmospheric and Space Environments Conference** **AIAA Ground Testing Conference**	San Diego, CA	*Jun 12*	**20 Nov 12**
14–18 Jul	**43rd International Conference on Environmental Systems (ICES)** (Mar)	Vail, CO	*Jul/Aug 12*	**1 Nov 12**
15–17 Jul	**49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit** **11th International Energy Conversion Engineering Conference (IECEC)**	San Jose, CA	*Jul/Aug 12*	**21 Nov 12**
11–15 Aug†	**AAS/AIAA Astrodynamics Specialist Conference**	Hilton Head Island, SC (Contact: Kathleen Howell, 765.494.5786, howell@purdue.edu, www.space-flight.org/docs/2013_astro/2013_astro.html)		
12–14 Aug	**AIAA Aviation 2013: Charting the Future of Flight** **Continuing the Legacy of the AIAA Aviation Technology, Integration, and Operations (ATIO) Conference and Featuring the 2013 International Powered Lift Conference (IPLC) and the 2013 Complex Aerospace Systems Exchange (CASE)**	Los Angeles, CA	*Oct 12*	**28 Feb 13**
16–18 Aug†	**DC-X First Flight 20th Anniversary**	Alamogordo, NM (Contact: Cathy Harper, 575.437.2840 x41153, cathy.harper@state.nm.us, http://dc-xspacequest.org)		
19–22 Aug	**AIAA Guidance, Navigation, and Control Conference** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Modeling and Simulation Technologies Conference** **AIAA Infotech@Aerospace Conference**	Boston, MA	*Jul/Aug 12*	**31 Jan 13**
10–12 Sep	**AIAA SPACE 2013 Conference & Exposition**	San Diego, CA	*Sep 12*	**31 Jan 13**
23–27 Sep†	**64th International Astronautical Congress**	Beijing, China (Contact: http://www.iac2013.org)		
24–25 Sep†	**Atmospheric and Ground Effects on Aircraft Noise**	Sevilla, Spain (Contact: Nico van Oosten, nico@anotecc.com, www.win.tue.nl/ceas-asc)		
6–10 Oct†	**32nd Digital Avionics Systems Conference**	Syracuse, NY (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)		
14–16 Oct	**31st AIAA International Communications Satellite Systems Conference (ICSSC) and 19th Ka and Broadband Communications, Navigation, and Earth Observations Conference**	Florence, Italy (Contact: www.icssc2013.org)	*Feb 12*	**31 Mar 13**
21–24 Oct†	**International Telemetering Conference/USA**	Las Vegas, NV (Contact Lena Moran, 575.415.5172, lmoran@traxintl.com, www.telemetry.org)		
3–7 Nov†	**22nd International Congress of Mechanical Engineering – COBEM 2013**	Ribeirao Preto, Brazil (Contact: Joao Luiz F. Azevedo, joaoluiz.azevedo@gmail.com, www.abcm.org.br/cobem2013)		
5–7 Nov†	**8th International Conference Supply on the Wings**	Frankfurt, Germany (Contact: R. Degenhardt, +49 531 295 3059, Richard.degenhardt@dlr.de, www.airtec.aero)		
5–7 Nov†	**2013 Aircraft Survivability Symposium**	Monterey, CA (Contact: Laura Yuska, 703.247.2596, lyuska@ndia.org, www.ndia.org/meetings/4940)		
2014				
13–17 Jan	**AIAA SciTech 2014** **(AIAA Science and Technology Forum and Exposition 2014)** **Featuring:** **22nd AIAA/ASME/AHS Adaptive Structures Conference** **2nd AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **15th AIAA Gossamer Systems Forum**	National Harbor, MD		**5 Jun 13**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
	AIAA Guidance, Navigation, and Control Conference **AIAA Modeling and Simulation Technologies Conference** **10th AIAA Multidisciplinary Design Optimization Specialist Conference** **16th AIAA Non-Deterministic Approaches Conference** **55th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **7th Symposium on Space Resource Utilization** **32nd ASME Wind Energy Symposium**			
26–30 Jan†	**24th AAS/AIAA Space Flight Mechanics Meeting**	Santa Fe, NM Contact: http://www.space-flight.org/docs/2014_winter/2014_winter.html	*Jun 13*	**2 Oct 13**
27–30 Jan†	**Annual Reliability and Maintainability Symposium (RAMS) 2014**	Colorado Springs, CO (Contact: Jan Swider, 818.586.1412, jan.swider@pwr.utc.com)		
1–8 Mar†	**2014 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)		
30 Apr	**2014 Aerospace Spotlight Awards Gala**	Washington, DC		
5–9 May	**SpaceOps 2014: 13th International Conference on Space Operations**	Pasadena, CA	*May 13*	**5 Aug 13**
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)		
16–20 Jun	**AVIATION 2014** **(AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **20th AIAA/CEAS Aeroacoustics Conference** **30th AIAA Aerodynamic Measurement Technology 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** **22nd AIAA Computational Fluid Dynamics Conference** **AIAA Flight Testing Conference** **7th AIAA Flow Control Conference** **44th AIAA Fluid Dynamics Conference** **AIAA Ground Testing Conference** **20th AIAA International Space Planes and Hypersonic Systems and Technologies 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** **45th AIAA Thermophysics Conference**	Atlanta, GA		**12 Nov 13**
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	**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		**Nov 13**
2–10 Aug†	**40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events**	Moscow, Russia http://www.cospar-assembly.org		
5–7 Aug	**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**	San Diego, CA		**Feb 14**

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 Courses and Training Program

DATE	COURSE	VENUE	LOCATION
2013			
5 Jun	**Nuclear and Future Flight Propulsion: Advanced Concepts in Rocket Propulsion, Nuclear Systems, Advanced Physics, and High-Energy Density Propellants**	Webinar (1300–1430 hrs EDT)	
10–11 Jun	**Introduction to Spacecraft Design and Systems Engineering**	The Ohio Aerospace Institute	Cleveland, OH
10–11 Jun	**Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-on Training Using CIFER®**	The Ohio Aerospace Institute	Cleveland, OH
22–23 Jun	**Verification and Validation in Scientific Computing**	Fluids 2013 Conferences	San Diego, CA
18–19 Jul	**Liquid Propulsion Systems—Evolution and Advancements**	Joint Propulsion 2013 Conference	San Jose, CA
18–19 Jul	**A Practical Introduction to Preliminary Design of Air Breathing Engines**	Joint Propulsion 2013 Conference	San Jose, CA
18–19 Jul	**Missile Propulsion Design and System Engineering**	Joint Propulsion 2013 Conference	San Jose, CA
29–30 Jul	**Introduction to Space Systems**	National Aerospace Institute	Hampton, VA
29–30 Jul	**Phased Array Beamforming for Aeroacoustics**	National Aerospace Institute	Hampton, VA
29–30 Jul	**Turbulence Modeling for CFD**	National Aerospace Institute	Hampton, VA
10–11 Aug	**Guidance of Unmanned Aerial Vehicles**	AVIATION 2013	Los Angeles, CA
10–11 Aug	**Systems Engineering Verification and Validation**	AVIATION 2013	Los Angeles, CA
17–18 Aug	**Emerging Principles in Fast Trajectory Optimization**	GNC 2013 Conferences	Boston, MA
17–18 Aug	**Recent Advances in Adaptive Control: Theory and Applications**	GNC 2013 Conferences	Boston, MA
10–12 Sep	**Human Engineering Principles for Flight Deck Evaluations**	Univ. of Tennessee Space Institute	Tullahoma, TN
11 Sep	**Missile Defense: Past, Present, and Future**	Webinar (1300–1430 hrs EDT)	
23–24 Sep	**Gossamer Systems: Analysis and Design**	The AERO Institute	Palmdale, CA
23–24 Sep	**Sensor Systems and Microsystems: From Fabrication to Application**	The AERO Institute	Palmdale, CA

**Courses subject to change*

To receive information on courses listed above, write or call AIAA Customer Service, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344; 800.639.2422 or 703.264.7500 (outside the U.S.). Also accessible via the internet at www.aiaa.org/courses or www.aiaa.org/SharpenYourSkills.

From the Corner Office

A STRATEGY TO SUCCEED

Sandy H. Magnus, Executive Director

For the past few months Klaus Dannenberg, Mike Griffin, and I have been highlighting the fact that change is in the air and that the Institute is undergoing a significant transformation. This month I'd like to go into a bit more detail about the strategic direction we are taking. Of course, at the heart of our strategic plan is the recognition that we need to attract and maintain the membership, build on our strengths, deliver exceptional results and value, and build our brand. Under each of these goals we have outlined several objectives that are institute-wide and that take a broad view of what AIAA should be doing, not just focusing on the various interests in disconnected ways.

In evolving the strategic plan we started with the fundamental question: "Why does AIAA exist? What is our purpose?" The answer? We exist to ignite and celebrate aerospace ingenuity and collaboration. We are a community of people who are passionate and care deeply about making things fly, defying the laws of gravity, pushing the limits of what technology can do in its effort to get people off the ground and into the air, the atmosphere, and space. It is our common love of things flying, in any way, shape, or form, which brings us together. We solve the hard problems and take on difficult missions and make them look easy. AIAA is the organization that facilitates collaboration across the community, celebrates our accomplishments, and communicates with the world about our achievements.

As AIAA members we come together to talk about the nuts and bolts of what we do—the details of an airfoil, the exact fuel ratios for optimization of an engine, the materials of choice for a structure. We also come together to discuss, dissect, and evaluate where the industry is headed and where we would like it to go. We share knowledge at all levels. One way or another, all AIAA activities boil down to collaboration, celebration, and communication.

So what does this mean to you as a member and an aerospace professional? What it means is that AIAA is your vital lifelong link to—and champion for—the collective creativity, brainpower, and achievements of the aerospace profession. I have been able to attend several of our student events, and during my talks there I ask them to stop for a moment and look around the room. I point out that as they look around they will see the people they are going to spend the next 30 years with as they travel through their professional career. We are a tight-knit community. No matter where you go in industry, academia, or government, you will find AIAA members providing you an instant connection. An important element of our strategic plan as we move forward is to ensure that the Institute continues to promote, nurture, and build our community.

AIAA is not only about community and connectivity. I have discussed in earlier columns the fact that we live in an increasingly dynamic world with changes happening quickly. One of the elements of the strategic plan addresses how to position the Institute to be flexible and evolve as the world around us evolves. Adaptation is not only needed on the financial and business fronts, with today's environment of shrinking budgets, but also on the technical landscape. As technology is developed, new areas of interest—areas that concern the aerospace industry—are constantly appearing on the horizon. AIAA needs to engage in these areas as well. Cybersecurity, a discipline no one could have predicted as one of major concern a decade ago, is of huge interest to our whole community. Green energy and its application to the aviation industry is another. In addition, along with new technologies come policy issues around utilization and the public interest. AIAA must stay abreast of the issues and participate, if not lead, in that dialogue.

Another strong element of our strategic plan is communication. AIAA exists to celebrate and highlight the achievements of the aerospace industry and the professionals who work in it. We do great things. We do hard things! We do innovative things! The Institute not only serves to communicate our collective accomplishments to our members, but also translates what those accomplishments mean for the benefit of society. Finally, by bringing together a constant, vital community that serves as a catalyst for inspiration, we encourage young people to follow their dreams of flight and join us in this wonderful profession.

Community, collaboration, and communication—these are the things that make AIAA worthwhile to so many of us and these are the themes we captured in our strategic plan: celebrate the profession, encourage new members, build and strengthen the relationships we have across our industry, advocate for an industry we love. Stay connected to the community—the future is bright!

CALL FOR PAPERS
ICNPAA 2014 World Congress: Mathematical Problems in Engineering, Sciences and Aerospace
Narvik University, Norway, 15–18 July 2014

On behalf of the International Organizing Committee, it gives us great pleasure to invite you to the ICNPAA 2014 World Congress: 10th International Conference on Mathematical Problems in Engineering, Aerospace and Sciences, which will be held at Narvik University, Narvik, Norway.

Please visit the website, **http://www.icnpaa.com**, for all the details. This is an AIAA, Narvik University (Norway), Norut Narvik (Norway), Luleå University of Technology (Sweden), etc., cosponsored event. Proceedings will be published by AIP, USA.

AIAA Deputy Executive Director Klaus Dannenberg welcomes Kiyoshi Higuchi, IAF President and Vice President of JAXA, to AIAA Headquarters on 26 April.

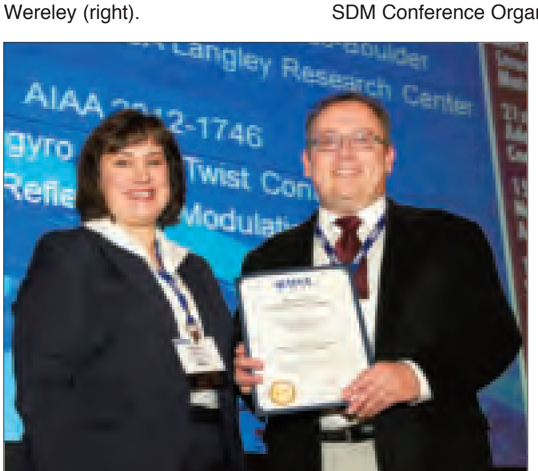
RECIPIENTS HONORED AT THE APRIL SDM CONFERENCE

Michael Hyer, Virginia Polytechnic Institute and State University (left), and Keith Kedward, University of California, Santa Barbara (center), recipients of the 2013 AIAA-ASC James H. Starnes, Jr. Awards. On the right is Dewey Hodges of Georgia Institute of Technology, recipient of the AIAA Ashley Award for Aeroelasticity.

Rauno Cavallaro and Luciano Demasi, San Diego State University, winners of the Collier Research HyperSizer/AIAA Structures Best Paper with Craig Collier and Director Kathleen Atkins (right). Not shown is Andrea Passarelli of Tiscali Italia SpA.

ASME Keynote/Adaptive Structures Prize Lecturer Alison Flatau, University of Maryland, College Park (left) with Norman Wereley (right).

SDM Conference Organizing Committee



Best Gossamer Systems Paper Author William Keats Wilkie (right) with Director Kathleen Atkins (left)

ASME/Boeing Best Papers Authors Robert Britt, Boeing Research & Technology, and Matthew Scott, NextGen Aeronautics Inc. with General Chair Anthony Waas and Director Kathleen Atkins (right).

17TH ANNUAL AIAA STUDENT DESIGN/BUILD/FLY WINNERS ANNOUNCED

Stephen Brock

AIAA congratulates the winners of the 2012–2013 Cessna Aircraft Company/ Raytheon Missile Systems/ AIAA Foundation Student Design/Build/Fly (DBF) Competition, held 19–21 April at TIMPA Field, Tucson, AZ. The DBF Competition, which encourages and recognizes excellence in aerospace engineering skills at the undergraduate and graduate level, drew 59 teams from 25 states and 14 foreign countries. There were 595 participants at this year's competition. Final results were based on the team's written report and the scores of each team's flight opportunities.


1st place winners: University of California, Irvine

Winners were announced and congratulated on Sunday afternoon. AIAA Executive Director Sandy Magnus was present and personally congratulated each of the teams. The winning teams were: University of California Irvine, Irvine, CA, received the $2,500 first place award; San Diego State University, San Diego, CA, received the $1,500 second place prize; Rensselaer Polytechnic Institute, Troy, NY, received the $1,000 third place prize.

2nd place winners: San Diego State University

One of the event's organizers, Russ Althof, an Engineering Fellow at Raytheon Missile Systems, stated: "Raytheon Missile Systems is proud to sponsor this event along with AIAA and Cessna Aircraft. I would also like to recognize all of the student teams for their effort. Congratulations to the winners as well as all of the students who have worked so hard to design, build and ultimately fly their airplanes in this competition."

Now in its 17th year, the Cessna Aircraft Company/ Raytheon Missile Systems/AIAA Foundation Design/Build/ Fly Competition challenges teams of undergraduate and graduate students to design and fabricate a radio-controlled aircraft conforming to strict guidelines, fly it over a defined course while carrying a payload, and land it without damage. The judges also evaluate the written design report submitted by each team with its aircraft. The final score is a combination of the points awarded for an aircraft's flights and for its design report. Final official results and rankings of all participants will be available from the DBF website after final verification and validation. For more information about the AIAA Design/Build/Fly Competition, visit **www.aiaadbf.org**.


3rd place winners: Rensselaer Polytechnic Institute

AIAA REGION 1 ROCKET COMPETITION

Chris Kilzer, AIAA Deputy Director for Young Professionals, Region 1

In late summer 1862, Confederate and Union forces clashed on a field at Cedar Mountain, VA. Some 151 years later, on 6 April 2013, that field saw a different kind of battle. Amateur rocket teams from all around Region 1 of AIAA gathered to launch their rockets in a battle to compete for the title of champion.

The competition, now in its third year, was a collaboration between AIAA and our hosts and resident rocket experts from Tripoli Central Virginia. Each year, teams are charged with building a rocket that could hoist a hen's egg and return it and the rocket safely back to Earth. To keep things interesting, their rockets also faced a few additional challenges:

- The Price is Right: Participants pick an altitude between 1500 and 2013 feet and get as close as possible without going over.
- What Goes Up, Must Come Down … in one piece: Once they've hit their target, bring the whole rocket back down again as fast as possible. If teams exceed the target, they're disqualified. Suffer a broken egg? Disqualified. Crash or destroy any piece of the rocket? Disqualified.

To be crowned the winner, the judges combined a score factoring in the team closest to their target altitude plus their flight time in seconds; the lowest score wins. Each team had six hours and three tries to post their best score.

Super Optimistic Noodle Squad, a team from the National Capital Section, went first. Their rocket, Gemelli I, had four rear fins and four small front fins. They had a successful launch, but the rocket separated into two sections after reaching apogee. The rear of the rocket crash landed, and the front came down 46 seconds after liftoff. The team was disqualified for the first attempt and one of the rear fins was broken.

The second team, the Egg Splatters, had a rocket made from fiberglass, kevlar, and epoxy, stuffed with flight-tested electronics. The egg was secured in a bed of sawdust. The flight up was quick, but the parachute deployment mechanism failed to fire, and the rocket plunged into the red clay of the field, four feet of its eight buried in the Earth.

The Naval Academy Rocket Team was the third and final team to compete. Their rocket successfully reached a peak altitude of 1595 feet, and separated cleanly. It made a slow return to Earth, with final touchdown 152 seconds after first motion. The egg survived the descent.

The Super Optimistic Noodle Squad received guidance from the rocket experts at Tripoli Central Virginia, and they used some repair tape, pulled out their epoxy, and reattached the fin, preparing for round two. The Egg Splatters checked out their rocket. Remarkably, all of the components survived intact; they were ready to give it another shot.

The Naval Academy Rocket Team plotted strategies to better their score. After some minor tweaks and reassembly, the team readied their equipment for attempt number two. They predicted a lower altitude of 1650 feet, and sent their rocket into the sky. It was a solid flight—great acceleration, clean flight arc, successful separation, and a clean descent. The modifications to the parachute worked as well; the descent time was cut in half from their first attempt. But their altitude prediction was too low, and the flight went over by 36 feet. The second flight was disqualified.

The Super Optimistic Noodle Squad's rocket cruised to its maximum altitude of 1508 feet, just barely above the minimum requirement, and only 67 feet under their 1575-foot prediction. The separation and descent were picture perfect with a clean break at apogee, and the chutes opened as planned for a smooth and gentle landing and a total descent time of 61 seconds. The egg was safe and unbroken—a clean scoring flight. The Super Optimistic Noodle Squad was now in the lead.

The Egg Splatters were ready to show what their rocket could really do. It was a great second flight, everything worked as planned, especially the dual deployment parachute system—1578 foot max altitude with a 62-second total flight time. The run scored an impressive 134 points, just barely missing out on the top spot.

Teams and volunteers at the AIAA Region I Rocket Competition. Volunteers: Chris Kilzer, Ben Jimenez, George Blaha, Ryan Noble, Mike Moore, Ed Stinnett, Adonay Jimenez, Bruce Milam; Tripoli Central Virginia: Will Marchant, Ivan Galysh, Elaine Russell; Super Optimistic Noodle Squad, from the National Capitol Section (Randy Spicer, Dale Schick, Brian Langmyer, William Dupuis); Egg Splatters, from the Mid-Atlantic Section (Brian Wadsley, Daniel McKinney, Brad Marples, Alex Malone, Adam Nicholl, Sharon Singer); Naval Academy Rocket Team, from the Mid-Atlantic Section (S. Hayes Friddle, Thor Stensrud, Austen Suqi, Troy McKenzie, Sam Sipe, Alex Vogel, Dan Kuerbitz, Zachary Blanchard, Jin Kang)

The winning team from National Capitol section.

Naval Academy Rocket Team

Spectators were treated to a host of other activities while the AIAA competitors were away from the field. The hosts, Tripoli Central Virginia, held the Battle of the Rockets (rocketbattle.org) for students at the high school and college level. The Battle featured a target altitude competition, an astro-egg lander event, and a Mars rover event. Teams from the University of Cincinnati, the University of Texas at Arlington, Yale University, Case Western Reserve University, Amity University, Thomas Jefferson High School, and Chantilly High School participated in the events.

Along with competition launches, it was a great day for families and their amateur rockets. People launched everything from small quick-build kits off the low-powered launch pads, to multi-stage, high-powered rockets. There was even a rocket-plane that both launched and soared through the sky. For AIAA, it was a great opportunity to chat with aerospace and rocket enthusiasts from all over the region, and share the benefits we provide to the community.


Egg Splatters Squad

The teams finished up their modifications and reloadings, prepped their rockets and eggs for launch, and headed out to the pads for one last try. First was the Naval Academy Rocket Team, who predicted 1700 feet. The flight was clean and successful, but they overshot their goal by just 10 feet, and their egg didn't survive the flight. Even with the great flight time of 82 seconds, the final flight was disqualified.

Second was the Super Optimistic Noodle Squad, with a prediction of 1550 feet. The Gemelli I performed great on liftoff, but didn't reach the minimum 1500-foot altitude. They still had the best score of the day from the second round.

The Egg Splatters set their final target at 1610 feet, and launched their rocket one last time. The flight went better than expected, but they overshot their prediction by 16 feet. Their 38-second flight time was the best of the day, but the Price is Right rule took its final victim.

As the teams congratulated one another, they were already setting their sights on next year, with great ideas for future competitions. "How about greatest acceleration without breaking an egg?" "What if we have to deploy a camera and record a scene to broadcast?" "How about returning the rocket closest to the launch pad?" "What if we include all the other AIAA sections in the country?" were all ideas thrown out in the waning hours of the day. Who knows what next year will bring, but rest assured, the competition will be back, and better than ever!

Thanks to our great team of volunteers who helped out during the day, to the National Capital Section and Young Professional Committee for sponsoring the event, and to the great folks at Tripoli Central Virginia for hosting us again this year. We look forward to seeing everyone in 2014!

CREATING STANDARDS TO ADVANCE THE AEROSPACE INDUSTRY

AIAA is an ANSI (American National Standards Institute) accredited standards developing organization (SDO), committed to the development and management of standards that serve the aerospace industry. AIAA standards are provided to our members at no cost through our website at **http://arc.aiaa.org/action/showPublications?pubType=standards**.

AIAA's Standards Program develops documents in the form of Guides, Recommended Practices, Standards, and Special Projects, which provide for the advancement of the aerospace industry by reducing costs and cycle times while increasing productivity, performance, and reliability. The technical scope of these documents covers all areas of interest to AIAA's 69 Technical Committees, including systems, components, materials, products, technologies, methods, and practices in voluntary aeronautical and aerospace applications. Standards cover topics such as human factors, safety, design, testing, construction, maintenance, performance, natural and induced environments, and operation of aerospace devices, equipment, and systems.

The AIAA Standards Program is managed through two primary groups, the Standards Executive Council (SEC) and various Committees on Standards (CoS) of which AIAA currently has 11 groups. These bodies serve very different purposes, but together they allow AIAA to produce the documents that provide the rigorous technical practices that are needed in the aerospace industry. The technical knowledge to develop a specific standard resides within a CoS. The CoS develops the proposal for a new standards document and develops the content through a consensus process. A CoS is comprised of representatives of industry, government, and academia and interest categories of producer, user, or general interest that reflect the segment of aerospace for which the standard is applicable. In addition to developing standards, the CoSs are responsible for maintaining and updating existing AIAA standards and guides to ensure that they are still technically correct in their content and relevant to the industry.

The SEC maintains the policies and procedures for AIAA's accredited Standards Program, provides oversight for the CoSs in the development of the standards and related documents, reviews and approves standards and related documents, and collaborates with other areas of the Institute to integrate standards activities. The SEC works to ensure that standards are developed in a manner that ensures consensus, provides appropriate technical rigor, and are structured to provide significant value to the aerospace industry.

The development of an AIAA standard is a volunteer effort requiring a significant investment of time to complete. The members of the SEC and the CoS come from many areas of the aerospace community and from organizations large and small. The common denominator is that these folks are passionate about the subjects in which they work. They have seen a need for collaboration across organizations, and they are committed to develop the documents that capture best practices and other guidance that will enable various areas of the community to work together in a more efficient manner, through the use of AIAA standards documents. We appreciate all of their efforts.

AIAA thanks the CoS Chairs and all of their members for their contributions to the AIAA Standards Program in 2012:

Aerospace Pressure Vessels
Nathanael Greene, NASA WSTF/JSC
Michael Kezirian, Boeing

Atmospheric Space Environment
Kent Tobiska, Space Environment

Computational Fluid Dynamics
Urmila Ghia, University of Cincinnati

Electric Propulsion Testing
John Dankanich, NASA GRC

Ground Testing
Richard White, ViGYAN, Inc.
Ray Castner, NASA Glenn

Hydrogen
Steve Woods, NASA WSTF
Steve McDougle, NASA WSTF

Mission Assurance
Tyrone Jackson, Simanima

Solar Cells/Solar Panels
Ed Gaddy, Johns Hopkins University Applied Physics Laboratory
Amalia Aviles, Boeing
Henry Brandhorst, Carbon Free Energy
Robert Francis, Aerospace Corp.

Space Internetworking
Robert Durst, Mitre

Space Plug and Play
Fred Slane, Space Infrastructure Foundation

Space System Battery Safety
Judy Jeevarajan, NASA Johnson Space Center
Rengaswamy (Srini) Srinivasan

Systems Engineering
Satoshi Nagano, The Aerospace Corp.
Jim Van Gaasbeek, Northrop Grumman Corp.

In addition, the following AIAA members served on the Standards Executive Council in 2012:

Allen Arrington, Sierra Lobo, Inc. at NASA Glenn
Dave Cahill, Arnold AFB
Wilson Felder, FAA/Stevens Institute of Technology
David Finkleman, AGI
Joy Fitzpatrick, Boeing
Linden Harris, Airbus SAS
Adrian Hooke (deceased), NASA JPL
Ron Kohl, RJ Kohl and Associates
Laura McGill (VP, Standards), Raytheon
Satoshi Nagano, The Aerospace Corp.
Clinton Plaisted, a.i. Solutions
Fred Slane, Space Infrastructure Foundation
William Vaughan, University of Alabama at Huntsville
Trudie Williams, Department of Defense

If you are interested in lending your expertise to this fundamental work, which benefits the entire aerospace profession, please contact the AIAA Director of Standards, Nick Tongson at nickt@aiaa.org.

CALL FOR BOARD OF DIRECTORS NOMINATIONS

The 2013–2014 AIAA Nominating Committee will meet on 15 August 2013 to review nominees and select candidates to participate in the Board of Directors election to fill the following vacancies by election in 2014:

- Vice President-Elect, Finance
- Vice President-Elect, Publications
- Vice President-Elect, International
- Vice President-Elect, Standards
- Director—Aircraft & Atmospheric Sciences Group
- Director—Engineering & Technology Management Group
- Director—Space and Missile Systems Group
- Director—Region 1
- Director-at-Large
- Director-at-Large International

AIAA members may submit themselves or other members qualified for the chosen position as nominees by submitting a nomination through the AIAA website (go to **www.aiaa.org**, log in, and select Board of Director Nomination from the left-hand navigation bar) no later than **9 August 2013**. Nominations will open 14 June.

Bill Seymore
AIAA Corporate Secretary

CALL FOR PAPERS FOR *JOURNAL OF AEROSPACE INFORMATION SYSTEMS*

Special Issue on "Software Challenges in Aerospace"

Special Issue on "Aerospace and Mechanical Applications of Reinforcement Learning and Adaptive Learning Based Control"

The *Journal of Aerospace Information Systems* (formerly the *Journal of Aerospace Computing, Information, and Communication* (*JACIC*)) is devoted to the applied science and engineering of aerospace computing, information, and communication. Original archival research papers are sought that include significant scientific and technical knowledge and concepts. In particular, articles are sought that demonstrate the application of recent research in computing, information, and communications technology to a wide range of practical aerospace problems in the analysis and design of vehicles, onboard avionics, ground-based processing and control systems, flight simulation, and air transportation systems.

Information about the organizers of these special issues as well as guidelines for preparing your manuscript can be found in the full Call for Papers under Featured Content in Aerospace Research Central; **arc.aiaa.org**. The journal website is **http://arc.aiaa.org/loi/jais**.

Special Issue on "Software Challenges in Aerospace"

Deadline: Submissions are due by **15 August 2013**.
Anticipated Publication Date: **November 2013**.
Contact Email: Misty Davies, misty.d.davies@nasa.gov or Lyle Long, lnl@psu.edu

Key research areas included in the special issue are:

- *Software Synthesis for Aerospace*: including model-based approaches to software and software-intensive system design, compositional and hierarchical design approaches for reducing and managing complexity, approaches to building intelligent and adaptive systems within a safety-critical framework, the generation of code that is correct-by-construction, and the design of maintainable systems.
- *Software Analysis for Aerospace*: including verification and validation for safety-critical software systems, security analysis for aerospace communications, compositional analysis of code for scalability, automated testing techniques, and statistical techniques (including data mining and learning) for program and software behavior analysis.
- *Aerospace System Integration*: including architectures for safety-critical aerospace systems containing software, hardware, and people; approaches to, benefits of, and limitations of Integrated Modular Avionics frameworks; human-computer interaction including intelligent cockpits/control towers; and adaptive airspace implementations.
- *Aerospace Software Policy and Implementation*: including the certification of software systems using traditional or safety-case based approaches and decision-making in air systems (including both autonomy and human factors issues).
- Creating and maintaining a skilled workforce for aerospace software, college curricula, and certification of software engineers.
- Intelligent systems software for aerospace systems.
- Software issues in cybersecurity related to aerospace systems.
- Use of COTS software in critical systems.

These areas are only indicative. The special issue is also open to manuscripts that are relevant to the applied science and engineering of aerospace computing, information, and communication but do not fit neatly into any of the above areas. We do envisage, however, that successful manuscripts will include experimental results, sophisticated simulations of aerospace systems, or (in the case of a paper in the areas of education or policy) well-researched and thorough arguments for policies and their implementations.

Special Issue on "Aerospace and Mechanical Applications of Reinforcement Learning and Adaptive Learning Based Control"

Deadline: Submissions are due by **15 August 2013**.
Anticipated Publication Date: **January 2014**.
Contact Email: Jonathan How, jhow@mit.edu

Key research areas included in the special issue are:

- Learning with limited data and/or in domains for which obtaining data is expensive or risky
- Real-time reinforcement learning with resource constraints (e.g., limited memory and computation time)
- Use of reinforcement learning for risk sensitive or safety critical applications
- Scaling reinforcement learning to multi-agent systems
- Distributed reinforcement learning
- Adaptive learning-based control in the presence of uncertainty

These areas are only indicative. The special issue is also open to manuscripts that are relevant to the applied science and engineering of aerospace computing, information, and communication but do not fit neatly into any of the above areas. We do envisage, however, that successful manuscripts will include experimental results, or at least sophisticated simulations of real-life mechanical or aerospace systems.

Reinforcement learning and learning-based adaptive control are powerful techniques to perform planning and control for systems with significant model errors and uncertainty. In the computer science community many benchmark types examples have been tackled successfully, showing the advantage of these learning techniques. The goal of this special issue is, however, to assemble high-quality papers that highlight the use of these techniques in more complex aerospace and mechanical engineering applications. In particular, papers are encouraged that demonstrate the use of these learning-based planning and control approaches on physical systems operating in real-world situations with significant disturbances and uncertainties. Classes of uncertainties could include modeling error, uncertainty due to environmental/external effect, hybrid/switched dynamics, sensing/actuation errors, noise, sensing/actuation failures, and structural damage/failures. Model-free and model-based control/planning techniques should highlight online long-term learning through construction and exploitation of (approximate) models of the agent, the environment, value functions, state/action constraints, etc. Long-term learning could be characterized by improved tracking, improved mission-score, online generation of optimal policy, predictive ability, and accurate prognosis.

Examples of classes of planning and reinforcement learning techniques include, but are not limited to: approximate dynamic programming, temporal difference learning, adaptive function approximation techniques, planning under uncertainty, intelligent exploration scheme, and learning with risk mitigation.

Examples of classes of control techniques of interest include, but are not limited to: indirect adaptive control, hybrid direct/indirect adaptive control, dual-control, adaptive model predictive control, direct optimal adaptive control using reinforcement learning, learning-focused neuro-adaptive and neuro-fuzzy control, nonparametric control. In general, papers that leverage exploitation of predictive ability of online learning and adaptation are encouraged, whereas papers that focus on adaptation based on reactive short-term learning would risk being outside the scope of this issue.

MEMBERS RECOGNIZED IN APRIL

AIAA Fellow Dr. Peter Kurzhals Honored by Virginia Tech

Pictured from left are: Bill Grossmann, Peter Kurzhals, Richard C. Benson (dean of the college of engineering); Eric Paterson (department head of aerospace and ocean engineering), and Howard Robins (past inductee).

Peter Kurzhals, who earned his bachelor's, master's, and doctoral degrees in aerospace engineering from Virginia Tech in 1960, 1962, and 1966, respectively, is a 2013 inductee into Virginia Tech's College of Engineering Academy of Engineering Excellence, joining an elite group of 119 individuals out of more than 60,000 living engineering alumni.

The Academy of Engineering Excellence was founded in 1999. The inductees are engineering graduates of Virginia Tech who have made continuous and admirable engineering or leadership contributions during their careers. This year marked the fourteenth anniversary of the first induction.

Kurzhals was at NACA when Sputnik was launched in 1957 and quickly became involved in America's task of putting its own astronauts on the moon. Motivated to learn more, Kurzhals headed back to Virginia Tech to obtain his master's and doctoral degrees. At Virginia Tech, he developed and patented a double-gimbaled Control Moment Gyro (CMG) system to control the attitude of spacecraft with significant cost savings. NASA advanced $50 million to build a prototype system, and Kurzhals and his colleagues traveled to the Marshall Space Flight Center where they made a presentation on the new technology. Although met with resistance, one person believed it would work—Wernher von Braun.

In 1969, Kurzhals was transferred to NASA headquarters as chief of the guidance and control branch, and soon was promoted to director of the electronics division. He directed NASA's Search for Extraterrestrial Intelligence (SETI) Program and the Artificial Intelligence and Robotics Program, which developed the predecessors to today's planetary rovers, such as the *Curiosity* robot now maneuvering itself around Mars. From 1979 to 1980, Kurzhals was director of NASA's Space Division and from 1981 to 1984, he was assistant director of mission operations at Goddard Space Flight Center in Maryland.

In 1984, he joined the private sector, first at Booz Allen, and then at McDonnell Douglas Astronautics Company. In 1992, he was promoted to its director of Advanced Space Flight Programs. When Boeing acquired McDonnell Douglas in 1995, Kurzhals was named director of Boeing's product support for the International Space Station. He retired in 2011 as director of systems and software for the Boeing's space exploration division.

Kurzhals has sponsored leadership scholarships at both Virginia Tech and Harvard to give future generations opportunities for higher education. The aerospace engineer has won many accolades, including AIAA Fellow and Orange County (California) Engineer of the Year.

2013 RNASA Stellar Award Winners Announced

In April, the 2013 Rotary National Award for Space Achievement (RNASA) Stellar Award winners were recognized. The winners were selected based on which accomplishments hold the greatest promise for furthering future activities in space and how well it meets the goal of recognizing "unsung heroes."

Two AIAA members were among those who were honored this year. AIAA Senior Member **Dr. William M. Marshall**, NASA Glenn Research Center, was given the 2013 Stellar Award Winners in the Early Career Category "for exceptional leadership and technical expertise in rocket combustion research and testing that has enhanced numerous NASA programs and significantly aided the technical community."

AIAA Senior Member **Mary Cerimele** was on the NASA Johnson Space Center Webb Space Telescope Chamber A Modification Team that was among those given the 2013 Stellar Award Winners in the Team Awards Category "for exceptional accomplishments in the modification of JSC's Chamber A to provide deep space environmental testing of the James Webb Space Telescope."

The luncheon speaker at the awards ceremony was AIAA Executive Director **Sandra Magnus**, who flew on ISS assembly mission STS-112 in 2002; returned to the ISS on STS-126 to serve as flight engineer on Expedition 18 from November 2008 until returning on STS-119 in March 2009. She flew on the final Space Shuttle flight, STS-135, in July 2011. Magnus shared how being in space increased her appreciation for our planet. "Earth is our spaceship," she said. "We really have to take care of it." On a lighter note, she said, "Gravity is horrible! I can't believe we can get anything done on this planet." But, she added, "Humans are extremely adaptable. After three days in space, I felt like I'd been there forever." She urged the nominees to keep active, embrace the unknown, and "spend time doing what you love."

AIAA Associate Fellow Daniel T. Jensen Honored

Daniel Jensen was selected to be a recipient of the 2013 Aerospace Distinguished Alumnus Award. The award honors University of Illinois graduates who have made professional and technical contributions that bring distinction to themselves, the department, and the university.

Mr. Jensen is Head of Engineering for Services–Indianapolis, Rolls-Royce Corporation. Besides being an AIAA Associate Fellow, he is also the AIAA Emerging Technologies Committee Chair and involved in several other AIAA technical committees.

OBITUARIES

AIAA Associate Fellow Tsirimokos Died in October 2012

John X. Tsirimokos, 80, passed away on 18 October 2012.

Mr. Tsirimokos went to Boston University and MIT, earning a master's degree in aeronautical engineering.

He began a notable aeronautical career as a field engineer with Sperry Corporation, then worked for North American Aviation in Columbus, OH, and moved to San Diego in 1960, having joined Convair. In 1965, he worked in Philadelphia for Boeing Vertol.

Mr. Tsirimokos returned to San Diego where he joined General Dynamics. Among the projects on which he was instrumental were the A-5 Vigilante, the Atlas ICBM, the CH-47 Chinook, the FB-111 Aardvark, and the BGM-109G ground-launched cruise missile. He retired from General Dynamics as director of Systems Engineering, Cruise Missile Programs. A versatile designer, he also worked for Fansteel, where he developed award-winning graphite tennis racquets for Wilson Sporting Goods.

Mr. Tsirimokos was chair of the Systems Effectiveness & Safety Technical Committee from 1993–1994. He was honored by AIAA with the Systems Effectiveness and Safety Award for new and innovative methodology and analytical techniques achieving advances in nuclear safety certification for weapon system hardware and software that were essential to the success of the Intermediate Nuclear Force Treaty.

Associate Fellow Lee Died in November 2012

Dr. Vernon Albert Lee, 80, died 19 November 2012.

Dr. Lee earned BS and MS degrees in aeronautical engineering at the University of Texas at Austin in 1954 and 1956. He joined General Dynamics' Fort Worth Division in 1957 and took a leave of absence in 1961 to obtain his doctorate in aerospace engineering from UT.

Upon return to General Dynamics, Dr. Lee served in a variety of engineering and management positions. He was leader of the space systems, aircraft performance and aerothermodynamics engineering groups. He was then director of support engineering and was program director of the F-16 programs for Israel and Greece.

Dr. Lee was appointed vice president and program director of the Japan FSX aircraft development program, a challenging initiative with Japanese government. He was involved in testimony with U.S. congressional committees and with senior Japanese officials to obtain approval to establish the program. When the Japan program moved into production of the F-2 aircraft, Dr. Lee was appointed vice president of the Systems Development Center (advance design programs), including aircraft programs with South Korea and Taiwan. He retired from Lockheed Martin on 31 December 1998, after 43 years of service. He was an AIAA member for 60 years.

AIAA Senior Member Carmody Died in December 2012

Robert G. Carmody, 65, died on 12 December 2012.

Mr. Carmody held graduate degrees from the University of Buffalo, University of Colorado, and the University of Houston. He was passionate about his work and science especially when it came to meteorology. He had implemented new techniques that improved severe weather forecasting lead times and accuracy at Ellington Field, TX. He was employed in the aerospace industry for over 30 years, both at Boeing and Lockheed Martin.

Mr. Carmody was commissioned in the U.S. Army and served in Vietnam. He was also a Master Sargent in the Air National Guard.

AIAA Honorary Fellow Holtby Died in March

Kenneth F. Holtby, key designer for Boeing 747, 757, and 767 Aircraft, died on 27 March. He was 90 years old.

Mr. Holtby served in the U.S. Air Corps during World War II before finishing his aeronautic studies at Caltech. He began working as an aerospace engineer at Boeing in 1947, and became chief of the aerodynamics staff six years later—first at Wichita, and in Renton. In 1962, he became a Sloan Fellow at MIT, a yearlong fellowship offered to managers exhibiting notable success to become even stronger leaders.

Mr. Holtby helped shape Boeing's 747, 757 and 767 commercial jetliners with his wide-ranging grasp of airplane design. Some engineers specialize, but Mr. Holtby did it all. His technical expertise structured everything from the size of an engine to the precise curvature of a wing.

Holtby played a primary role in designing the Boeing 747 "Jumbo Jet," a groundbreaking aircraft design that debuted in 1969. Teaming with Joseph Sutter and Robert Davis, Holtby was able to design a commercial aircraft that for nearly 40 years was unmatched in design, speed, passenger capacity, and passenger comfort.

Holtby was made vice president and general manager of Boeing's 747 line in 1972, moving on six years later to run Boeing's 757 and 767 jetliner projects. Holtby's 757 and 767 designs featured a two-crew cockpit and uniform control structures for both planes, allowing airlines, for the first time, to have two separate airliners single rated for the same type of crew proficiency. This allowed for great flexibility in assigning crew and more efficient air routes and service. The designs introduced the "glass cockpit," where all relevant flight data was displayed on computer monitors instead of traditional analogue dials and gauges, enhancing safety by allowing for simpler transmission and understanding of flight data. The glass cockpit is now the industry standard.

In 1997 the 747 team earned the Francois-Xavier Bagnoud Aerospace Prize, a biennial award honoring outstanding aerospace achievement. In 1984, Mr. Holtby, Everette Webb, and Philip Condit received the AIAA Aircraft Design Award for their managerial and technical leadership on the 757 and 767.

After 40 years working at the aerospace giant, Mr. Holtby retired in 1987 as Boeing's top technical engineer. Mr. Holtby continued to coach engineers about the construction of various Boeing jetliners and his design suggestions can be found in many that fly today.

CALL FOR NOMINATIONS

Recognize the achievements of your colleagues by nominating them for an award! Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 July**. Awards are presented annually, unless other indicated. However AIAA accepts nomination on a daily basis and applies to the appropriate year.

Any AIAA member in good standing may serve as a nominator and are highly urged to carefully read award guidelines to view nominee eligibility, page limits, letters of endorsement, etc. AIAA members may submit nominations online after logging into **www.aiaa.org** with their user name and password. You will be guided step-by-step through the nomination entry. If preferred, a nominator may submit a nomination by completing the AIAA nomination form, which can be downloaded from www.aiaa.org.

All nominations, whether submitted online or in hard copy, must comply with the limit of 7 pages for the nomination package. The nomination package includes the nomination form, a one-page basis for award, one-page resume, one-page public contributions, and a minimum of 3 one-page signed letters of endorsement from AIAA members. Five signed letters of endorsement (including the 3 required from AIAA members) may be submitted and increase the limit to 9 pages. Nominators are reminded that the quality of information is most important.

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 odd 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 is presented for 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)

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 odd 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, carols@aiaa.org or 703.264.7623.

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.

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24th AAS/AIAA Space Flight Mechanics Meeting

26–30 January 2014
La Fonda Hotel
Santa Fe, New Mexico

Abstract Deadline: 2 October 2013

The 24th Space Flight Mechanics Meeting will be held Sunday, 26 January through Thursday, 30 January 2014 at the La Fonda Hotel in Santa Fe, NM. The conference is organized by the American Astronautical Society (AAS) Space Flight Mechanics Committee and cosponsored by the AIAA Astrodynamics Technical Committee. Manuscripts are solicited on topics related to space-flight mechanics and astrodynamics, including but not necessarily limited to:

- Asteroid and non-Earth orbiting missions
- Atmospheric re-entry guidance and control
- Attitude dynamics, determination and control
- Attitude-sensor and payload-sensor calibration
- Dynamical systems theory applied to space flight
- Dynamics and control of large space structures and tethers
- Earth orbital and planetary mission studies
- Flight dynamics operations and spacecraft autonomy
- Orbit determination and space-surveillance tracking
- CubeSat and Nano Satellite mission design and operations
- Orbital debris and space environment
- Orbital dynamics, perturbations, and stability
- Rendezvous, relative motion, proximity missions, and formation flying
- Reusable launch vehicle design, dynamics, guidance, and control
- Satellite constellations
- Spacecraft guidance, navigation, and control (GNC)
- Space Situational Awareness (SSA), Conjunction Analysis (CA), and collision avoidance
- Trajectory/Mission/Maneuver design and optimization

Manuscripts will be accepted based on the quality of the extended abstract, the originality of the work and/or ideas, and the anticipated interest in the proposed subject. Submissions that are based on experimental results or current data, or report on ongoing missions, are especially encouraged. Complete manuscripts are required no later than **22 January 2014**. English is the working language for the conference.

Additional and up-to-date information can be found at the conference website: **http://www.space-flight.org/docs/2014_winter/2014_winter.html**.

Special Session

In addition to the above general topics, papers are also solicited for a special session on mission concepts, analysis, implementation, and operations for CubeSat/Nano Satellite design. Authors are asked to indicate on the abstract submission if you would like to be considered for inclusion in this special session. Manuscripts not selected for the special session will be allocated to other relevant sessions.

Breakwell Student Travel Award

The AAS Space Flight Mechanics Committee announces the John V. Breakwell Student Travel Award. This award provides travel expenses for up to two U.S. and Canadian students presenting at this conference. Students wishing to apply for this award are strongly advised to submit their completed manuscript by the abstract submittal deadline. The maximum coverage per student is limited to $1000. Details and applications may be obtained via **http://www.space-flight.org**.

Information for Authors

Because the submission deadline of **2 October 2013** has been fully extended for the convenience of contributors, there are no plans to defer this deadline due to the constraints of the conference planning schedule. Notification of acceptance will be sent via email by **30 October 2013**. Detailed author instructions will be sent by email following acceptance. By submitting an abstract, the author affirms that the manuscript's majority content has not been previously presented or published elsewhere.

Authors may access the web-based abstract submittal system using the link available via the official website: **http://www.space-flight.org**. During the online submission process, authors are expected to provide:

1) A paper title, as well as the name, affiliation, postal address, telephone number, and email address of the corresponding author and each co-author,
2) An extended abstract in the Portable Document File (PDF) format of at least 500 words that includes the title and authors, and provides a clear and concise statement of the problem to be addressed, the proposed method of solution, the results expected or obtained, and an explanation of its significance to astrodynamics and/or space-flight mechanics, with pertinent references and supporting tables and figures as necessary,
3) A condensed abstract (100 words) to be included in the conference program, which is directly typed into the text box provided on the web page and avoids the use of special symbols or characters, such as Greek letters.

Foreign contributors requiring an official letter of acceptance for a visa application should contact the Technical Chairmen by email at their earliest opportunity.

Technology Transfer Notice

Technology transfer guidelines substantially extend the time required to review abstracts and manuscripts by private enterprises and government agencies. To preclude late submissions and withdrawals, it is the responsibility of the author(s) to determine the extent of necessary approvals prior to submitting an abstract.

No-Paper/No-Podium Policy

A complete manuscript must be electronically uploaded to the website prior to **22 January 2014** in PDF format, be no more than 20 pages in length, and conform to the AAS manuscript format. If a complete manuscript is not received on time, then its presentation at the conference shall be forfeited; and if a presentation is not made by an author at the conference, then the manuscript shall be omitted from published proceedings.

Questions concerning the submission of manuscripts should be addressed to the technical chairs:

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All other questions should be directed to the General Chairs:

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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.

Upcoming AIAA Professional Development Courses

5 June 2013
This 90-minute webinar will take place at 1300–1430 EST

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

AIAA Member	$149
Nonmember*	$189
AIAA Student Member	$60
Full-Time Student (Nonmember)*	$70

*Nonmember fee does not include AIAA membership

Nuclear and Future Flight Propulsion: Advanced Concepts in Rocket Propulsion, Nuclear Systems, Advanced Physics, and High-Energy Density Propellants (Instructor: Bryan Palaszewski)

The Nuclear and Future Flight Propulsion Course includes information on many different topics in advanced nuclear space propulsion. A short overview is provided on the wide breadth of advanced propulsion concepts, ranging from advanced chemical propulsion to solar sails, to aerocapture, to fission, fusion, and antimatter. The remaining discussions will focus on vehicle system design, construction, and operation for missions throughout the Solar System. These presentations will include Radioisotope Thermoelectric Generators (RTGs), nuclear thermal propulsion, nuclear electric propulsion, nuclear spacecraft options and configurations, and a basic overview of future nuclear power and propulsion systems.

10–11 June 2013
The following standalone course is being held at The Ohio Aerospace Institute in Cleveland, Ohio.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

	Early Bird by 10 May	*Standard (11 May–3 Jun)*	*On-site (4–10 Jun)*
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

Introduction to Spacecraft Design and Systems Engineering (Instructor: Don Edberg)

This course presents an overview of factors that affect spacecraft design and operation, beginning with an historical review of unmanned and manned spacecraft, including current designs and future concepts. All the design drivers, including launch and on-orbit environments and their affect on the spacecraft design, are covered. Orbital mechanics is presented in a manner that provides an easy understanding of underlying principles as well as applications, such as maneuvering, transfers, rendezvous, atmospheric entry, and interplanetary transfers. Considerable time is spent defining the systems engineering aspects of spacecraft design, including the spacecraft bus components and the relationship to ground control. Design considerations, such as structures and mechanisms, attitude sensing and control, thermal effects and life support, propulsion systems, power generation, telecommunications, and command and data handling are detailed. Practical aspects, such as fabrication, cost estimation, and testing, are discussed. The course concludes with lessons learned from spacecraft failures.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

	Early Bird by 10 May	*Standard (11 May–3 Jun)*	*On-site (4–10 Jun)*
AIAA Member	$995	$1125	$1220
Nonmember*	$1115	$1245	$1340

*Includes a one-year AIAA membership

Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-on Training Using CIFER® (Instructor: Dr. Mark B. Tischler)

The objectives of this course are to 1) review the fundamental methods of aircraft and rotorcraft system identification and illustrate the benefits of their broad application throughout the flight vehicle development process; 2) provide the attendees with an intensive hands-on training of the CIFER® system identification, using flight test data and 10 extensive lab exercises. Students work on comprehensive laboratory assignments using student version of software provided to course participants (requires student to bring NT laptop). The many examples from recent aircraft programs illustrate the effectiveness of this technology for rapidly solving difficult integration problems. The course will review key methods and computational tools, but will not be overly mathematical in content. The course is highly recommended for graduate students, practicing engineers, and managers. The AIAA textbook, *Aircraft and Rotorcraft System Identification: Engineering Methods with Flight-Test Examples, Second Edition*, is included in the registration fee.

22–23 June 2013
This Continuing Education course is being held at the AIAA Fluid Dynamics and collocated conferences in San Diego, CA. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

To register for one of the Fluid Dynamics 2013 courses, go to **www.aiaa.org/fluids2013.**

	Early Bird by 29 May	*Standard (30 May–21 Jun)*	*On-site (22 Jun)*
AIAA Member	$1278	$1378	$1478
Nonmember*	$1388	$1488	$1588

*Includes a one-year AIAA membership

Verification and Validation in Scientific Computing

(Instructors: William Oberkampf, Engineering Consultant, WLO Consulting and Chris Roy, Aerospace and Ocean Engineering Department, Virginia Tech)

The performance, reliability, and safety of engineering systems are becoming increasingly reliant on modeling and simulation. This course deals with techniques and practical procedures for assessing the credibility and accuracy of simulations in science and engineering. It presents modern terminology and effective procedures for verification of numerical simulations and validation of mathematical models that are described by partial differential equations. While the focus is on scientific computing, experimentalists will benefit from the discussion of techniques for designing and conducting validation experiments. A framework is provided for estimating various sources of errors and uncertainties identified both in simulations and in experiments, and then combining these in total prediction uncertainty. Application examples techniques and procedures are taken primarily from fluid dynamics, solid mechanics, and heat transfer. This short course follows closely the instructors' book *Verification and Validation in Scientific Computing* (Cambridge University Press, 2010).

18–19 July 2013

The following Continuing Education courses are being held at the 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and the 11th International Energy Conversion Engineering Conference in San Jose, CA. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

To register for one of the JPC 2013 courses, go to **www.aiaa.org/JPC2013.**

	Early Bird by 17 Jun	Standard (18 Jun–12 Jul)	On-site (14–18 Jul)
AIAA Member	$1293	$1393	$1493
Nonmember*	$1403	$1503	$1603

*Includes a one-year AIAA membership

Liquid Propulsion Systems—Evolution and Advancements **(Instructors: Alan Frankel, Business Development, Moog-ISP, Space and Defense Group; Dr. Ivett Leyva, Combustion Devices Group, AFRL/RZSA; Patrick Alliot, Senior Technical Expert, Space Engine Division of SNECMA)**
Liquid propulsion systems are critical to launch vehicle and spacecraft performance, and mission success. This two-day course, taught by a team of government, industry, and international experts, will cover propulsion fundamentals and topics of interest in launch vehicle and spacecraft propulsion; non-toxic propulsion; microsat and cubesat propulsion; propulsion system design and performance; and human rating of liquid engines. In keeping with the theme of the 2011 JPC, "Turning Propulsion Ideas into Reality," lessons learned from development and flight of components and systems will be discussed.

A Practical Introduction to Preliminary Design of Air Breathing Engines **(Instructors: Dr. Ian Halliwell, Senior Research Scientist, Avetec; Steve Beckel, Director for Advanced Propulsion, Alliant Techsystems (ATK) Missile Products Group)**
The course presents an overview of the preliminary design of air-breathing engine systems that is determined primarily by the aircraft mission, which defines the engine cycle—and different types of cycle are investigated. Preliminary design activities are defined and discussed in the context of the overall engine development process and placed in perspective. Some basic knowledge of aerodynamics and thermodynamics is assumed so the mathematical material that appears in many good textbooks is minimized and the question "What do you actually do as an engine designer?" is addressed. The practical means and processes by which thermodynamic concepts are turned into hardware are covered and some design techniques are demonstrated. The fact that an air breathing engine is much more than the flowpath component is discussed and the future of engine design methods is raised. Class participation is encouraged throughout.

Missile Propulsion Design and System Engineering **(Instructor: Eugene L. Fleeman, International Lecturer on Missiles)**
A system-level, integrated method is provided for the missile propulsion system design, 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. Attendees receive course notes.

29–30 July 2013

The following standalone course is being held at the National Aerospace Institute in Hampton, Virginia.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

	Early Bird by 1 Jul	Standard (2–22 Jul)	On-site (23–29 Jul)
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

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

Phased Array Beamforming for Aeroacoustics

(Instructor: Robert Dougherty)

This course presents physical, mathematical, and some practical aspects of acoustic testing with the present generation of arrays and processing methods. The students will understand the capabilities and limitations of the technique, along with practical details. They will learn to design and calibrate arrays and run beamforming software, including several algorithms and flow corrections. Advanced techniques in frequency-domain and time-domain beamforming will be presented. The important topics of electronics hardware and software for data acquisition and storage are outside the scope of the course, apart from a general discussion of requirements.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

	Early Bird by 1 Jul	*Standard (2–22 Jul)*	*On-site (23–29 Jul)*
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

Turbulence Modeling for CFD **(Instructor: David Wilcox)**

The course begins with a discussion of turbulence physics in the context of modeling. The exact equations governing the Reynolds stresses, and the ways in which these equations can be closed, is outlined. Starting with the simplest turbulence models this course charts a course leading to some of the complex models that have been applied to a nontrivial turbulent flow problem. It stresses the need to achieve a balance among the physics of turbulence, mathematical tools required to solve turbulence-model equations, and common numerical problems attending use of such equations.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

	Early Bird by 1 Jul	*Standard (2–22 Jul)*	*On-site (23–29 Jul)*
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

10–11 August 2013

The following Continuing Education courses are being held at the AVIATION 2013 Conference in Los Angeles, CA. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

To register for one of the AVIATION 2013 courses, go to **www.aiaa.org/aviation2013.**

	Early Bird by 15 Jul	*Standard (16 Jul–9 Aug)*	*On-site (10 Aug)*
AIAA Member	$1320	$1420	$1520
Nonmember*	$1430	$1530	$1630

*Includes a one-year AIAA membership

Guidance of Unmanned Aerial Vehicles

(Instructors: Dr. Rafael Yanushevsky, University of Maryland)

The developed course presents a rigorous guidance theory of unmanned aerial vehicles. It can be considered as the further development and generalization of the missile guidance theory presented in the author's book *Modern Missile Guidance* (2007). Guidance of the unmanned aerial vehicles (UAVs) differs from missile guidance; its goal is different. Moreover, since UAVs can perform a variety of functions, the goal depends on a concrete area of their application. To address a wide class of guidance problems for UAVs, a more general guidance problem is formulated and a class of guidance laws is developed. In addition, the obstacle avoidance problem for UAVs is discussed and avoidance algorithms are considered. The material of the course can serve as a basis for several graduate courses in the aerospace departments. It can be used by researchers and engineers in their everyday practice and will help them to generate new ideas in the area of unmanned aerial vehicles.

Systems Engineering Verification and Validation

(Instructor: John C Hsu, CA State University, The University of CA at Irvine, Queens University and The Boeing Company, Cypress, CA)

This course will focus on the verification and validation aspect that is the beginning, from the validation point of view, and the final part of the systems engineering task for a program/project. It will clarify the confusing use of verification and validation. Familiarize yourself with validating requirements and generating verification requirements. Start with the verification and validation plans. Then learn how to choose the best verification method and approach. Test and Evaluation Master Plan leads to test planning and analysis. Conducting test involves activities, facilities, equipments, and personnel. Evaluation is the process of analyzing and interpreting data. Acceptance test assures that the products meet what intended to purchase. There are functional and physical audits. Simulation and Modeling provides virtual duplication of products and processes in operational valid environments. Verification management organizes verification task and provides total traceability from customer requirements to verification report elements.

17–18 August 2013

The following Continuing Education courses are being held at the Guidance, Navigation, and Control and collocated conferences in Boston, MA. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

To register for one of the GNC 2013 courses, go to **www.aiaa.org/boston2013.**

	Early Bird by 22 Jul	*Standard (23 Jul–16 Aug)*	*On-site (17 Aug)*
AIAA Member	$1255	$1355	$1455
Nonmember*	$1365	$1465	$1565

*Includes a one-year AIAA membership

Emerging Principles in Fast Trajectory Optimization

(Instructors: I. Michael Ross, Professor, Program Director, Naval Postgraduate School, Monterey, CA, and Qi Gong, Assistant Professor, University of California, Santa Cruz)

The confluence of major breakthroughs in optimal control theory and new algorithms has made possible the real-time computation of optimal trajectories. This implies that mission analysis can be carried out rapidly with the only limitation being the designer's imagination. This course will introduce the student to the major advancements that have taken place over the last decade in both theory and algorithms for fast trajectory optimization. Students will acquire a broad perspective on recent developments in the mathematical foundations of trajectory optimization; "old hats" will also acquire a new perspective to some old ideas. The overall objective of this course is to outline the new foundations related to convergence of solutions that have emerged in recent years and the accompanying breakthroughs in general techniques for problem solving. These techniques are intended to enhance, not replace, special techniques that are in common use. Anyone involved in aerospace research will benefit from this course.

Recent Advances in Adaptive Control: Theory and Applications

(Instructors: Tansel Yucelen, Research Engineer, School of Aerospace Engineering, Georgia Institute of Technology, Atlanta, GA; Eric Johnson, Professor, School of Aerospace Engineering, Georgia Institute of Technology, Atlanta, GA; Anthony Calise, Professor of Aerospace Engineering, Georgia Institute of Technology, Atlanta, GA; Girish Chowdhary, Research Engineer, Georgia Institute of Technology, Atlanta, GA)

Research in adaptive control theory is motivated by the presence of uncertainties. Uncertainties may be due to a lack of accurate modeling data combined with modeling approximations that result in unmodeled dynamics. They may also be due to external disturbances, failures in actuation and airframe damage. Adaptive control is also motivated by the desire to reduce control system development time for systems that undergo frequent evolutionary design changes, or that have multiple configurations or environments in which they are operated. Model reference adaptive control (MRAC) is a leading methodology intended to guarantee stability and performance in the presence of high levels of uncertainties.

This course will present a review of a number of well-established methods in MRAC. Starting with MRAC problem formulation and an overview of classical robustness and stability modifications, this course will continue to introduce the adaptive loop recovery approach that allows the approximate retention of reference model loop properties such as relative stability margins. The course will also present Kalman filtering in adaptive control, in which a Kalman Filter framework is used to update adaptation gains that enables meeting a given performance criteria without excessive tuning.

Two novel adaptive control laws are also presented: concurrent learning adaptive control and derivative-free adaptive control. Concurrent learning is a memory-enabled adaptive control method that uses selected recorded data concurrently with instantaneous measurements for adaptation. Concurrent learning guarantees exponential tracking combined with parameter identification for a wide class of adaptive control problems, without requiring persistency of excitation. Derivative-free adaptive control is particularly well suited for systems with sudden (and possibly discontinuous) change in uncertain dynamics, such as those induced through reconfiguration, payload deployment, docking, or structural damage. It provides superior adaptation and disturbance rejection properties, and computable transient and steady-state performance bounds.

The course will also discuss emerging results in connecting machine learning with adaptive control. A special section will be devoted to implementation and flight testing of adaptive control methods, including discussion of the pseudo control hedging methods for handling actuator dynamics and saturation. The course will conclude with discussing extensions to decentralized adaptive control, output feedback adaptive control, unmodeled dynamics, and unmatched uncertainties.

11 September 2013
This 90-minute webinar will take place at 1300–1430 EST

Missile Defense: Past, Present and Future

Missile defense, especially national missile defense, has changed drastically from the air and missile defense systems once in place in the 1960s to the current strategic missile defense planned for the United States today and for NATO Europe in the coming decade to 2020. The nature of the air and missile threat has changed rapidly over the intervening years including new forms of both strategic and theatre ballistic missiles, the new forms of cruise missiles, and now drones. The changing guidance systems of these missiles have changed the targeting and kill probability challenging the defenders against such new missile forms. Unfortunately, the development times of today's defensive missile systems are much slower than the time taken to introduce these radically new threats. This webinar reviews the historical threats and attacks against the United States together with the past and present proposed national missile defense systems with their shortcomings. The technology of new defense systems currently in the laboratories is reviewed to postulate possible new air and missile defense systems for the future. The webinar is liberally filled with actual historical and technical data on all aspects of the threat and the necessary defense.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

AIAA Member	$149
Nonmember*	$189
AIAA Student Member	$60
Full-Time Student (Nonmember)*	$70

*Nonmember fee does not include AIAA membership

23–24 September 2013
The following standalone course is being held at The AERO Institute in Palmdale, California.

Gossamer Systems: Analysis and Design

An evolving trend in spacecraft is to exploit very small (micro- and nano-sats) or very large (solar sails, antenna, etc.) configurations. In either case, success will depend greatly on of ultra-lightweight technology, i.e., "gossamer systems technology." Areal densities of less than 1 kg/m2 (perhaps even down to 1 g/m2!) will need to be achieved. This course will provide the engineer, project manager, and mission planner with the basic knowledge necessary to understand and successfully utilize this emerging technology. Definitions, terminology, basic mechanics and materials issues, testing, design guidelines, and mission applications will be discussed. A textbook and course notes will be provided.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

	Early Bird by 23 Aug	*Standard (24 Aug–15 Sep)*	*On-site (16–23 Sep)*
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

Sensor Systems and Microsystems: From Fabrication to Application

The introduction of sensor technology, including smart micro-sensor systems, into aerospace applications is expanding rapidly to allow improved system monitoring and provide gains in efficiency, performance, critical data, and safety. This short course is taught by three experts in sensor technology and its application to provide not only an overview of microsensor fabrication and development, but also a practical discussion of the implementation of sensor systems in space applications. The first half day of the course will concentrate on micro/nano-fabrication techniques and processes taught by Prof. Peter Hesketh of Georgia Institute of Technology. The second half day of the course will discuss case studies in sensor development taught by Dr. Gary Hunter of NASA Glenn Research Center. The last half day of the course will discuss sensor system implementation ranging from Payloads such as Mars Pathfinder to Launch Vehicle Sensor Implementation such as The Ares I Launch Vehicle; taught by Mr. Larry Oberle of NASA Glenn Research Center.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

	Early Bird by 23 Aug	*Standard (24 Aug–15 Sep)*	*On-site (16–23 Sep)*
AIAA Member	$950	$1075	$1175
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Standard Information for all AIAA Conferences

This is general conference information, except as noted in the individual Event Preview information.

On-Site Check-In

Partnering with Expo Logic, we've streamlined the on-site registration check-in process! All advance registrants will receive an email with a registration barcode. To pick up your badge and conference materials, make sure to print the email that includes your ExpressPass Barcode, and bring it with you to the conference. Simply scan the ExpressPass barcode at one of the ExpressPass stations in the registration area to print your badge and receive your meeting materials.

Photo ID Needed at Registration

All registrants must provide a valid photo ID (driver's license or passport) when they check in. For student registration, valid student ID is also required.

Certificate of Attendance

Certificates of Attendance are available for attendees who request documentation at the conference itself. Please request your copy at the on-site registration desk. AIAA offers this service to better serve the needs of the professional community. Claims of hours or applicability toward professional education requirements are the responsibility of the participant.

Conference Proceedings

Proceedings for AIAA conferences will be available in online proceedings format. The cost is included in the registration fee where indicated. Attendees who register in advance for the online proceedings will be provided with access instructions. Those registering on site will be provided with instructions at that time.

Young Professional Guide for Gaining Management Support

Young professionals have the unique opportunity to meet and learn from some of the most important people in the business by attending conferences and participating in AIAA activities. A detailed online guide, published by the AIAA Young Professional Committee, is available to help you gain support and financial backing from your company. The guide explains the benefits of participation, offers recommendations and provides an example letter for seeking management support and funding, and shows you how to get the most out of your participation. The online guide can be found on the AIAA website, **http://www.aiaa.org/YPGuide**.

Journal Publication

Authors of appropriate papers are encouraged to submit them for possible publication in one of the Institute's archival journals: *AIAA Journal*; *Journal of Aircraft*; *Journal of Guidance, Control, and Dynamics*; *Journal of Propulsion and Power*; *Journal of Spacecraft and Rockets*; *Journal of Thermophysics and Heat Transfer*; or *Journal of Aerospace Information Systems* (formerly *Journal of Aerospace Computing, Information, and Communication*). You may now submit your paper online at **http://mc.manuscriptcentral.com/aiaa**.

Timing of Presentations

Each paper will be allotted 30 minutes (including introduction and question-and-answer period) except where noted.

Committee Meetings

Committee meeting schedule will be included in the final program and posted on the message board in the conference registration area.

Audiovisual

Each session room will be preset with the following: one LCD projector, one screen, and one microphone (if needed). A 1/2" VHS VCR and monitor, an overhead projector, and/or a 35-mm slide projector will only be provided if requested by presenters on their abstract submittal forms. AIAA does not provide computers or technicians to connect LCD projectors to the laptops. Should presenters wish to use the LCD projectors, it is their responsibility to bring or arrange for a computer on their own. Please note that AIAA does not provide security in the session rooms and recommends that items of value, including computers, not be left unattended. Any additional audiovisual requirements, or equipment not requested by the date provided in the Event Preview information, will be at cost to the presenter.

Employment Opportunities

AIAA is assisting members who are searching for employment by providing a bulletin board at the technical meetings. This bulletin board is solely for "open position" and "available for employment" postings. Employers are encouraged to have personnel who are attending an AIAA technical conference bring "open position" job postings. Individual unemployed members may post "available for employment" notices. AIAA reserves the right to remove inappropriate notices, and cannot assume responsibility for notices forwarded to AIAA Headquarters. AIAA members can post and browse resumes and job listings, and access other online employment resources, by visiting the AIAA Career Center at **http://careercenter.aiaa.org**.

Messages and Information

Messages will be recorded and posted on a bulletin board in the registration area. It is not possible to page attendees.

Membership

Nonmembers who pay the full nonmember registration fee will receive their first year's AIAA membership at no additional cost.

Nondiscriminatory Practices

The AIAA accepts registrations irrespective of race, creed, sex, color, physical handicap, and national or ethnic origin.

Restrictions

Videotaping or audio recording of sessions or exhibits as well as the unauthorized sale of AIAA-copyrighted material is prohibited.

International Traffic in Arms Regulations (ITAR)

AIAA speakers and attendees are reminded that some topics discussed in the conference could be controlled by the International Traffic in Arms Regulations (ITAR). U.S. Nationals (U.S. Citizens and Permanent Residents) are responsible for ensuring that technical data they present in open sessions to non-U.S. Nationals in attendance or in conference proceedings are not export restricted by the ITAR. U.S. Nationals are likewise responsible for ensuring that they do not discuss ITAR export-restricted information with non-U.S. Nationals in attendance.


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