June 2012

AEROSPACE AMERICA

Deconstructing the defense budget

A conversation with William H. Gerstenmaier

Fast track to truly fast flight

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COVER

The FY13 defense budget request is lower than originally planned, and has a different focus than earlier years. Find out about that focus by turning to page 30. DOD photo by Sgt. Christopher R. Rye, U.S. Marine Corps.

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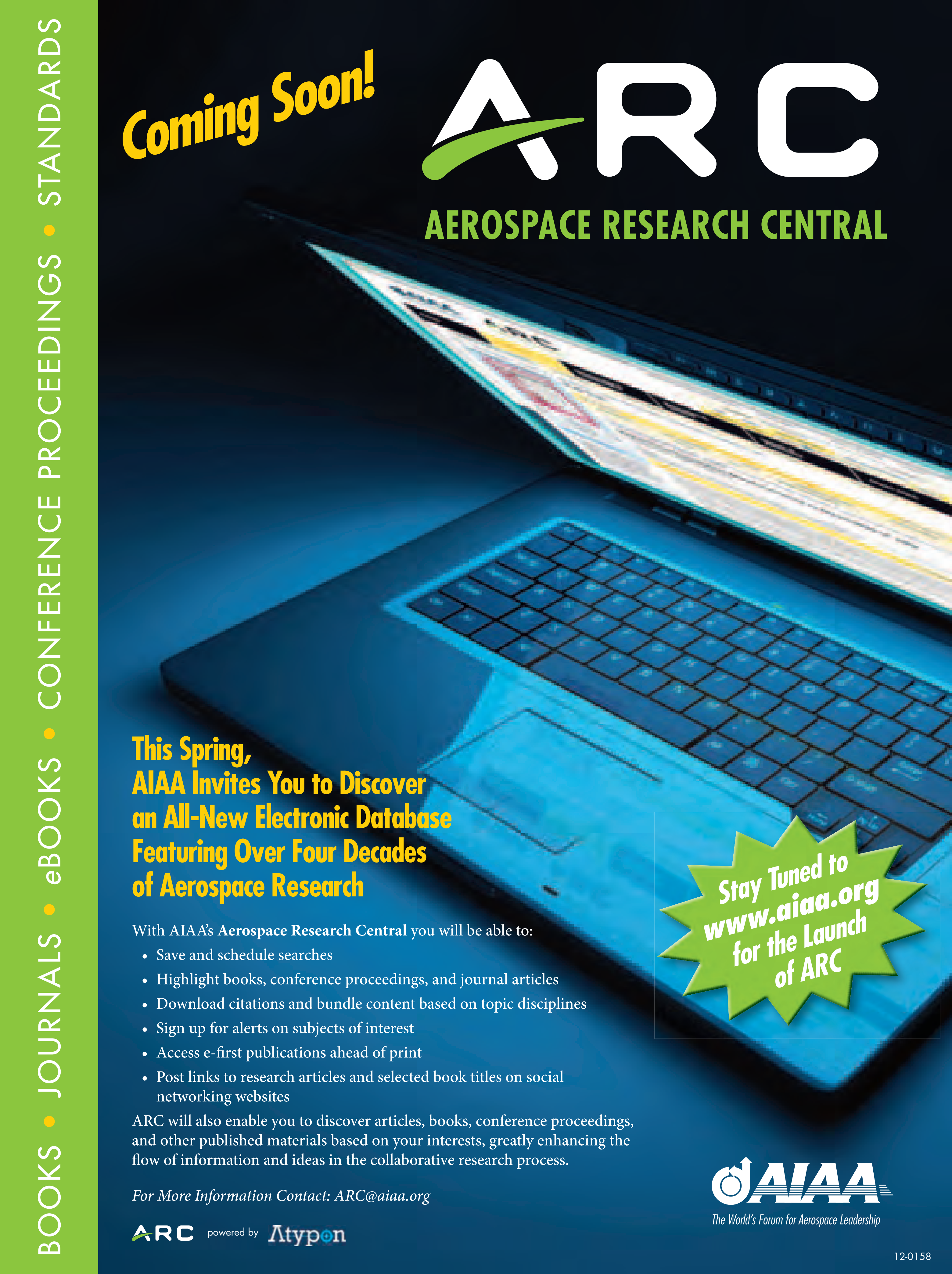
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Commentary

Develop cislunar space next

Our national space program is adrift, without an attainable and affordable strategic horizon. A vibrant, competitive society relies on constant advances in space technology, including weather monitoring, positioning, global communications, remote sensing, national security surveillance, and countless other activities. The U.S. deserves and expects a vital, active, and affordable space program that fundamentally contributes to national economic, scientific and security needs.

Experience with the space shuttle and international space station demonstrated that people and machines working together in space can assemble, maintain, and repair large, distributed, highly capable space systems. Satellites are located in a variety of orbits, ranging from low Earth orbit to distances beyond the Moon. Gaining the ability to routinely access the space between Earth and Moon (cislunar space) to repair, upgrade, and remove assets would fundamentally change the economics and template of spaceflight. Access is costly, because everything must be launched from Earth's surface—the deepest gravity well in the inner solar system. The current operational template for space is to design custom spacecraft, launch them on expendable vehicles, then use and, ultimately, discard them.

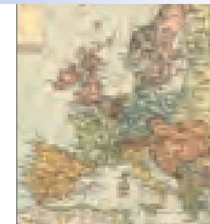
Learning to use lunar resources can change this template. By provisioning ourselves with material already in space, we create an explosion in capability leading to unprecedented levels of space development. Establishing (initially) robotic resource-processing facilities at the poles of the Moon for water extraction allows for the manufacture of rocket propellant from lunar ice and the development of a reusable, refuelable space transportation system. Areas near the poles also provide near constant sunlight for power generation.

Once the civil space program demonstrates the feasibility of using space resources, opportunities for economic and industrial development will rapidly unfold. A cislunar infrastructure serving both commercial and national needs creates a 'transcontinental railroad' in space.

It is critical that the U.S. spearhead the movement of humanity into cislunar space lest powers that do not believe in free enterprise or champion liberty fill this leadership vacuum. Our ultimate goal for spaceflight is to freely and routinely send human and robotic assets and resources needed to do any job in space, anywhere, for however long they are needed. Although we do not have such capability now, it can be created using the Moon's natural resources to supply our space transportation system and new off-planet industry. The first step in this process is to define our objectives and then define the launch vehicles and the human and robotic systems and spacecraft needed to realize our objectives.

This new direction can be pursued under constrained budgets by creating a flexible architecture that uses small, well-defined, incremental yet cumulative steps. Such a goal redirects the space program from flags-and-footprints to routine space access and development. It will create new economic zones that benefit the terrestrial economy. Learning how to access and harvest the resources of space will spur unprecedented levels of space development, discovery, and the creation of new wealth. Cislunar space is the logical next step for America's space program.

Paul Spudis
www.cislunarnext.org

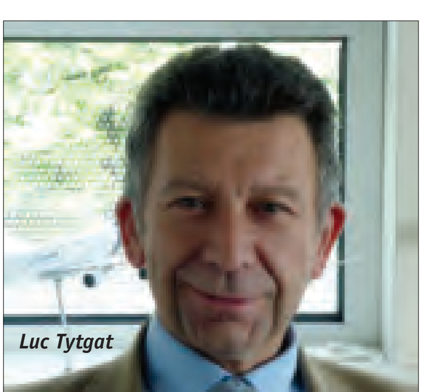


A long road for UAS integration in Europe

The technical and regulatory problems of agreeing on a common European-wide approach to integrating unmanned air systems (UASs) in European civilian-controlled airspace will make it unlikely that UASs will be routinely sharing airspace with airliners before 2020 in Europe. As elsewhere around the world, a number of complex technology and regulatory hurdles remain to be overcome, but in Europe the institutional problems look particularly complicated.

"The first step is to establish the right regulatory framework to enable them to fly in nonsegregated airspace; it's not a new set of regulations but an adaptation of existing Single European regulations," according to Luc Tytgat, who heads the Single Sky Directorate at the Brussels-based European organization for the safety of air navigation, Eurocontrol. "Second, we have to ensure the UASs are as safe as manned aircraft and can safely fly across borders. What will happen if a UAS takes off, for example, from Luxembourg, flies over France, but has a crash and the pilot is based in Germany? We have to work out where the responsibilities and liabilities lie.

"Third, we have to have standardized and harmonized equipment for sense-and-avoid and other technologies. Today there are different technical solutions and different radio frequencies, and we need to analyze which type of equipment is needed for what type of mission, from the very heavy to the very light. And we'll need to see whether we need European legislation for this."


Luc Tytgat

Eurocontrol forecasts that by 2020 there could be 200 MALE (medium-altitude, long-endurance) UASs and 10 HALE (high-altitude, long-endurance) UASs operating in Europe. "Assuming a high utilization—that is, flying for 12 hours out of every 24 hours—these UASs could accumulate 920,000 flight-hours each year," says the organization. "This is approximately 6% of the current IFR [instrument flight rules] flight-hours per year."

Gauging the difficulty

So how difficult will it be to integrate inhabited and noninhabited air vehicles in Europe's busy airspace?

According to Tytgat: "Legally it's easy; technically it's easy. The problem is to synchronize the implementation and adopt a single set of legislation at the European level."

An important first step has already been taken in researching appropriate technologies covering sense-and-avoid, datalink, and safe recovery from unplanned changes to automatic flight profile functions that will need to be brought into operation. There is considerable debate, however, about how mature these systems really are.

"I haven't seen any technology yet to do what is necessary," says Geoff Ambler, commercial director of the U.K.-based civil UAS trade association EuroUSC. "It is probably 5-10 years away in terms of availability, and then if you add assessment and validation, you are looking at 15 years."

This seems a very pessimistic view. After all, European regulators, industry, and aircraft operators have been working on the issue for years, and demonstrations have already yielded some considerable successes. In the U.K., the ASTRAEA (autonomous systems technology-related airborne evaluation and assessment) consortium is a £62-million program to demonstrate separation assurance and control technologies along with a forced landing system, communication system, several new sensors, and autonomous decision-making software.

BAE Systems has flown its Jetstream testbed as part of the second phase of the program, which runs until March 2013, as a surrogate UAS to test control systems. The two on-pilots hand over control to the prototype avionic systems during the flights; around 20 of these are planned for this year. Some will include an intruder aircraft to help test the surrogate UAV sense-and-avoid systems.

Advanced airborne technologies

In 2009 the European Defence Agency (a Brussels-based body comprising the defense departments of the 26 EU states) began work on a €60-million UAS midair collision avoidance system (MIDCAS), with Sweden, France, Germany, Italy, and Spain as participating member nations. The first flight of the MIDCAS demonstrator, which will test an automated collision avoidance function, is scheduled for next year. Other elements in the research program include datalinks, communications, and training.

The key to developing mature airborne technologies is the development of a new kind of transponder, according to independent ATC safety expert David Gleave.

"The UAS community would rather that the other targets carried the complex technology, to minimize their onboard power processing requirements and external skin sensor requirements, so solutions such as ADS-B would be their preferred answer," says Gleave. "The pilot-in-command is still responsible for taking all necessary actions to avoid a collision. Changes to, and clarification of, legislation is still necessary to integrate UAV operations safely with normal civilian traffic in daily operations. Contingency procedures still have to be refined for the failure of individual items of equipment, as well as lack of communication with the UAV and its own zone of surveillance for sense and avoid."

The key principle here is equivalence—UASs must have safety systems that are at least as good as those on manned aircraft, comprising radar or radar-like capabilities for all-weather, day-and-night operations, the appropriate electrooptics, some kind of aircraft collision avoidance system, or ACAS, and a transponder and antenna to cope with Mode-S and ADS-B signals. However, all these capabilities would need to be packaged in a system with much smaller size, weight, and power requirements than those on a manned aircraft.

Any UAS ACAS equipment would have to be designed so that collision avoidance advice is automatically presented to the remote pilot. The ACAS antennae would need to be designed to withstand more aggressive maneuvering than that traditionally seen in conventional civil fixed-wing aircraft, and be able to operate alongside other boxes of data-processing and datalink systems without impairing performance. The ACAS must also be able to operate within guaranteed specific response times.

Eurocontrol has commissioned U.K. research agency QinetiQ to undertake a research study known as CAUSE (collision avoidance requirements for unmanned aircraft systems). Its purpose is to assess various aspects of potential UAS equipage with a collision avoidance system as part of the UAS's sense-and-avoid functionality, and to advise Eurocontrol and other regulatory bodies such as EASA (European Aviation Safety Agency) and ICAO (International Civil Aviation Organization) on how best to incorporate UASs into nonsegregated airspaces.

BAE Systems is using its Jetstream testbed as a surrogate UAS to test control systems.

Harmonization questions

Both MIDCAS and ASTRAEA program managers are working with national and European regulators to ensure the authorities can shape new standards and procedures, and not just for European environments. The European Commission (EC) has organized a series of workshops as part of its UAS 'panel process,' which will deliver a UAS strategy for Europe, encompassing regulators, operators, industry, and research organizations. In May the panel was due to examine how European standards might be harmonized with ICAO and FAA standards.

"We have to be ready to be transatlantic in our approach," says Eurocontrol's Tytgat, who believes the first civil applications for this technology will be "courier companies flying UASs over the ocean. So we will need to coordinate standards and frequencies, for example, for this to happen."

But even developing a common set of European standards might prove a lengthy, complex procedure. "Europe, as a concept, is still highly fragmented," says Gleave. "On a UAS flight that crosses national boundaries, are both countries members of NATO, the European Defence Agency, Eurocontrol, and the European Union? Is the air traffic control service provided by each nation up to the border, or is airspace delegated between the countries or even to another service provider not related to the two countries?

"Does the airspace through which the flight will pass have the same classification on both sides of the border? Has the national aviation regulator passed adequate regulations to allow the flight to be carried out following

European institutions and their UAS integration roles

*•**JARUS:** A group of European national authorities developing operational and technical regulations for UASs.*

*•**European Organisation for Civil Aviation Equipment Working Group 73**: Developing a technical standards framework that would allow UASs to operate within the constraints of the current ATM system without segregation from other airspace users. It has four working groups: SG1 UAS Operations; SG2 UAS Airworthiness; SG3 Command, Control, Communications, Spectrum and Security; and SG4 UAV under 150 kg.*

*•**European Commission:** At the Paris Air Show is June 2011 the commission launched a process for developing a strategy for the future of UAS in the EU, including work to define the economic importance of UASs; insertion into nonsegregated airspace (including radio frequency management); safety-related issues, airworthiness, the societal dimension, and R&D. The commission also directly funds UAS research as part of its seventh framework research program.*

*•**Eurocontrol:** The agency is developing ATM requirements for the integration of UASs in segregated airspace and the harmonization of procedures for the use of military UAVs outside segregated airspace.*

*•**European Defence Agency:** As part of the European Framework Cooperation for Security and Defence, which was launched in 2009 by European defense ministers, the insertion of UASs into regulated air traffic was singled out as one of the areas most benefiting from enhanced European civil/military cooperation. The EDA has for many years been involved in coordinating pan-European research on behalf of defense departments.*

*•**European Aviation Safety Agency**: Europe's pan-national safety regulator, plans to initiate work on developing rules for UASs above 150 kg in 2013.*

*•**The UAS working group at the Aerospace and Defence Industries Association of Europe:** Provides a single point of contact for industry views into policymaking bodies.*

the lead of Eurocontrol and the European Aviation Safety Agency in producing harmonized templates? Have the national parliaments amended their national laws to allow the flight to be carried out following the lead of the European Commission and EASA? For a flight across continental United States, these issues are far easier to address between the various elements of the government and UAV operators," says Gleave.

Much of the preparatory work in establishing a pan-European regulatory and standards regime has already been done. The EC strategy is linked to the Single European Sky EU master plan and its SESAR technology research area. The European Commission has also funded a number of tactical UAS research programs as part of its sixth and seventh framework research strategy. Meanwhile the EDA—which is not an EC body but an EU intergovernmental agency—has sponsored a number of programs, including the EREA for UAS consortium, or E4U—which has identified the relevant technology gaps for flying UASs in unsegregated airspace—and the Air4All, MIDCAS, and SIGAT research areas.

In March EASA announced plans to initiate work in 2013 on developing rules for UASs larger than 150 kg. Meanwhile, Eurocontrol is developing UAS ATM requirements into a comprehensive set of globally interoperable certification and operational approval criteria requiring UASs to fit in with the existing ATM system, rather than adapting the system to accommodate the unmanned systems.

Finding acceptance

There is also a third element to consider, beyond the merely technical and regulatory.

"There is a further caveat—acceptability to citizens [who will be] overflown by these type of vehicles," says Tytgat. "We don't want to start this sort of program without having a debate with citizens about the acceptability of UASs. We are used to seeing aircraft flying overhead, but if you see an unmanned helicopter flying overhead, it is natural to ask what it is doing there."

This was the subject of the November 2011 UAS Commission workshop, which discussed some of the issues involving social acceptance of UASs, along with questions regarding responsibility, liability, insurance, privacy, and data protection. The workshop concluded that the current legal framework governing privacy protection, data processing, and liability is applicable and might only need small adjustments to accommodate for the specificities of UAS technology.

But how, exactly, Europe's citizens are to be involved in the process of integrating these UASs into the continent's airspace has yet to be mapped out in detail.

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Correspondence

In response to the **Correspondence** submitted by Robert L. Sackheim and Yvonne C. Brill (May, page 8) regarding to **The greening of satellite propulsion** (February, page 26): ECAPS understands and appreciates that there are many technical issues which must be addressed in order to fully transition away from hydrazine. We have therefore made a concerted effort to proactively disseminate as much information about our High-Performance Green Propulsion (HPGP) technology as possible via as many open forums as possible. As a result, most of the questions raised by the respondents have already been addressed in various conference presentations and publicly available technical papers.

In response to the specific items raised by the respondents:

• The combustion by-products of HPGP are H_2O (50%), N_2 (23%), H_2 (16%), CO (6%), and CO_2 (5%). Witness plate and electron scanning microscope analysis have also been performed to determine the extremely low levels (≤5 ppm) of other plume constituents.

• Catalyst preheat requirements and PRISMA thruster in-flight preheating power consumption were presented in "Spacecraft System Level Design with Regards to Incorporation of a New Green Propulsion System," presented at the 2011 Joint Propulsion Conference.

• Thrust chamber materials are Ir/Rh, or other refractory metals. Importantly, however, the increased costs of these higher temperature resistant materials are more than offset by the cost savings provided by simplified transportation and handling—as HPGP is transport classified as UN/DOT 1.4S (allowing shipment on commercial passenger aircraft) and handling/fueling operations are able to be performed without SCAPE suits.

• With respect to integrated propulsion system synergies, a 220-N thruster is currently in development and further up-scaling to 400 N is being assessed. Since many geosynchronous communication satellites implement an apogee engine of about 400 N, a combination of large and small HPGP thrusters could provide a shared-tank architecture similar to that of current 'dual mode' hydrazine systems.

• Because HPGP is a blended solution, performance enhancements can be achieved by altering the constituent ratios. As a result, it is possible to increase performance characteristics such as specific impulse and density impulse for shorter duration applications such as launch vehicle roll control

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thrusters. Viability for use in gas generator applications (such as auxiliary power units) has also been assessed, and work continues in this area.

• Compatibility testing has been performed with most types of commercially available hydrazine propulsion system components, including tank diaphragm elastomers, seals, and propellant valves.

• Hydrazine fueling and subsequent system pressurization operations require not only the few individuals donning SCAPE suits, but also a significant number of safety, fire, and medical personnel to all be in stand-by mode. None of these additional stand-by personnel were required during the PRISMA HPGP fueling operations.

Finally, the respondents acknowledge—but downplay the significance of the fact—that HPGP has been flight-proven to provide higher performance than monopropellant hydrazine. This attribute by itself offers an important capability increase to many satellite missions. However, when combined with the numerous other benefits afforded by HPGP (such as air transport, no SCAPE, insensitivity to air/humidity and shock, low toxicity, non-carcinogenic, etc.), the 'big picture' becomes even clearer.

Aaron T. Dinardi
ECAPS

The otherwise excellent article **Orbiting twins tackle Moon's mysteries** (February, page 32) contains an egregious error in the first sentence. GRAIL's cost is reported as $696 million when it is actually $496.2 million.

Along with the enviable technical achievement of precision formation flying around another planetary body and the science being enabled by the remarkably precise observations now being collected, the GRAIL team is equally proud of meeting every project milestone on schedule and delivering the twin spacecraft into lunar orbit with a healthy budget margin.

A planetary mission delivering under cost should be celebrated .

Maria T. Zuber
GRAIL principal investigator

Events Calendar

JUNE 4-6
Eighteenth AIAA/CEAS Aeroacoustics Conference, Colorado Springs, Colorado.
Contact: 703/264-7500

JUNE 4-6
Nineteenth St. Petersburg International Conference on Integrated Navigation Systems, St. Petersburg, Russia.
Contact: Prof. V. Peshekhonov, +7 812 238 8210; elprib@online.ru; www.elektropribor.spb.ru

JUNE 7
Aerospace Today...And Tomorrow—An Executive Symposium, Williamsburg, Virginia.
Contact: Grant Belden, grantb@aiaa.org

JUNE 18-20
Third International Air Transport and Operations Symposium and Sixth International Meeting for Aviation Product Support Process, Delft, The Netherlands.
Contact: Adel Ghobbar, 31 15 27 85346; a.a.ghobbar@tudelft.nl

JUNE 19-21
AIAA Infotech@Aerospace Conference, Garden Grove, California.
Contact: 703/264-7500

JUNE 25-28
Twenty-eighth Aerodynamics Measurement Technology, Ground Testing, and Flight Testing Conferences, including the Aerospace T&E Days Forum; 30th AIAA Applied Aerodynamics Conference; Fourth AIAA Atmospheric Space Environments Conference; Sixth AIAA Flow Control Conference; 42nd AIAA Fluid Dynamics Conference and Exhibit; 43rd AIAA Plasmadynamics and Lasers Conference; 43rd AIAA Thermophysics Conference. New Orleans, Louisiana.
Contact: 703/264-7500

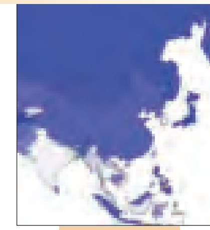
JUNE 27-29
American Control Conference, Montreal, Quebec, Canada.
Contact: Tariq Samad, 763/954-6349; tariq.samad@honeywell.com

JULY 11-14
ICNPAA 2012 - Mathematical Problems in Engineering, Aerospace and Sciences, Vienna, Austria.
Contact: Seenith Sivasundaram, 386/761-9829; seenithi@aol.com

JULY 14-22
Thirty-ninth Scientific Assembly of the Committee on Space Research and Associated Events 2012, Mysore, India.
Contact: http://www.cospar-assembly.org

JULY 15-19
Forty-second International Conference on Environmental Systems, San Diego, California.
Contact: 703/264-7500

JULY 30-AUG. 1
Forty-eighth AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit: Future Propulsion - Innovative, Affordable, Sustainable, Atlanta, Georgia.
Contact: 703/264-7500



Asia in space: Trials and tribulations

A FLURRY OF ACTIVITY IN ASIAN ROCKetry during recent months has apparently brought one major failure, one significant success, and the expectation of a major step toward performing an orbital rendezvous.

The failure came with the first-stage breakup—or possible self destruction—of North Korea's latest major rocket test in April. The significant success came a few days later, when India launched a medium-range version of its Agni (Fire) missile, which is capable of reaching cities in northern China—thus making up some distance in the nuclear deterrence stakes with Beijing. And the major technological step is that this month China may achieve a space rendezvous controlled by human astronauts, possibly including a woman.

Failure and conjecture

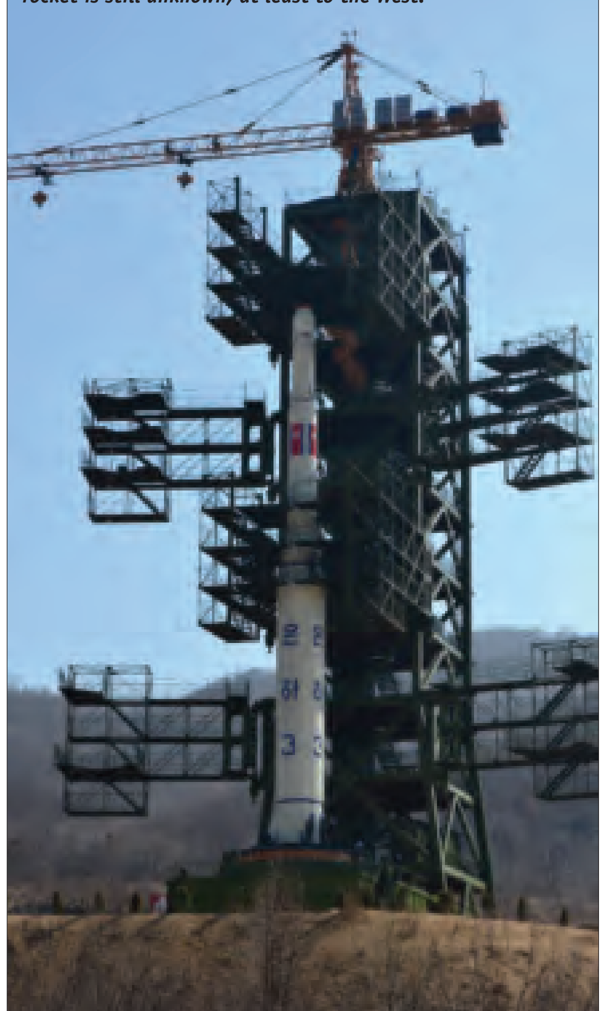
North Korea's failure brought with it a welter of political speculation and pressure, none of it unexpected. Conjecture centered on what went wrong, with the prime candidate among analysts being a structural failure at or about Max Q, the point at which aerodynamic pressure is greatest after launch. This is where rockets generally throttle back to ease structural stresses from vibration until the critical time has passed. After this, as air pressure decreases with altitude, the rocket can be throttled up again to reach orbit.

The other widely discussed possibility is a guidance failure that made it necessary to destroy the rocket before it intruded into other nations' airspace. North Korea's position leaves it only two viable launch directions: eastward, toward and over Japan (which proved highly unpopular the last time North Korea tried and failed to launch a satellite to orbit), and southward, past and near South Korea and the Philippines. Precise control of the rocket's path was therefore essential.

The southern path from North Korea's northwest was chosen as the direction in which to aim the three-stage Unha (Milky Way) 3 rocket, ostensibly to place a Bright Star weather satellite into a 310-mi.-high polar orbit, though some suspect this was really a missile test in disguise.

But the rocket broke up about 90 seconds after launch and fell into the sea west of South Korea. This was the fourth failure of a major North Korean rocket since 1998—the country has not yet managed to place a satellite into orbit, although it has made claims to the contrary.

The exact cause of the April failure of North Korea's Unha 3 rocket is still unknown, at least to the West.



As with the earlier failures, this launch was timed to help celebrate a major political event—in this case, the 100th anniversary of the birth of the country's founding father, Kim Il-sung. Thus it was not a test so much as an intended demonstration of power. Moreover, a widely expected underground nuclear bomb test (the country's third) predicted soon afterward may well have been intended to mark North Korea joining the world's nuclear missile 'club.' Instead, the failed launching demonstrated a continuing lack of capability in long-range and orbital rocketry.

It is regarded as certain that North Korea will try again to launch a long-range rocket, probably in the next two or three years. The country's short-range rocket experience came from the former Soviet Union and was sold on to Iran (which had observers at the April 13 launch), but the North Koreans are finding it hard to shift to longer range rockets.

What is not certain is whether this impoverished country has the resources to begin, let alone sustain, the level of testing that would help bring reliability to its rocket program. Until or unless this happens, it seems likely that the U.S. can ignore North Korea as a source of nuclear missile threats. Even with a reliable rocket, the time taken to fuel it (Unha 3 and its predecessors were all liquid fueled) would allow so much warning that the

U.S. would be able to detect the process easily and take steps to nullify any potential threat.

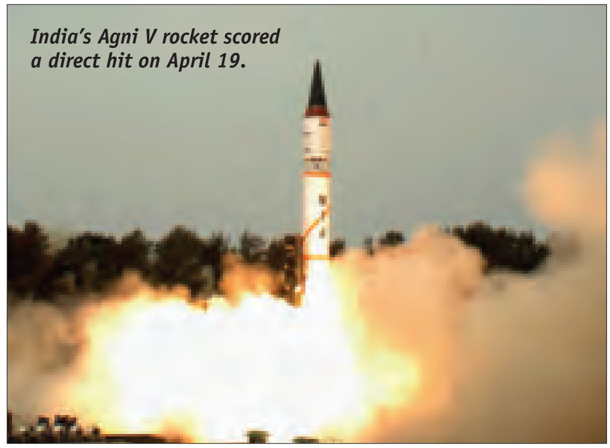
India's efforts

A similar calculus applies to India's achievement with its Agni V, a solid-fuel three-stage rocket that was fired from Wheeler Island off the country's east coast on April 19 and hit its target in the sea. Its maximum range is said to be 3,100 mi., enough to reach Beijing and Shanghai, though the April 19 firing was in effect a technology demonstration as the missile is not yet in production. It is expected to enter India's arsenal in 2014-2015.

Talk of women in space usually concerns female astronauts, but in India's case the woman under discussion is Tessy Thomas, who holds a doctorate in engineering and is the Agni V project director. Known as the 'Missile Woman,' she regards the rockets on which she works as "instruments of peace" because of their deterrent value. Having said that, she is currently working on guidance systems for multiple independent reentry vehicles, or multiple warheads delivered by one rocket.

Indian officials say China has no real need to feel threatened, and indeed they have made efforts to discount any such motive. China has a huge advantage in nuclear weaponry and missiles over India, and India's aim was not to achieve an overnight parity but to level the field somewhat for discussions. When you know you are stronger than someone else but that person is now capable of hurting you, any talks become less one-sided.

On the civilian side, India is having problems with its heavy-lift GSLV (Geosynchronous Satellite Launch Vehicle), intended for satellites weighing over 1 ton. Two successive launch failures in 2010 were attributed to different causes—one to the failure of a cable connector and the other to a problem with the India-developed cryogenic rocket engine used in the third stage.



India's Agni V rocket scored a direct hit on April 19.

Tessy Thomas, the Agni V project director, is known as the 'Missile Woman."

Earlier missions had used a Russian cryogenic engine. India's difficulties with its own version may cause long delays in developing the rocket sufficiently to participate in the lucrative satellite launch market, officials fear. The engine problem may also delay India's planned 2013 second unmanned lunar mission, Chandrayaan-2, in which the 2.6-ton spacecraft is intended to carry a 1.25-ton lander and rover vehicle.

The Indian Space Research Organization is partnering with Russia's Federal Space Agency in designing Chandrayaan-2's lander and Moon rover. The plan is for the rover to drive over the lunar surface, pick up soil samples and rocks, analyze them chemically, and transmit the data back to the orbiter.

India's GSLV bursts into a ball of fire as it ascends into the sky. The rocket has suffered two successive failures. Photo: V. Ganesan.

China's aspirations

It is expected that China will soon attempt to advance its own level of space-related technology with the manned docking of a space capsule called Shenzhou (Divine Vessel) 9 and an orbiting module named Tiangong (Heavenly Peace) 1. The three-person mission will likely take place between now and August—two rendezvous rehearsals in November were conducted using automatic systems and ground control. Tiangong 1 has been in orbit since last September.

The event is part of China's efforts to set up its own space station and enlarge its pool of astronauts, which may for China's first time include a woman as one of the crew. Six Chinese male astronauts (taikonauts in Chinese parlance) have flown in three manned missions so far.

The country is also slowly and quietly reducing its dependence on foreign technology in satellite navigation by setting up its own constellation of satellites to rival the U.S.-controlled GPS. China's Beidou (Compass) system began operating in 2000 and now covers China and immediate surrounding areas, say Chinese officials. Six satellites are to go up this year to give coverage of Asia and the Pacific, with the full set of 35 to be in place by 2020 for worldwide coverage.

Japanese activities

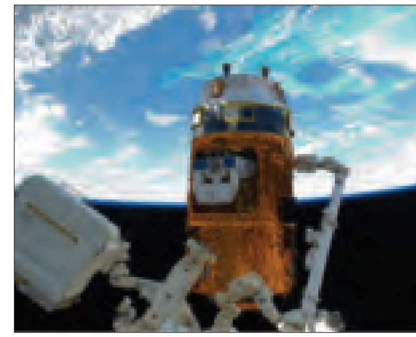
Having no human-rated launcher of its own, Japan has relied on sending its astronauts via U.S. or Russian spacecraft to work as payload or mission specialists on Spacelab, the ISS, or the space shuttle. (The country had 11 astronauts, although one woman and two men have retired.) In July engineer Akihiko Hoshide is due to start a four-month stint at the ISS, reaching it via a Russian Soyuz—his second space mission.

Japan's main space interest at present centers on Kibo, a pressurized human-rated module that is part of the ISS. It accommodates four astronauts conducting space medicine and life and materials science experiments.

Has JAXA been able to show any concrete benefits from the money that taxpayers have invested in it? Yes, says Keiji Tachikawa, the space agency's president. For example, during last year's earthquake and tsunami disaster, he says, "At JAXA, although facilities at the Tsukuba Space Center and the Kakuda Space Center incurred damage, we had just implemented a Business Continuity Plan as a disaster measure, so we were able to set up a response headquarters an hour after the earthquake struck and react quickly. I also felt yet again that space technology is effective at times of disaster, because JAXA was able to contribute to the disaster response and assistance effort by providing satellites for communications and other needs."

Is Japan likely to build its own manned rocket to reach orbit? If so, it is some way off, but it really is a matter of necessity, Tachikawa feels. "We also have to think about how we are going to transport people to the ISS in the future," he explains. "We must continue sending astronauts to the space station, because it is a very useful asset shared by all of humankind.

"Now that the space shuttle has been retired, our only way to send astronauts to the ISS is the Russian Soyuz spacecraft, so if the Soyuz has an accident then we'll have no means of transporting astronauts at all. As we discuss how to secure transportation redundancy, people are looking to Japan's Kounotori [robotic] space station supply ship (also known as the H-II transfer vehicle, or HTV), which could be converted into a manned spacecraft.



Japan's Kounotori (also known as the H-II transfer vehicle, or HTV)could be converted into a manned spacecraft.

"After the space shuttle's retirement, Kounotori became the sole transport vehicle capable of carrying heavy cargo to the ISS; but currently it is a single-use vehicle, burning up when it reenters the atmosphere.

"So Kounotori cannot bring back samples from completed space experiments or anything else. That's why we are currently proceeding with research on a [heavy transport vehicle] with additional retrieval function—HTV-R—which we plan to have ready in about five years.

"If we can make the HTV retrievable, then it must be expected for us to turn it into a manned spacecraft, too. However, the decision on whether or not Japan goes ahead with this rests with the Japanese government. So before we move in that direction, the government has to give us the go-ahead. Personally, I think that if we continue to cooperate with the international community in space, our partners will ask Japan, a country with a highly developed space program, to help build an infrastructure for manned space transport. This is another reason why I believe that we should develop a made-in-Japan manned spacecraft."

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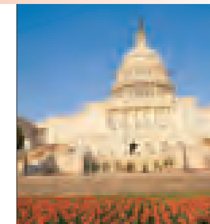


Struggles in a season of avoidance

THE BIG AND URGENT ISSUES CONfronting leaders in the nation's capital are likely to remain on hold throughout the spring and summer while the election looms and campaign rhetoric heats up.

Congress is not expected to enact budget legislation for FY13, which begins October 1, until after Election Day on November 6. Lawmakers are definitely at work—doing the preliminaries known as markups on the National Defense Authorization Act, for example—but what Rep. Steny Hoyer (D-Md.) calls "the really big stuff" seems to be off the table until after the political season.

In Washington this spring, tens of thousands of federal workers were showing up every day and performing necessary duties with skill and dedication; but much of the media attention was focused on GSA and Secret Service employee indiscretions. Hoyer's "big stuff"—Afghanistan, the debt, the deficit, immigration—were paid lip service but pushed to the right on the calendar.

In the aerospace world, spring and summer are not expected to bring decisions about the NASA human spaceflight program, the costly and controversial F-35 Lightning II Joint Strike Fighter, or the long-delayed NextGen navigation system for the nation's air routes. All will become part of the discussion when Congress and the White House inch closer to the statutory measure called sequestration, which mandates dramatic spending cuts starting January 2. Many observers in Washington wonder whether JSF, a program often called 'too big to fail,' will be shot down by the sequestration process simply because its size makes it a highly visible target.

Satellite skirmishes

Retired Air Force Gen. Bruce Carlson, director of the secretive National Reconnaissance Office, the agency that manages the nation's spy satellites, resigned unexpectedly on April 18 in the midst of what the *Washington Post* called a 'clash' over who should build America's orbiting eyes in the sky. The nominee to replace Carlson is Betty Sapp, currently the principal deputy director.

Betty Sapp

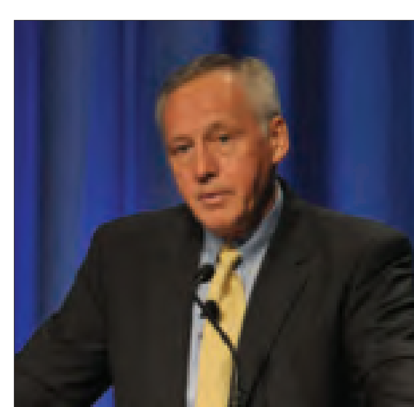
Carlson, who took over the NRO in June 2009, is credited with helping to restore the agency's reputation for technical excellence. He will be leaving his post on July 20. Carlson had no background in intelligence or space, but was brought on to lead the budget-troubled NRO because he was a logistics and acquisition specialist. On his watch, the agency completed six successful launches last year. Carlson is also widely credited with restoring the NRO's reputation for quiet competence and for enhancing its orbital intelligence-gathering capabilities.

Debate over the future of intelligence satellites pits private-sector advocates against those who want government to make and maintain the spacecraft. Today's technology enables private companies to develop high-resolution sensors and perform surveillance that in the past was possible only with classified platforms developed by the intelligence agencies. Some see the orbital information-gathering business as a potential gold mine for industry.

Retired Marine Gen. James E. Cartwright, former vice chairman of the Joint Chiefs of Staff, has become vocal in supporting private-sector satellite development, while James R. Clapper Jr., the director of national intelligence, wants spy satellite work to stay in government hands.

Carlson is on Clapper's side of the argument. Cartwright, having been passed over for the nation's top military job, no longer has official duties but still enjoys enormous influence in Washington. Clapper, occupying a slot created after the events of September 11, 2001, and following a reorganization that remains controversial, holds the nation's top intelligence job but has little clout in Congress.

Aerospace companies and their friends on Capitol Hill are riled up at an Obama administration proposal to cut contracts for commercial satellite imagery in half next year, from $540 million to $250 million, and at the roles of Carlson and Clapper in crafting the proposal. The proposed cuts would hit GeoEyeInc and DigitalGlobe, which provide imagery to the intelligence agencies.



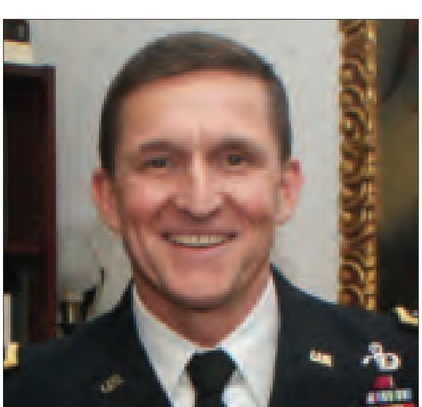
Gen. Bruce Carlson (USAF, Ret.)

The cuts will reduce spending by NRO, the maker of spy satellite hardware, and the National Geospatial-Intelligence Agency, which handles the modern-day equivalent of worldwide charting and mapping. The expertise of NGA in using satellite data and other sources to plot the lay of the land is credited with helping substantially in the U.S. commando operation that killed al-Qaeda chieftain Osama bin Laden in Pakistan on May 2, 2011.

At a recent conference in Colorado Springs hosted by the Space Foundation, officials expressed reassurances about the proposed cuts, saying that government will continue to encourage private satellite work and will be able to make do with less imagery. Greg Schulte, deputy assistant secretary of defense for space policy, told Reuters the decision to cut the commercial imagery funding had been difficult to make, especially given constantly growing demand from military commanders. Schulte said that, in view of increased successes by government-owned satellites, military commanders are "still going to get more, despite the cut in commercial imagery."

The cuts, like so many proposals on the table in Washington, will depend on what actions are taken by Congress and the White House on the FY13 budget after the election.

In another intelligence-related development, Army Lt. Gen. Michael Flynn has been named to become the next director of the Defense Intelligence Agency. The nomination comes at a time when the Pentagon is forming a new Defense Clandestine Service to conduct intelligence gathering overseas—a task not previously performed by military personnel.



Lt. Gen. Michael Flynn

Drones in the sky

It is unlikely that a jetliner and an unmanned drone would ever come together in midair, but congressional caucuses collide on a daily basis. The office of Rep. Gerry Connolly (D-Va.) says "no one really knows" how many exist. There are about 350 such panels, with each Capitol Hill lawmaker being a member of typically half a dozen. A caucus is defined as "a group of members of the United States Congress that meets to pursue common legislative objectives." All of them bill themselves as bipartisan and many enjoy semiformal status as congressional member organizations (CMOs) under House of Representatives chamber rules. Some have no formal standing but bring lawmakers together to discuss issues of common concern.

The latest collision, figuratively speaking, is between the Unmanned Systems Caucus, headed by Rep. Buck McKeon (R-Calif.) and Rep. Henry Cuellar (D-Texas), and the Bipartisan Congressional Privacy Caucus, chaired by Rep. Ed Markey (D-Mass.) and Rep. Joe Barton (R-Texas). Hill unmanned systems advocates want to encourage and expand the use of robot aircraft, commonly called drones, for a variety of civilian and military purposes, including surveillance by law enforcement. Privacy advocates worry that these drones may be used for surveillance and monitoring in circumstances where a law officer would need a search warrant.

On February 14, President Barack Obama signed the FAA Modernization and Reform Act of 2012, requiring the FAA to find a safe, expedient solution to integrate unmanned aircraft systems into the national airspace system, or NAS, and to complete the process in 2015. UAS is the official FAA term for what many call a drone, while NAS is the formal name for the nation's regulated airways.

Rep. Ed Markey

The NAS includes 18,000 airports, 750 air traffic control facilities, 4,500 air navigation facilities, and about 48,000 FAA employees who administer airline, general aviation, and some military flying. As a first step toward complying with the legislation, the FAA in March took initial steps to have six UAS test ranges set up by this summer. Preliminary flying exercises are scheduled to begin in these locations this month. As the FAA makes progress, a variety of organizations—as well as private hobbyists—will be permitted to operate drones in U.S. airspace.

In a letter dated April 20, Markey and Barton wrote to Michael Huerta, acting FAA administrator (and nominee to fill the job permanently) asking how the agency will protect Americans from surveillance by operators of these aircraft, including police departments. The language in the FAA bill and in ensuing regulations deals with safety issues and control of unmanned aircraft, but not privacy concerns, an area the agency should address, Barton and Markey wrote. Many drones carry surveillance equipment such as infrared thermal imagers, video cameras, and radar. This raises questions about how the privacy of individuals will be safeguarded and how the public will be informed about drone activities, whether by law enforcement, commercial enterprises, or private individuals, the two wrote.

"We must ensure that as drones take flight in domestic airspace, they don't take off without privacy protections for those along their flight path," Markey said in a statement.

And what about safety? Benjamin Wittes and John Villasenor, both of the Brookings Institution, wrote that the FAA "has a lot on its plate. There are the basic regulatory questions: How do you put large numbers of unmanned systems in the air without endangering commercial and general aviation? Who can fly [a drone]—not to mention, of what size, how high, and how far—without its posing a threat? What rules should apply, and how should they be enforced?"

The need for a clear nationwide policy is highlighted in Hawaii, where the state spent $75,000 to purchase a drone to conduct aerial surveillance over Honolulu Harbor. But the FAA refuses to give the state permission to fly the device over the harbor, saying the drone cannot be deployed in airspace near Honolulu International Airport because the skies are too crowded, according to the *Hawaii Reporter*.

"It works, we're maintaining it, but we just can't fly it," Harbors Division administrator Davis Yogi told the newspaper. The drone, which is equipped with a high-tech camera to scan and track ground activity, was part of a Honolulu and Maui harbor security system financed with $1.4 million in federal grants and $900,000 from FEMA—and was purchased in 2010 without anyone bothering to check with the FAA to get approval to fly the aircraft.

Warbird worries

What should the rules be for flying restored military aircraft, known as warbirds, at air shows and public events?

About 1,000 warbirds are now airworthy in the U.S., and many will be highly visible as the summer air show season arrives. The planes vary from the world's only B-29 Superfortress heavy bomber, named Fifi, to an F-4D Phantom II twinjet fighter-bomber.

Warbird groups such as the Experimental Aircraft Association, the Commemorative Air Force (CAF), and the Collings Foundation have offices in Washington. They quickly mobilized in late April when Rep. Michael Turner (R-Ohio) announced that he would introduce legislation to curb warbird flying. The statement appeared on Turner's official website and referred to an amendment he would propose during markups on the National Defense Authorization Act, H.R. 4310.

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The National Museum of the United States is located in Turner's constituency near the city of Dayton, where Turner was once mayor. The museum and its director, John L. 'Jack' Hudson, are vocal supporters of caring for and preserving historic aircraft in indoor, climate-controlled settings.

This is not the view of the entire Air Force, however: The service has something of a split personality about warbirds. It conducts heritage flights in which a real combat aircraft such as an F-22 Raptor will make a flyover at an air show alongside a civilian-owned, restored P-51 Mustang from WW II.

Rep. Michael Turner

Gen. Norton Schwartz, Air Force chief of staff, has spoken of the need for "a fine balance" between those who want to 'keep 'em flying' and those who want to park restored military planes permanently in museums. But some USAF leaders, such as Air Force Historian C.R. 'Dick' Anderegg, share Turner's view that flying former military aircraft, especially more recent ones, puts the military in jeopardy of being associated with safety risks.

Turner never submitted his proposed amendment. It was removed from his website and replaced by a statement, dated April 21, that referred to the risks of flying former military aircraft but expressed support for warbird operators. Turner's communications director, Thomas Crosson, told this author that "worries by warbird owners" were exaggerated and that the lawmaker was not planning to ground anyone. The congressman, who continues to oppose making post-1947 jet aircraft available to civilian operators, declined a request to be interviewed for this column.

Michael D. Brown, pilot of the B-29 named Fifi and an experienced air show veteran, says that the FAA, not the Air Force or the Congress, should handle safety concerns about warbird flying. Brown says he would oppose any legislation that restricts flying by preserved military aircraft. "The warbird community plays an important role in bringing World War II-era aircraft to our nation's citizens," he says. The plane has been on 'conditional loan' to the CAF from the Air Force since 1971, has been completely rebuilt, and has a full schedule of appearances planned for the summer.

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William H. Gerstenmaier

The ISS is one of your major responsibilities as chief of NASA's Human Exploration and Operations Mission Directorate. What's going on with the space station?

First of all, the station is incredibly important to us from the standpoint of human spaceflight. There's a lot of vital research going on there every day, probably between five and 10 research investigations a day. I don't think that's widely known. We need to find a way to get that message out better than we have; communicate to the American people what's going on, what the station's crews are doing.

For example?

The ISS is the only space-based international testbed for research on the potential risks to human health of deep-space travel and on identifying, mitigating, and counteracting those effects. ISS research is providing incredibly critical data on human performance in the microgravity environment. We're finding that there are lots of things in the human body that react differently in microgravity.

We've got to learn about all that now, so we don't go on a journey to Mars and discover that some things about our bodies don't work very well. If we're going to travel great distances to asteroids or to Mars over a long period of time, we really need to know how the human body reacts to the environment of space.

Tell us more about all that.

One effect that we were fairly surprised to discover in space station research was intracranial hypertension, where we noticed changes in the visual acuity of astronauts. The shape of their eyes was altered and it affected their vision. That condition doesn't appear to be always recoverable, even after astronauts return to the ground. So now we're working to understand the basis—the cause—of it, and to find a good preventative measure we can apply in space.

The research has implications for life on Earth, too, I assume.

That's right. We find it intriguing that some of our research findings have a direct application to folks here on Earth. Bone density loss in space is similar to what the elderly experience on Earth. We've also found that the human immune system tends to be not as effective in space. We're not sure exactly why. It mimics what happens in some elderly people on Earth.

The same with inner ear response, vestibular response, where astronauts' balance and motion stability are affected. That's also something that occurs in the elderly. We've been able to develop training to help astronauts overcome that. It decouples their visual cues from their inner ear responses, and they can acquire skills to make them more stable. We think it has a direct application to the elderly, who sometimes have problems with stability of motion.

"If we had set out on a journey in space without all the knowledge we have gained, it would have been a big gamble instead of a risk that we'd be willing to take."

Is it an exaggeration to say that it would have been impossible or very dangerous to send astronauts into deep space without the findings of space station research, without being able to prepare them for the physical effects?

I think it would have been difficult to do that in the right way. We've now got pretty good techniques to maintain bone density at reasonable levels and keep muscle tone fairly decent. We also have a good understanding of what some drugs do in space—whether their dosage in space is measured the same as it is on the ground, what their shelf life is in space, how effective they are in space. If we had set out on a journey in space without all the knowledge we have gained, it would have been a big gamble instead of a risk that we'd be willing to take. So we are learning some really important things on space station.

Would you go so far as to say there would have been no justification for attempting a long journey in space without the findings of space station research on human effects?

I think that's right.

This is good stuff.

It is very good stuff. And it's the same with our technology development. Space station systems are fairly high technology, requiring a lot of maintenance and, sometimes, a lot of spares to keep them up and operating. So just like with humans, we need to make sure that technology is mature enough before we go commit to a long-duration flight in space. Once we commit to a Mars-type journey, we'd better make sure that all systems are really ready to go. We'd better make sure that both our technology and our astronauts are at the same high level of readiness. Space station plays a big role in this.

How would you rate the operational readiness of the space station itself?

I think it's in good shape. The final flight of the shuttle to the station last year was tremendously helpful to us. It provided all the spares we may need for the space station for an extended period of time. And then the European automated transfer vehicle delivered some unique equipment to

Interview by James W. Canan

the station. A Japanese cargo vehicle will deliver cargo to the station this summer, and we're hoping to get one of the commercial cargo providers—SpaceX or Orbital—to deliver more cargo in the coming year.

How are SpaceX and Orbital Sciences coming along with the cargo transfer vehicles they're building?

I think they're doing well. I think they were more optimistic, schedule-wise, than we would have guessed. And that's why we needed to fly the shuttle to the station last year and commit to the flight eight months before it actually flew. Adding that flight to the shuttle schedule gave us the margin to allow SpaceX and Orbital to have a little more flexibility of schedule with their vehicles.

Talk a bit more about cargo resupply, cargo transfer vehicles, all that.

We've done a very good job of understanding what it takes to approach station. When we brought on the European cargo transport vehicle and the Japanese cargo vehicle, they succeeded right away in docking with space station. The European ATV docks in the back of the service module on the Russian side of the station. It goes right in. The Japanese HTV stops short of the station—just like the SpaceX and Orbital modules will—and is picked up by the remote manipulator system on the space station.

What part do you—does NASA—play in all that?

We took the same approach with both of those European and Japanese vehicles as we are taking with all our commercial providers. They have to demonstrate each piece of hardware and procedures they will use in space before they'll be ready to commit to flight. For example, they will have to show that they are prepared to stop on their approach to space station, back off, and hold at a different point while they check out their software to make sure it will actually work when approaching directly into the station's berthing box.

In the process, their vehicles will demonstrate what the back-out maneuver looks like if for some reason they have to abort, and show that the vehicles maintain proper position relative to the station. After it is demonstrated that everything is working exactly the way it was designed to work, we'll allow the vehicles to approach and eventually go into the berthing box. The main goal in all this is to make sure of the safety of the ISS.

Is NASA giving commercial contractors greater flexibility in preflight testing, compared to NASA's requirements for preflight testing of government-owned vehicles?

In the government world, we'd do every test on the ground that we could possibly do, because we would have more test resources than a commercial company. A commercial com-

William H. Gerstenmaier is the associate administrator for the Human Exploration and Operations Directorate at NASA Headquarters. He provides strategic direction for all aspects of NASA's human exploration of space, including continued operation and utilization of the ISS and development of the SLS and Orion spacecraft. He also provides guidance for the commercial crew and cargo programs.

Gerstenmaier began his NASA career in 1977 at the then-Lewis Research Center, doing aeronautical research. Beginning in 1988, he headed the Orbital Maneuvering Vehicle Operations Office at Johnson.

Subsequently he headed the Space Shuttle/Space Station Freedom Assembly Operations Office. He also served as Shuttle Mir Program operations manager, serving as the primary interface to the Russian Space Agency for operational issues.

In 1998, he was named manager, space shuttle program integration, responsible for overall management, integration, and operations. In December 2000, he was named deputy manager of the ISS program; two years later he became manager. Named associate administrator for the Space Operations Directorate in 2005, he directed the safe completion of the last 21 space shuttle missions that witnessed assembly complete of the ISS.

Gerstenmaier received a B.S. in aeronautical engineering from Purdue University in 1977 and a master of science degree in mechanical engineering from the University of Toledo in 1981. He has completed course work for a doctorate in dynamics and control with emphasis in propulsion at Purdue. An AIAA Fellow, he has received numerous awards, including two NASA Exceptional Service Medals, the Meritorious Executive Presidential Rank Award, and several AIAA awards, including the von Karman Lectureship in Astronautics.

pany may not be able to take advantage of all the testing facilities that we have. So they will inevitably experience some things for the first time in space. We think that's reasonable, because in a test flight, some things may not go right, and they may not get into the berthing box. But that doesn't mean that they've failed. It only means that they carried into space some of the testing NASA would have done on the ground.

We're having this conversation in advance of SpaceX's first demonstration flight to the station. You cannot predict how it will go, of course, but talk about it anyhow. It's a test flight, after all.

That's right. And we all expect to learn from the first test flight, and if it doesn't go perfectly, we'll fix it and recover from it, and then go on to the next flight, which could be a cargo resupply flight under contract or another demonstration flight, depending on what we learn from the first one. If the first one is a total swing-and-miss, we'll need to repeat it. But if it went all right except for one little thing, we'll fix it and not repeat it the next time. We'll use our engineering judgment. We want to enable the commercial companies to fly as soon as they are ready to go. We've got to be careful not to put too much emphasis on the total success of the first flight.

Will you cut SpaceX and Orbital Sciences some slack if they say they're going to have to spend too much money on making absolutely certain a possible problem does not arise, and they decide to fly regardless? How tightly are you monitoring them in this regard?

We are monitoring them closely. But keep in mind that our main concern at this stage is the safety of the space station, not the delivery of cargo to the station. Last summer, a Progress vehicle failed to achieve orbit and we lost all the cargo. That didn't really impact the space station because it had enough spares and supplies aboard.

Cargo can be replaced. I'm trying to ensure that commercial vehicles will not do anything to damage the station, that they will not miss their mark and take out a solar array, for example. By taking steps to ensure the safety of the space station, I could give up some mission success—lessen their ability to deliver the cargo. But I can do that with cargo because cargo isn't critical.

Mission success is more the responsibility of the contractors. They are free to decide on their own what they want to do to make their mission successful. But on the safety side, I hold them to the same standards that NASA adheres to.

And crew transfer is something else again, isn't it?

With crew, I've got to emphasize both mission-success and safety. Crew transfer is a very different animal. Sometimes people look at what we're doing for cargo and say, well, it applies directly to what we're doing for crew, too. It does not. I don't have the same freedom to pay less attention to mission success. I have to keep the crew alive and well and get them safely to the station.

How do you assess the progress of crew-transportation contractors?

I think they're making good progress. I am a little more focused on the cargo aspect right now because that will be critical in this next year. If we don't get cargo to the station in the next year, there won't be a facility—a space station—to take crew to in the future. So our near-term requirement is to make sure that the cargo transportation really works.

We're in the ready-to-deliver stage for cargo transfer. But we're also working very hard on the next phase, to get the designs in place for crew transfer. We'll be going into critical design review for crew capsules, and we fully intend to be at the station with crew sometime around the 2017 time frame if we get adequate funding.

Speaking of which, what's your financial situation?

We're challenged. I think our directorate has adequate resources to do what we've been tasked to do. Our budget is pretty well balanced across all the things we're doing, but we don't have a lot of margin. We cover a lot of programs—from commercial cargo and crew activities to the more traditional government programs like the heavy lift launch vehicle, the Orion capsule, expendable launch vehicles, and space communications.

Talk about the space launch system, SLS, development. Where are you on that?

First of all, on Orion, we're making very good progress. We're assembling the final test article, which will be flown in 2014. We'll launch it on a Delta IV accelerated to 80% of the return velocity from the Moon, and then reenter it. The purpose of that is to look at the heat shield performance. The heat shield that sits underneath the capsule is designed for low-Earth-orbit reentry, so this reentry will really stress the heat shield. Understanding how it will actually perform in a reentry and obtaining that data before the critical design review for the Orion capsule will be tremendously important in getting the [operational] heat shield sized just right.

The flight test will also enable us to see how our parachutes operate and assess other things, like launch-abort separation capability, during ascent. This single test flight will enable us to retire about 11 of our critical risks, among others, in the Orion program. So it's a really important test.

"This single test flight will enable us to retire about 11 of our critical risks, among others, in the Orion program. So it's a really important test."

What's happening with the Orion capsule?

We're building it right now in New Orleans. It will get shipped to Florida, probably this month, and will undergo final assembly there. It will be ready to fly toward the end of 2013, and then we'll get the rocket for it to launch on—the Delta IV—sometime in 2014.

What about the heavy launch vehicle development?. Where does it come in?

Our systems requirements review for the SLS heavy launch vehicle was recently completed. We've already made decisions on some configuration items. We were looking to carry three, four, or five engines underneath the core vehicle, but concluded that four is the right number, and it won't vary. We think four engines will give us good launch capability. That came out of our systems requirements review.

"The decisions we make now, we will carry with us for the rest of our lives. The decisions may seem pretty simple and straightforward at the moment, but they carry a long tail."

What else?

We're designing the core configuration of the vehicle to have either solid or liquid boosters on the sides. We will award a demonstration study contract this summer that will lead us ultimately to a decision on the boosters. The vehicle involves a tremendous amount of work. It is not easy to design a core that can take either set of boosters. The tank sizing is getting set. The basic manufacturing approach is getting set. We're making some decisions about what kinds of materials we'll use, where and how we'll manufacture, what weld schedules we'll set. Everything will be decided in the next several months.

So it's crunch time, right?

It's tremendously important for us to get everything right as we go forward. The decisions we make now, we will carry with us for the rest of our lives. The decisions may seem pretty simple and straightforward at the moment, but they carry a long tail. We see this vehicle being in operation for a long time, and we'd better do our best to make sure it will do the job.

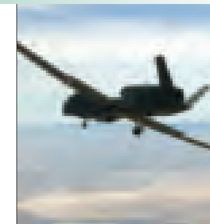
Sum up. How is everything going in the directorate, with your programs, all things considered.

We're making tremendous progress, and I think we're very lucky to have the resources we have in this pretty tough environment of fiscal restraint for the country. As an agency, we're gong to make the absolute best out of what we're given in resources, and deliver the goods for the American people.

Narrow it down to how you see your job, your role, in all that.

I think it is really cool that I'm able to do my job in a couple of different ways—in the traditional NASA way with SLS and Orion and in a very different way with our commercial cargo and crew programs. And what is really cool is that I can learn from one program to the other. I can take some of the concepts the commercial contractors are pushing, like when they say they don't really need all the customary documentation, and I agree with them and go modify a typically NASA program by removing some documentation I don't think adds much value. Or, if there are requirements in my government world that I've learned are truly important, I can infuse those into the commercial activities.

So I can see two different ways of doing business and I can take the best of one and apply it to the other, and then take the best of the other and apply it in reverse. I also have the privilege of working with a truly amazing NASA team. The team helps make my job easy.



Reduced budgets change the game, and U-2 rises

In July 2011, the Pentagon asked Congress for approval to shift more than $920 million to intelligence, surveillance, and reconnaissance (ISR) efforts, especially several UAV and special operations programs. This was in addition to more than $5 billion in ISR transfers requested earlier by DOD.

But by early this year, in the current budget-cutting environment, even highly valued new ISR capabilities had come under scrutiny. Past Defense Secretary Robert Gates' goal—to increase buys of Air Force MQ-9 Reaper endurance UAVs from 65 to 80 combat air patrols—initially was denied; it now looks to be on hold indefinitely, with reduced Reaper platform procurement. Several other UAV and manned ISR platform buys have been postponed or reduced.

But Teal Group believes that in many defense markets the desire for greater capability with lower spending will favor sensors and electronics over other hardware, including nonsensor upgrades to important ISR planes such as new engines for manned JSTARS aircraft. Instead, funding is shifting to sensor upgrades for existing platforms.

U-2 trumps Global Hawk

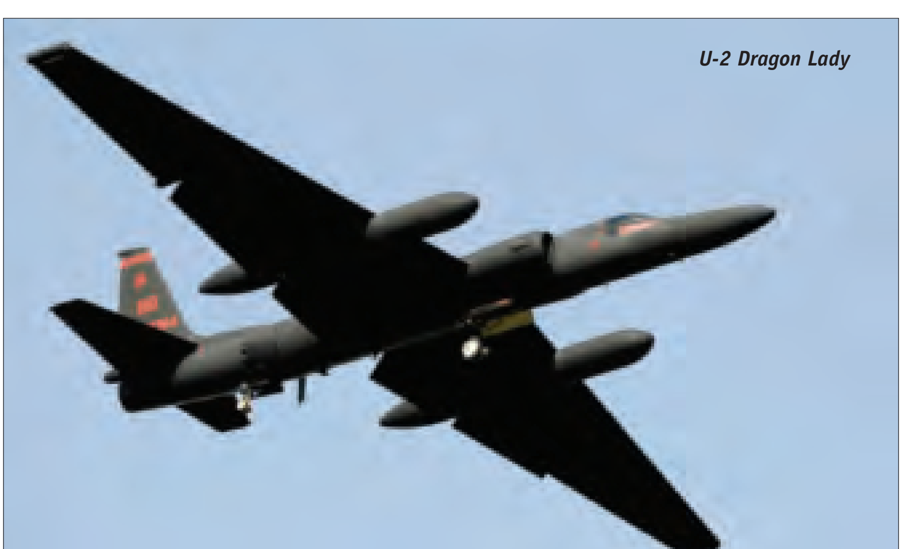
An unexpected example of this—and a superb illustration of the growing *primary* importance of sensors and electronics over the aircraft themselves—is the Global Hawk debacle. The UAV has been in development for more than a decade as a long-endurance, high-altitude 'sensor truck' intended to be a cheap replacement for the Cold-War-era manned U-2 Dragon Lady, because it is now grudgingly admitted that sensors trump the whiz-bang coolness of men in pressure suits on the edge of space.

But in a twist of fate, those men in pressure suits are still cheaper truck drivers than the troubled and overbudget Global Hawk and its massive ground-based logistics tail. With the Block 30 Global Hawk canceled in the FY13 budget—and existing air vehicles slated for an unlikely warehouse storage—the Air Force's 30-odd U-2s will continue to fly with the newest, most sophisticated sensors and continuing sensor upgrades.

Global Hawk's downfall has been a long time coming. In June 2010, USAF senior acquisition executive David Van Buren said, "We are not happy with the cost of the air vehicle and the sensors." Specifically criticized were Raytheon's integrated sensor suite (ISS) and enhanced ISS (EISS), and Northrop Grumman's MP-RTIP radar. In May 2011, the Global Hawk initial operational test and evaluation report found the aircraft to be "effective with significant limitations…not suitable and partially mission capable." Many problems were reported, including poor performance of the EISS infrared (IR) sensor at range. The sensor operated well over a target, but slant-range performance was poor. The U-2's slant range performance is considered excellent.

The Air Force's chief tester, Maj. Gen. David Eichorn, claimed the Pentagon had already decided that "the [EISS] sensors are what the sensors are," and that major fixes were not planned. Finally, in late 2011, Air Force sources admitted there have been image quality problems with the UAV's sensor data fed through Raytheon's distributed common ground system (DCGS). These troubles have been due to software, not sensors, including flaws in data processing and digital image 'stitching,' but reflect yet more problems with making Global Hawk an effective ISR provider.

These issues, and operational costs arguably still higher than those of the U-2, contributed to the Air Force's decision to cancel Global Hawk and increase future funding for the U-2—funding that will now concentrate on sensor upgrades rather than on making operational the still new and relatively unreliable Global Hawk air vehicle. Another factor in the Air Force's decision is that more than 30 recently upgraded U-2s are flying today—and are deemed structurally sound enough to fly through at least 2040 (today's fleet was built in the 1980s, although the U-2 has a 50-year heritage).



U-2 Dragon Lady

Bigger and better

Another major plus, in addition to reliability, availability, and cost, is the U-2's payload capacity—5,000 lb compared with 3,000 lb for the Block 20/30/40 Global Hawk. This allows for larger sensors such as the high-resolution, wide-angle, wet-film optical bar camera (OBC). It produces 6-ft-long negatives with a much higher resolution than any digital focal plane array and is too big for Global Hawk. In early 2012, OBC upgrades gave even higher resolutions at low altitudes, according to the Air Force. Other U-2 sensors have also received classified upgrades recently.

Carried simultaneously with the OBC is Goodrich's upgraded SYERS (senior year electrooptical reconnaissance system), a seven-band multispectral EO (electrooptic) long-range oblique photographic reconnaissance system, which adds green, red, near-IR, two short-wave, and midwave IR bands to the visual spectrum. In July 2010, USAF officials said they had successfully located improvised explosive devices with the multispectral abilities of SYERS, something that would not have been as effective from Global Hawk with its dual-band EO/IR EISS.


Global Hawk

In March 2011, Goodrich began upgrading SYERS to add further multispectral imaging capability in a new SYERS-2A version.

In February, the Air Force announced it is buying one BAE Systems SPIRITT (spectral infrared remote imaging transition testbed) hyperspectral sensor to be mounted in the optical bar camera's 'Q-bay' behind the pilot in the U-2. SPIRITT will take up space needed for avionics to support the U-2's signals intelligence pod, but SPIRITT and the nose-mounted SYERS-2 will operate simultaneously.

Like most of the other U-2 sensors, SPIRITT will be controlled via data link from a remote DCGS station, emphasizing the 'sensor truck' application, similar to UAVs (only the OBC offers a degree of pilot control). Maj. Bill Evans, U-2 program monitor at Air Combat Command in Hampton Roads, says the Air Force hopes to deploy SPIRITT to support combat operations in the U.S. Central Command by this summer. If SPIRITT performs well, more systems will likely be bought.

SPIRITT was the first major hyperspectral EO reconnaissance system developed by the Air Force. BAE Systems won the Phase 1 advanced technology demonstration development award in April 2001. The system was originally planned for the U-2, shifted to Global Hawk soon after development began, and is now entering service on the reborn U-2. A functional SPIRITT imager was test flown in late 2005.

Hyperspectral imaging, also called imaging spectroscopy, refers to the imaging of a scene over a large number of discrete, contiguous spectral bands (more than 100), so that a complete reflectance spectrum is obtained. Most materials on the Earth's surface (or above and below) contain characteristic or diagnostic absorption features. Hyperspectral imagers measure these reflectance characteristics in different spectral bands, to determine features not visible to the human eye (or to IR or radar sensors), such as chemical and nuclear plumes, moisture stress levels of plants and soil, and so on. In late 2011, USAF sources claimed the Air Force will continue to push for additional hyperspectral capabilities beyond the "kind of experimental" capability in theater in 2011.

Other recent hyperspectral programs include Raytheon's ACES Hy

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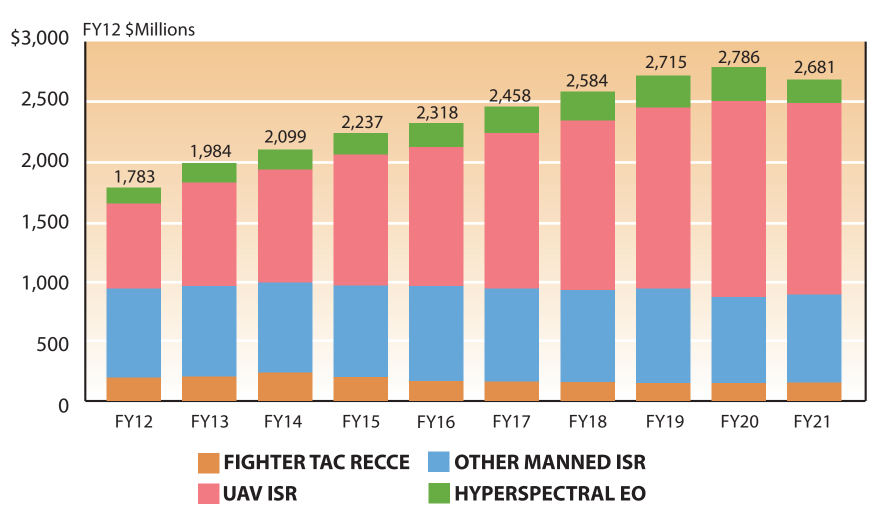


Grey Eagle

(airborne cueing and exploitation system hyperspectral), meant to be nose-mounted in Predator. In mid-2011, the USAF contracted for low-rate initial production, with deliveries to take place over the following nine months.

Other sensor upgrades

The U-2 will continue to provide high-altitude, high-end ISR, but hundreds of medium-altitude, long-endurance UAVs—MQ-1 Predator, MQ-9 Reaper, and Army MQ-1C Grey Eagle—are already providing dozens of round-the-clock ISR orbits to all services. These platforms will see continuing sensor upgrades and retrofits without waiting for next-generation platforms. In January 2011, the Air Force awarded Raytheon a $25.8-million contract to continue making improvements in Reaper's MTS-B multispectral targeting system sensor—particularly to augment system imaging from standard definition to high definition (HD), and to investigate image fusion and other performance enhancements.

In April 2011, the Air Force was reportedly looking to add the Army's MQ-1C HD Common Sensor Payload with full-motion video to its now-legacy Predator UAVs. This would presumably mean replacing Predator's similar but less advanced MTS-A sensor and upgrading logistics, in what would be a major program for Raytheon. As HD and full-motion video become baseline requirements, and hundreds of retrofits become likely (EO/IR sensors are typically replaced in lieu of major upgrades), look for sensor funding to stay fat through the next few years despite shrinking platform procurement.

Other new sensors are also being added to legacy platforms. In addition to new hyperspectral technologies, digital wide field-of-view (WFOV) sensors similar to the wet-film OBC are entering service. BAE Systems' autonomous real-time ground ubiquitous surveillance imaging system, ARGUS-IS, reportedly can image a 7.2-km-diam. area from 13,000-ft altitude with a sampling distance value of 0.15 m. In August 2011, the Air Force awarded a $9-million production contract for one ARGUS-IS with options for two more. This January, the Army planned to deploy three ARGUS-IS systems to Afghanistan aboard A160T Hummingbird UAVs as a quick reaction capability. In March 2011, the first Sierra Nevada/ITT Geospatial Systems Gorgon Stare pods arrived in Afghanistan for service aboard the Reaper, with the reported ability to track up to 12 moving targets within a 4x4-km area. Also in August 2011, the Naval Research Laboratory issued a notice for R&D of a nighttime WFOV persistent surveillance sensor for the Marine Corps Shadow 200 UAV.

Stealth still sought

Global Hawk's time may have passed, for reasons beyond just expense and a small sensor payload. Both Global Hawk and the U-2 are vulnerable to high-altitude surface-to-air missiles, the kind of weapon developed effectively by the Soviet Union and now increasingly available to the U.S.'s few near-peer competitors.

After a decade of having 24-hour-taskable ISR available against opponents already bombed into the stone age, the U.S. will not be content to return to Cold-War-era satellite intelligence in the event of a conflict with China, or even a midlevel threat that has bought some new SAMs. There will be a need for multiple high-altitude ISR orbits with no risk of U.S. casualties, which means a return to unmanned and stealthy platforms. Unlike shorter range IR-guided SAMs, high-altitude missiles are still radar guided, and only radar stealth or countermeasures—available to neither U-2 nor Global Hawk—are effective defenses.

By mid-2011, the Air Force had publicly slipped the production of a stealthy 'MQ-X' UAV to a highly theoretical target date of 2017, following completion of MQ-9 Reaper production (now itself delayed). In June 2011, the Congressional Budget Office (CBO) proposed several options for cheaper and more capable alternatives to current large UAVs. The MQ-SX was proposed as a 'notional aircraft' with performance very similar to General Atomics' stealthy jet-powered


Predator-C

Avenger, a company-funded design that first flew in 2009. The CBO proposed MQ-SX both as a more capable alternative to Reaper, requiring fewer aircraft for the same mission, and as a slightly less capable but far cheaper substitute for Global Hawk ($3 billion less for 24 aircraft).

By February of this year, General Atomics had inserted a 4-ft fuselage plug into Avenger/Predator-C, and made other upgrades, to offer a 16-hr-endurance, 400-kt, 50,000-55,000-ft stealthy UAV. Moreover, the vehicle's payload capacity is greater than that of U-2 and double that of Global Hawk—3,000 lb internally, another 3,000 lb on wing hardpoints, and several hundred lb in the forward electronics bay, according to General Atomics. Two new Predator-Cs were already flying by January 2012.

Even if operating costs go down, Global Hawk may have missed its usefulness window for electrooptic ISR. MQ-X/SX may still be a few years in the future, but a *major* classified production program could also materialize—the Air Force will not be content with only a few stealth orbits or prototype systems. The EO sensor could be a derivative of Raytheon's Global Hawk ISS/EISS, or Lockheed Martin/Northrop Grumman's stealthy EOTS/DAS (electrooptical targeting system/distributed aperture system) aboard the JSF, or a new competition. In late 2011, the Navy tested a new ISR suite for Predator B during its 'Trident Warrior 2011' experiment, based on FLIR Systems' Star SAFIRE 380HD high-definition EO/IR system.

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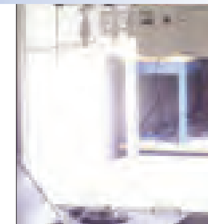


NOVA: Bright new star for CubeSat testing

In the early days of CubeSats, students and engineers would carry the 10-cm^3 satellites outside into the sunlight to test the cubes' ability to turn solar energy into electricity. Critical factors such as center of gravity, attitude control, and pointing accuracy might not be verified at all.

How did a student or instructor know if he had overlooked something? "Pretty much through just flying it," says satellite engineer Steve Wassom of Utah State University's not-for-profit Space Dynamics Laboratory (SDL) in North Logan, Utah. If the CubeSats worked, that was great—and any data gathered concerning space weather or magnetic fields would be a bonus on top of the learning experience for the students.

Today, that attitude is beginning to change. U.S. government customers have taken an interest, and CubeSats are becoming more and more complex. This has created a need for vigorous testing to characterize performance and validate requirements.

Small room with big prospects

Enter the Nanosat Operation Verification and Assessment (NOVA) Test Facility. Since August 2010, a 10x20-ft room at the SDL has been equipped with a Sun simulator and a magnetic-field-generating Helmholtz cage for verifying attitude control. There is also a mass measurement table containing numerous sensors for determining center of gravity to within 1 mm and mass to within 2 g. These, along with other equipment, are designed specifically for testing nanosatellites, loosely defined as satellites of up to 10 kg, which most often means a CubeSat. Universities and government agencies pay for services at the facility, and NOVA managers do their best to allow students and outside engineers to participate under legal liability constraints.

"NOVA is unique in its focus on servicing very small sats. Without such facilities we have to use standard much larger facilities, which are more costly and in some cases are not appropriate for CubeSats," explains Jordi Puig-Suari of Cal Poly, in an email.

Consider a spacecraft's center of gravity (cg). It must be known for precise pointing control. The designer of a large satellite might be satisfied to verify the spacecraft's cg to ±10 cm, but that margin of error would be the width of an entire CubeSat, says Wassom's colleague at NOVA, mechanical engineer Quinn Young. "When you scale down to these tiny little satellites, you have to be much more sensitive," says Young.

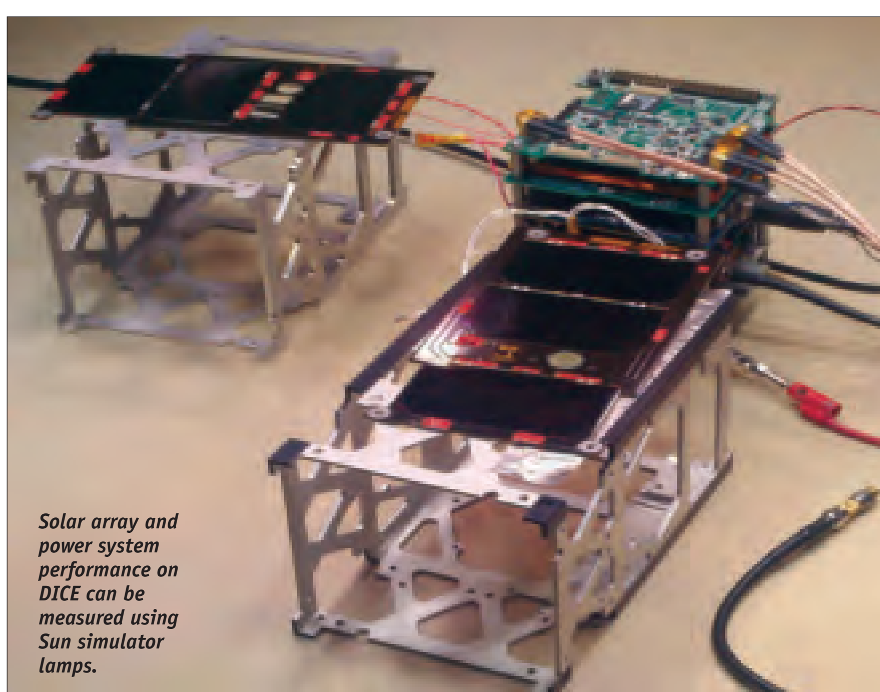
Testing for major customers

Universities are expected to remain important customers, but the low cost of CubeSats has caught the eye of the Air Force Research Laboratory (AFRL), the Air Force's Space and Missile Systems Center, the Naval Research Lab, NASA, and the intelligence community.

With tax dollars at stake, government CubeSat managers must rigorously test and characterize the performance of their spacecraft before launch.

So far, NOVA has tested a pair of identical space weather satellites called DICE, for Dynamic Ionosphere CubeSat Experiment. The satellites were built at SDL and were sponsored by the National Science Foundation. They will spin in orbit approximately 200 km from each other to study how magnetic storms and variations in the density of ionospheric plasma affect electric field properties. Engineers want to know how those variations might impact communications and navigation signals near Earth's surface and in space.

Next, NOVA officials are preparing to test PEARL, the Picosatellite Exo-Atmospheric Research Lab, for AFRL.



Solar array and power system performance on DICE can be measured using Sun simulator lamps.

This 30-cm-long satellite is called a 3U CubeSat because it will have the dimensions of three CubeSats joined together. PEARL is a nonspinning spacecraft that will serve as a prototype for a standard satellite design that could be configured for different payloads.

"It was that PEARL effort that got us thinking really hard about how you do a government-class spacecraft that requires validation of its requirements, and that led us to development of the NOVA lab," says Young.

AFRL's interest in CubeSats might not be surprising given its research mission, but the Air Force's Space and Missile Systems Center's (SMC) sudden interest was a big breakthrough for CubeSats, Young says. SMC is best known for overseeing the construction of giant military communications and missile warning satellites. In April 2011 Boeing announced it had received a $5-million contract from SMC for construction of the Space Environmental Nano-Satellite Experiment, or SENSE, a 30-cm-long CubeSat.

Precision pointing

Given the growing interest of ,government customers, Wassom and Young have their sights set on key upgrades that would keep the facility up to date with anticipated advances in CubeSat designs.

"One of the things that really differentiates the university-based CubeSats from what we call military grade is the ability to point," Wassom explains. "Pointing is usually critical to mission capability, and so that's where we're headed." Because CubeSats are so small, imaging is not typically a focus of their missions, but accurate pointing is nevertheless important for precisely mapping magnetic fields or the directions of space weather phenomena.

To improve pointing, engineers are starting to look into installing star-tracking cameras on their CubeSats. Sensing a star pattern gives better attitude knowledge than mathematically combining the Sun angle with the orientation of the cube relative to Earth's magnetosphere. A star-tracking CubeSat would have a control accuracy of ±0.02 deg compared to an error of 0.2 deg for one with a Sun-sensor/magnetometer system. When a CubeSat is stabilized by spinning, the attitude control error averages about 5 deg.

Once a CubeSat's computer knows where it is, the satellite can adjust its attitude, firing up torque coils—electromagnets whose magnetic fields interact with Earth's—or, in the case of PEARL, by combining the force from torque coils with the inertia from spinning reaction wheels.

The CubeSat standard does not provide for thrusters or other kinds of propulsion, and in any case, a launch provider would have to provide a waiver, due to the real or perceived threat the propulsion system could pose to the main payload, Young says.

Large value in small packages

Professors Jordi Puig-Suari of Cal Poly in San Luis Obispo, California, and Bob Twiggs of Stanford began working on the CubeSat design standard in 1999 and published it in 2000. Their goal was to make use of unused volume aboard rockets and to give students valuable satellite building and flying experiences. Puig-Suari and Twiggs settled on a design that would be small and simple enough to be built and launched within the constraints of the average curricula.

By establishing standard dimensions for the CubeSats and a common launch mechanism, engineers would avoid having to conduct a lot of unique engineering for each launch. They would collaborate and share development costs across universities, says Puig-Suari. The CubeSats were small and light enough that universities would be able to afford the launch fees, which run on the order of $80,000.

Today, about 100 CubeSats have been orbited since the first batch was launched in 2003 aboard a Rockot from Plesetsk, Russia. CubeSats are dispensed from canisters called P-PODs—poly-picosat orbital deployers—which are typically attached to the bottom of a rocket's upper stage. The cubes are compressed into the P-POD on a metal coil, so that when the door is opened they are automatically ejected. A single pod can carry up to three cubes, or one 30-cm-long satellite 10 cm on a side.

A miniature version of much larger, costlier facilities, NOVA enables small satellites to be tested affordably and with greater precision.

New tools, new attitude

To test the new breed of CubeSats, Young and Wassom plan to add a starfield simulator and a Stewart platform, a table that would swivel with the satellite attached to it to mimic changes in attitude relative to the stars.

The combination of those tools and the specialized mass table is a powerful one, the two say. Engineers of more complex missions need to be confident that their spacecraft can cope with orbital forces. "A satellite will naturally rotate based on perturbations based on drag in the atmosphere, or other things like that. There are gravity gradients that you get from Earth, so it will drift. And so the satellite has to be designed to correct for that drift in order to stay pointing in the direction it wants to point. And all of that requires you to know where the center of gravity is," Young says.

But for many CubeSats, the availability of a Sun simulator and Helmholtz cage was breakthrough enough. Spinning versions can be suspended by thread inside the cage or set on an air bearing atop a nonmagnetic pedestal. Electric coils generate a magnetic field to simulate conditions in space.

"The unique thing we believe we have in that Helmholtz cage is that it's a fully dynamic unit," Young explains. "Most of the coils we've read about in literature are just static magnetic fields. We have the controls and the electronics to rotate the magnetic field any way that's needed," he explains. "You can put the satellite in there on a stable, nonmagnetic platform and hold it really still and move the magnetic field around it."

The Helmholtz cage is particularly valuable for testing the performance of torque coils, which are the electromagnets that CubeSat operators rely on to change a satellite's attitude or prevent it from tumbling. "You run a current through the coil and it creates a magnetic field, and that field interacts with the magnetic field around the Earth," Young says. CubeSat operators "use that in order to have the forces that cause the rotation of the satellite."

Once the satellite is in the Helmholtz cage, the craft's onboard control algorithms can be tested. When things go well, the tests provide confidence that the craft's magnetometer is measuring Earth's magnetic field correctly and that the torque coils are receiving the proper commands, which might be to counteract or augment the force imparted by the surrounding magnetic field. "In addition to validating the performance of the components, you are validating the full, end-to-end system capabilities to make sure everything is working the way it's supposed to prior to launch. That philosophy is actually the reason we built the facility," Young says.

As for testing power systems, engineers can do a lot better than carrying the craft outside or putting it on a car dashboard. NOVA includes a test cell specifically for verifying the power output of CubeSat solar arrays, which are typically mounted flush on the satellite's surfaces. To simulate solar illumination, lamps are shone on the arrays, either separately or after they are installed on the CubeSat. That way, they can validate the entire electrical power assembly. The intensity of the illumination is measured by a pyranometer built to National Institute of Standards and Technology standards.

"You generate power from the light, then charge the batteries, run the system, and validate that everything in that system—all the algorithms, all the software, all the connections—are working. It's a similar concept to the attitude control, where we're validating the end-to-end system, or the individual components," says Young.

NOVA is a miniature version of the test facilities available for multibillion-dollar satellites, and one with a built-in growth plan. Says Young, "There's some infrastructure you need to have, and we haven't had it until NOVA."

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Fabrication techniques grow greener

It is no secret that a top aerospace industry goal is to make aircraft more fuel efficient and also friendlier to the environment. Stated less often is the industry's desire for greener manufacturing processes, and for less waste of the materials used in fabricating aircraft and space vehicles. Efficient recycling of these materials is also a growing concern.

Reducing costs is the key factor driving industry interest in making aerospace fabrication technologies more efficient. However, researching ways of achieving this can serendipitously make manufacturing processes greener as well.

Two avenues of fabrication research under way at NASA Langley show great promise not only for designing stronger and lighter aircraft, but also for helping to make manufacturing techniques much more environmentally friendly.

Electron beam freeform fabrication

One of these promising approaches is electron beam freeform fabrication (EBF3). This technique uses electron beam welding to create small melt pools from wire feeds of one or more alloys. Using 3D drawings of the component to be fabricated, computerized numerically controlled spray heads deposit the materials from the melt pools one layer at a time to create the part. The layers vary from about 20 one-thousandths of an inch to one-quarter of an inch, depending on what is required.

The technique is similar to 3D printing, except EBF3 is performed within a vacuum chamber to prevent attenuation of the electron beam. Any size chamber can be used, so the component being manufactured can be large: NASA Langley's current chamber measures 7x9x9 ft, so it can be used for building aircraft bulkheads.

Karen Taminger, who leads the EBF3 team within NASA's subsonic fixed-wing research program, says this method has several advantages over traditional metal component manufacturing techniques. One is that it does away with almost all the waste and recycling associated with milling or casting of metal parts.

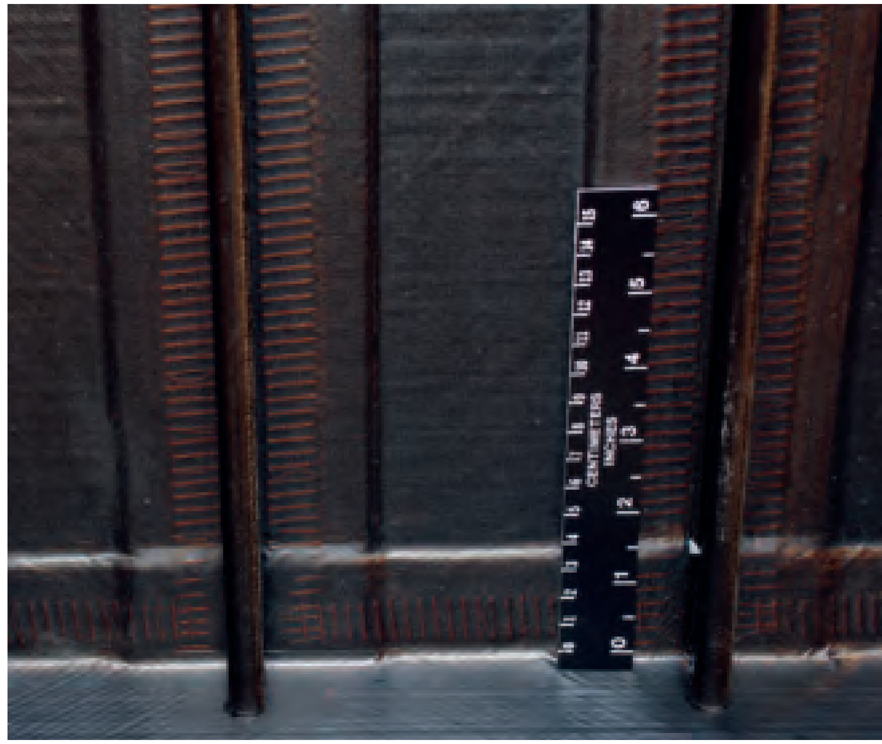
Today, she says, 'buy-to-build' ratios of 20:1 are common in the aerospace industry. Manufacturers begin with, say, a 6,000-lb solid billet of alloy to create a 300-lb part. The re-

A component being made by electron beam freeform fabrication is viewed through the heavy reflective glass of the EBF3 machine. Credit: NASA Langley/Sean Smith.

maining 95% must then be recycled, and all the cutting fluid used must be treated as hazardous waste. But EBF3 can make a 300-lb part from as little as 350 lb of alloy or metal. Its buy-to-build ratio is small, and far less electricity is used in manufacture.

Taminger says heat-treatment test data show titanium alloy parts made using EBF3 fabrication—from alloys such as Ti 6-4—have properties equivalent to forgings. The situation is trickier with aluminum plate alloys, but this has prompted NASA Langley to look at developing new aluminum alloys “that use the thermal history” of the fabrication process to produce “a crystalline structure giving the mechanical properties we desire.”

The small melt volume used at any one time, and EBF3’s ability to control precisely the deposition of alloy, allows Langley to control the microstructure of the alloys being laid down by changing the parameters of the process as needed. This ensures that tensional and bending strength properties are preserved equally throughout the entire component. In a part made using traditional casting, microstructure can vary, and properties are not constant throughout the component.



This PRSEUS panel was fabricated for a loads test. Credit: NASA Langley/Sean Smith.

EBF3 and alloys with gradients

As research continues, more exotic benefits are becoming apparent. One is the ability of the EBF3 process to take two wire feeds at the same time to create components that have different areas made from different alloys. Taminger says her team is working on using EBF3 to create parts with “functional gradients,” with different toughness and stiffness properties in different areas of the component. “We have already done some of the gradients,” she says.

One use for graded alloys could be in an integrated skin-and-rib structure, the skin featuring high toughness and the internal structures being graded for high stiffness. Taminger says the team plans the first demonstration of a functionally graded alloy part this summer and should have test data within two years. If experiments are successful, her team will have created integrated metal structures that do not require any fasteners—a big breakthrough.

EBF3 research is also looking to create parts into which structural fibers, fiber-optic lines, or sensors are integrated. This involves considerable technical challenge, particularly in shielding the structural fiber from the heat of the electron beam, and in being able to imprint over the top of the fiber without damaging it.

After obtaining surprising results testing Inconel 718, a nickel-based alloy used in engine hot sections, Taminger says Langley is even investigating ways that EBF3 fabrication might be able to ‘nudge’ some properties of alloys toward anisotropic behavior, such as increasing their modulus of elasticity. Normally, in polycrystalline alloys, the net result of crystal alignment is average and the alloy is isotropic in its properties. However, she says, “With single crystals, if you can orient them in a certain way, you can get low-modulus and high-modulus directions.”

Cracks in metal parts start at grain boundaries. Where a part has a hole machined in it, there is usually a grain boundary intersection. So the EBF3 team is trying to make grain boundaries surround holes instead, making cracking less likely.

Taminger believes design thinking must change if the industry is to take maximum advantage of the potential EBF3 fabrication offers. Its ability to create holes within an otherwise solid structure during fabrication would allow long, continuous passages for wiring, or precise geometries for cooling-air pathways in turbine blades.

EBF3 fabrication would allow now-solid components to be designed as hollow parts with trusses included to preserve load-bearing properties. Ultimately, Langley’s goal is to integrate two different components or systems within one piece—say, incorporating a heat exchanger within a solid bulkhead, or sensors within each layer of a part to allow real-time inspection.

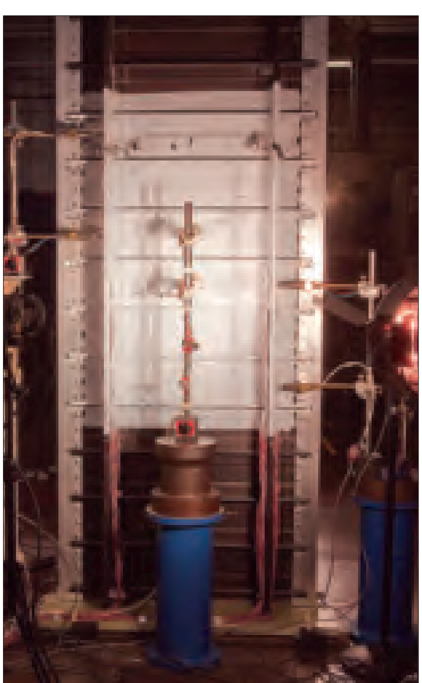
The first EBF3-fabricated component, a part installed in low-rate initial production Lockheed Martin F-35s, is undergoing certification with the Air Force and Navy. Taminger says, “I can see this [fabrication method] being five to 10 years away” for industry if the part is certified as fully equivalent.

PRSEUS

Another fabrication technique being studied at Langley, under NASA's Environmentally Responsible Aviation Project (ERAP), is PRSEUS (pultruded rod stitched efficient unitized structure). It focuses on carbon fiber composite and entails stitching together nine layers of dry composite material—placed on top of each other at angles differing by 45 deg—into a 'skin stack.'

This is then integrated with four other composite components to create a preform of a panel containing skin, longitudinal stiffeners, and latitudinal frames. In order of assembly, these other components include the frame cap stack, comprising strips of material stitched directly across the skin stack at 90 deg to provide a foundation for the frame stack. Next, running at 90 deg across the frame cap stack layer and along the top of the skin (in parallel with the skin's longitudinal axis) is the stringer center line, a layer of material on which the stringer rests.

The stringer itself is then laid down. Made from the same AS4 carbon fiber as the skin, the stringer is wrapped around a long, pultruded carbon rod. Last, laid across all the stringers are frame stacks, which are made from foam cores covered by the nine-ply skin material. Notches are cut out of the bottom of each frame at regular intervals to allow stringers to pass underneath.



The largest PRSEUS panel ever tested was put under extreme loads to determine some of its structural characteristics. The panel failed at 147,000 lb of pressure. Researchers had predicted it might withstand closer to 190,000 lb. Credit: NASA Langley/Sean Smith.

These components are stitched together, after which the preform is infused with resin by Boeing using its CAPRI out-of-autoclave, vacuum-assisted resin transfer molding process, and cured in an oven to create the thermoset panel.

Together with the Air Force Research Laboratory and Boeing, NASA has designed PRSEUS components for the fuselage of Boeing's ERAP design, a hybrid wing body (HWB). Since the fuselage would be flat-sided, handling the aircraft's interior pressurization would be a particular challenge for the PRSEUS structure, which would also have to handle tensional, stiffness, and impact loads.

Stitching: The vital factor

The key to PRSEUS is its stitching, which uses thread made of Vectran and relies on a two-needle head that does away with the need for a bobbin. The needles thread Vectran through all the skin layers and attach the various other components to the skin and to each other. The stitching technology originally came from East Germany and the heads are still made by a company located in the former Soviet satellite.

Dawn Jegley, a senior Langley aerospace engineer closely associated with PRSEUS, says the stitching has various crucial functions. First, it holds the entire assembly together before the resin is infused.

Second, it binds the layers of skin together so tightly and makes it so strong that far fewer layers of fabric can be used for the skin than would otherwise be required. The rule of thumb is that composite structures are 30% lighter than metal ones; and Jegley estimates the HWB's PRSEUS fuselage would be 10% lighter than a composite fuselage made from a conventional sandwich structure.

Third, the stitching eliminates the need for fasteners. "Even in the 787, there are a million fasteners," Jegley notes. "Fasteners are always a problem." Without them, aircraft skin does not have any sizable holes from which cracks can propagate, and the number of parts airlines need to hold in their spares inventories drops dramatically.

Fourth, the stitching creates an intensely strong and damage-tolerant structure. On impact, the stitching prevents delamination of the carbon fiber layers, and it also acts to stop cracks propagating. Jegley says that upon severe impact damage—such as a turbine blade hitting the skin—the stitching acts as a tear strap beyond which the crack will not run. Instead, it will turn back on itself, preventing the crack from propagating much more.

Langley is still researching why PRSEUS stitching acts to turn cracks around. But Jegley says even if impact damage were to cause stitches themselves to break, "there would have to be a very large area of damage" for the stitching to come apart. Repairs would be accomplished using a bolted metal or composite patch, to transfer loads from stiffeners to the patch.

After having first made small components, Jegley and her team graduated to flat panels, then to a curved panel (tested successfully at the FAA's William J. Hughes Technical Center) and next to a 4-ft cube. This spring they expect to complete the first panel of a 30x8x8-ft box that represents the center fuselage section of the Boeing HWB. This panel will be subjected to combined pressure-and-bending testing in Langley's Combined Loads Test System.

Jegley sees PRSEUS's major advantage as creating a lighter, stronger aircraft structure that would reduce fuel burn. But she also sees potential benefits in the damage tolerance of these structures—leading, perhaps, to a reduced need for recycling. Taminger's EBF3 work would minimize waste and energy use, but could also reduce aircraft weight and fuel burn. If both technologies are allowed to mature, aviation should become greener.

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Deconstructing the defense budget

The FY13 defense budget request reflects a new military strategy that shifts emphasis from Europe to the Middle East and Asia-Pacific theaters. The budget lowers spending significantly in some areas, as mandated by the Budget Control Act of 2010, but makes carefully chosen increases as well. Defense officials say the plan's new emphasis on modernization across the services will ensure "the most flexible, versatile, and technologically advanced platforms" needed over the long term.

by James W. Canan
Contributing writer

Early this year, the Obama administration issued guidelines for a new national defense strategy that breaks with the past by focusing less on Europe and more on the Asia-Pacific and Middle East theaters. In short order, the Pentagon brought forth a $613-billion FY13 defense budget that favors the weapons and forces best suited to putting its new strategy into play.

The budget is $45.3 billion lower than planned before fiscal austerity took hold throughout the government. It presages defense spending cuts of $259 billion over the next five years and of $487 billion over the next 10 years, as mandated by the Budget Control Act of 2011. It sets in motion substantial cuts for some weapons and forces, but also maintains or raises levels of spending on selected others (primarily those of the Air Force and Navy) that are synonymous with long-range projection of strategic firepower.

AIM-9X will receive a share of the funding for missile defense. Photo by Tom Reynolds.

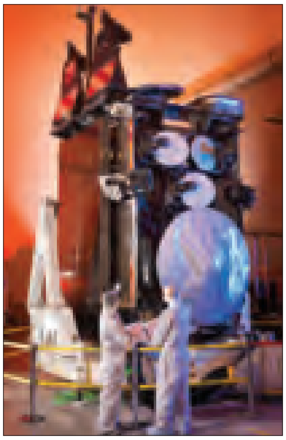
This means, among other things, that the tried-and-true nuclear triad of bombers, ICBMs, and sea-launched ballistic missiles will be sustained. For the foreseeable future, there will be enough money to preserve the Air Force's current fleet of B-2, B-52, and B-1 bombers and to proceed with development of the service's next-generation bomber.

Missiles and high-priority initiatives

Air-launched tactical air-to-air missiles account for $10.2 billion of the proposed expenditures. Funding will be shared among Raytheon advanced medium-range air-to-air missiles, AIM-9X heat-seeking air-to-air missiles, and joint standoff weapons; Lockheed Martin joint air-to-surface standoff missiles; and Boeing joint direct attack munitions and small-diameter bombs.

Proposed investments in DOD's 'high-priority initiatives' include $11.9 billion for science and technology, $9.7 billion for ballistic missile defense, $10.4 billion for special operations forces, $8 billion for space programs, $3.7 billion for unmanned air systems, $3.4 billion for new and improved cyber capabilities, and $1.8 billion for the Air Force/Boeing KC-46 tanker. Upgrading tactical sensors and other electronic warfare equipment will account for $1.8 billion.

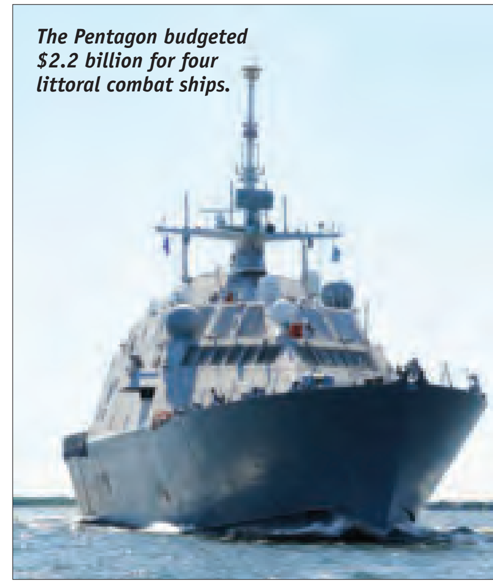
Funding for missile defense will include $778 million for Lockheed Martin's terminal high altitude area defense program, $903 million for the Boeing ground-



The budget calls for $786 million for the Lockheed advanced extremely high-frequency satellite program. Photo by Jim Dowdall.

based midcourse defense system, $763 million for 84 more Raytheon Patriot PAC-3 interceptor missiles, and $401 million for the medium extended air defense system.

Space systems and operations fare well in the FY13 budget, despite their spotty recent history of acquisition and cost problems. Their funding covers $1.7 billion for four United Launch Alliance EELVs, $1.3 billion for two Lockheed Martin GPS III satellites, $786 million for the Lockheed advanced extremely high frequency satellite program, and $950 million for the Lockheed space-based infrared system program. The only major space program to be axed is Northrop Grumman's defense weather satellite system, which DOD calls "premature" and extraneous for now "due to the availability of existing satellites."



The Pentagon budgeted $2.2 billion for four littoral combat ships.

Navy programs

The Navy, slated for a more prominent role in the new defense strategy, will come into enough money to sustain and upgrade its existing fleet of 11 aircraft carriers and 10 air wings, and its fleet of ballistic missile submarines (SSBNs). The sea service has budgeted $1.5 billion for Lockheed's Trident II ballistic missile program, and $320 million for 196 additional sea-launched Raytheon Tomahawk cruise missiles.

The Navy also will spend $100 million in FY13 to begin modifying its next and future Virginia-class cruise missile submarines to carry more land-attack missiles for non-nuclear inland strikes; develop a new SSBN-X submarine but stretch the program by two years; add one more ship to the current fleet of nine big-deck amphibious vessels; and develop a massive seagoing platform to serve as an "afloat staging base" for special operations forces; intelligence, surveillance, and reconnaissance (ISR) platforms; and countermine missions.

Plans for the seaborne staging base had been around but went nowhere until the Pentagon trained its sights more firmly on the Asia-Pacific theater. The base is designed to accommodate helicopters, Boeing tilt-rotor V-22 Osprey troop carriers, and STOVL strike fighters such as the Lockheed Martin F-35 variant being developed for the Marines. The new budget proposes funding 17 Ospreys for the Marines and four for the Air Force.

U.S. Marines board a V-22 Osprey aircraft at Control Base Karma in the Helmand province of Afghanistan. The new budget proposes funding 17 Ospreys for the Marines and four for the Air Force. Photo by Cpl. Lindsay L. Sayres USMC.

Carrier-based air power is clearly at a premium in Pentagon plans. "We've maintained the 11 carriers in the Navy in order to ensure that we have sufficient forward presence," Defense Secretary Leon Panetta told the Senate Armed Services Committee. "There's nothing like a carrier to be able to allow for quick deployment…and that will give us a great capacity to be able to show our force structure in the Pacific."

The Pentagon has budgeted $22.6 billion for new ships in FY13, including $3.5 billion for two Arleigh Burke-class destroyers, $2.2 billion for four littoral combat ships, and $966 million for the Navy's CVN 21 carrier replacement program. But the Navy will lose some ships, too, in the early retirement of seven cruisers and two outdated amphibious ships. Procurement of one Virginia-class submarine and two littoral combat ships will be deferred beyond the Pentagon's five-year-defense plan.

Operating in coastal waters, the littoral combat ships will be fast, with top speed of about 40 knots, lethal, and capable of performing such missions as antipiracy, antisubmarine warfare, and special operations. The Navy is negotiating with Singapore for permission to base two of these ships there at all times.

The Navy will invest amply in carrier-based air power. The service proposes to spend $2.2 billion for 26 Boeing F/A-18E/F Super Hornet fighters, $1.2 billion for five Northrop Grumman E-2D Hawkeye air control and reconnaissance systems, and $1.1 billion for 12 Boeing EA-18 Growler electronic warfare aircraft.

Overseas threats and the U.S. role

Separate from its mainline defense budget, the Pentagon is requesting $88.5 billion to support overseas contingency operations (OCO), primarily in Afghanistan—$26.6 billion less than the level of OCO expenditures for FY12. This reflects the withdrawal of U.S. combat troops from Iraq last December and the gradual reduction of U.S. military presence in Afghanistan.

The biggest, most immediate threats to U.S. interests are now said to be posed by nation-states in the Pacific and the Middle East, particularly North Korea and Iran. But China, thought to be heavily engaged in cyber espionage against the U.S. and other nations for some time, is regarded as perhaps the biggest potential long-term military threat in the vast Pacific theater.

Deputy Secretary of Defense Ashton Carter, speaking in early March, observed that "Asia-Pacific is a very dynamic region" and "is going to be…central to the world going forward." The U.S., he said, "has played a pivotal role in the Asia-Pacific region for decades," and has fostered peace and prosperity to many nations there, including China.

"That pivotal [U.S.] role is something we intend to maintain and sustain. So that's fundamentally the reason for being there," Carter declared.

Turning point

Following a decade of war and whopping annual increases in the defense budget, the Pentagon reviewed its operations and strategies last year to make its spending conform with the Budget Control Act. It did this also because, as Panetta said, the U.S. had come to "a strategic turning point" in recent history.

"We decided that it was important to make this an opportunity to develop a new defense strategy for the United States and for the U.S. military force that we wanted for the future," Panetta stated. He summarized the key elements of DOD's new strategy and priorities as follows:

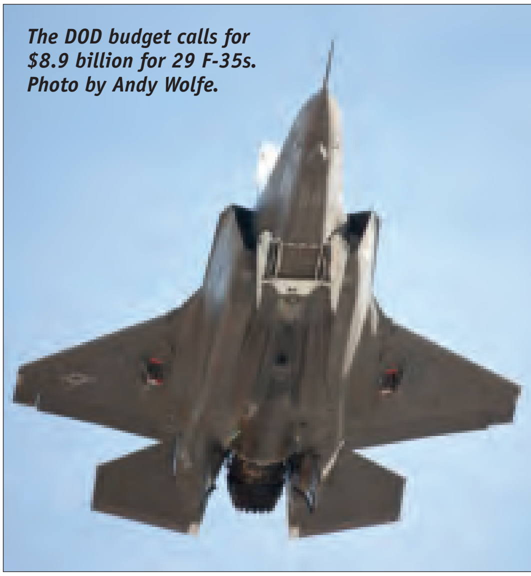
- We will ensure that we can quickly confront and defeat aggression from any adversary, any time, any place.
- The military will be smaller and leaner, but agile, flexible, rapidly deployable, and technologically advanced.
- U.S. global posture and presence will be rebalanced to emphasize the Asia-Pacific and Middle East regions, where the biggest problems and greatest threats are most likely to materialize.
- The U.S. will maintain its presence and power elsewhere in the world, notably in Europe, Africa, and Latin America, by strengthening alliances and developing new partnerships.
- The Pentagon will protect and prioritize key investments in technology and new capabilities, and will become increasingly able to mobilize forces and surge defense production as necessary.

"We committed ourselves not to hollow out the force, as has been done in the past," the defense secretary declared.

Far-ranging modernization

By and large, the proposed defense budget appears to foster the modernization of a wide range of weapons and other systems, despite cutting $25 billion, or 12%, from the

Marine Corps Sgt. Guillermo Floresmartines wades through a canal during a patrol around the villages of Sre Kala and Paygel in Helmand province, Afghanistan. The Pentagon is requesting $88.5 billion to support overseas contingency operations. Photo by Cpl. Alfred V. Lopez, USMC.



The DOD budget calls for $8.9 billion for 29 F-35s. Photo by Andy Wolfe.

Two A-10C Thunderbolt II aircraft pilots fly in formation during a training exercise. Older A-10s will be among the aircraft phased out over the next few years. USAF photo by Airman 1st Class Benjamin Wiseman.

total requested last year for this purpose. DOD is requesting $109 billion for procurement and $69.7 billion for R&D in FY13.

An Air Force white paper notes the importance of sustaining modernization while remaining able to afford it, noting that "perhaps the most significant challenge" facing the USAF "is our need to continue modernizing the force even as budgets decline." To meet this challenge, the paper says, "we are slowing the pace and scope of modernization while protecting programs critical to future warfighter needs."

Thus the Air Force will continue to focus its modernization investments on high-priority programs such as the F-35 JSF, the KC-46 air refueling tanker now in development, service-life extension of the F-16 fighter, space-based infrared and advanced EHF satellites, and enhancing space launch capability, the paper notes.

The Lockheed Martin F-35 is a standout program in the Pentagon's modernization budget, which proposes allocating $8.9 billion for 29 of the F-35s—19 for the Air Force and 10 for the Navy. This is widely regarded as a vote of confidence in the ultimate success of the F-35 program in general, but with caveats.

F-35 development and production is "too concurrent" and requires more time for testing, Panetta said. Thus the defense budget reflects a slowdown of F-35 procurement to allow for additional testing and developmental changes before the Pentagon puts the fighter into full-scale production and begins buying it in significant quantities.

Withal, the F-35 is "consistent with our strategy" and "remains essential for the future of our [air] superiority," Panetta declared. "We have to develop the next-generation fighter, and we will." Even so, the Pentagon proposes buying 179 fewer F-35s than previously planned, at a saving of roughly $15 billion, through the next five years. Procurement of the sidetracked 179 fighters is expected to take place further in the future, and the services may end up buying nearly 2,500 of the strike fighters all told, officials say.

"We want the airplane. We want all three variants," said Deputy Defense Secretary Carter. He observed that the STOVL variant of the F-35 had been put on probation because of cost and development problems but is now back in favor as "the result of some good engineering work done in the last year, and [this] means that all three variants can go forward," he said.

A different kind of threat: Sequestration

Sequestration casts a shadow over the Pentagon. It looms as the enforcer-in-waiting of the 2011 Budget Control Act, which requires a decrease of $1.2 trillion in federal spending over the next 10 years. If Congress fails to pass legislation overriding or deferring that requirement by next January 2, sequestration will automatically go into effect, triggering big spending cuts that top Pentagon and defense industry officials deem potentially disastrous to national security and the industry at large.

Sequestration would force the government to reduce nondefense discretionary spending by $750 billion and defense spending by $500 billion over the next 10 years—on top of the 10-year, $487-billion reduction already built into defense budgets through that period.

Conventional wisdom seems to be that sequestration will not be allowed to kick in because of its dire implications for national defense. Defense Secretary Leon Panetta said early this year that in drafting the defense budget he made no provision for possible sequestration because he trusted Congress not to let it take effect. But lawmakers seem unable to agree on a solution.

Tactical air and airlift cuts

Tactical air and airlift force structures take hits in the budget and will shrink in coming years. Over time, the Air Force will eliminate six of its 60 tactical air squadrons and one training squadron. Altogether, more than 280 Air Force aircraft will be phased out over the next five years, including 102 older A-10s and 21 older F-16s, as well as 133 air mobility transport and tanker planes—27 C-5As, 65 C-130s, 21 C-27s, and 20 KC-135s.

The administration's new strategic guidance "requires the joint force to be capable of fighting one large-scale, combined-arms campaign with sufficient combat power to also deny a second adversary," another Air Force document says. "The Air Force's approach to this new strategy is to retire fighter, mobility, and ISR [aircraft] that are beyond those needed to meet the capacity requirements of the new defense strategic guidance."

Despite substantial cuts of systems and forces, the USAF will remain fully capable of dominating air and space and providing rapid mobility, global striking power, and persistent ISR, its leaders say. "Although smaller, we will sustain global operations through our continuing presence in the Asia-Pacific and Middle East, while tailoring our presence in Europe," an Air Force budget paper proclaims.

Reduction of airlift assets was made possible by the proposed downsizing of Army and Marine Corps ground forces that rely on them for long- and short-range mobility. Those forces were earmarked for reduction because the large-scale, prolonged wars for which they were designed are seen as no longer likely.

The Army will eliminate at least eight brigade combat teams out of 65. The Marines will cut back to 35 combat battalions from 41, and will shed four of 20 tactical air squadrons. The active Army will shrink to 490,000 men and women from the current level of 562,000, and the Marines will shrink to 182,000 from 202,000.

ISR aircraft

As a result of the military drawdowns in Iraq and Afghanistan, the demand for remotely piloted ISR aircraft in all the services has dropped off, officials note. Reflecting this, 30 ISR platforms will be cut from the existing and planned ISR force, including 18 RQ4 Block 30 Global Hawk remotely piloted aircraft.

Air Force and DOD leaders concluded that the Northrop Block 30 Global Hawk had become too expensive and that the U-2 manned reconnaissance plane, which Global Hawk was designed to replace, is not only much cheaper but carries more capable sensors in some respects. Block 30 Global Hawks already in service or in production will be set aside but kept in shape for possible future operations.

An MQ-9 Reaper takes off from Joint Base Balad, Iraq. The Reaper, deployed from Creech AFB, flew its first combat mission over Iraq July 18. USAF photo/Senior Airman Julianne Showalter.

The budget also cuts back production of General Atomics Predator and Reaper UAS for ISR and land attack from 48 to 24 a year, but provides enough money to maintain the current level of UAS air patrols. The Pentagon proposes spending $1.9 billion to buy 43 Predators and Reapers in FY13.

Production of Global Hawk Block 40 aircraft will continue, because those ISR platforms are equipped with moving target indicators. These sensors are indispensable to the success of many ISR missions and are not carried by U-2s, explained Gen. Norton Schwartz, Air Force chief of staff, at an Air Force budget briefing.

The Air Force "generally maintained, and in some areas increased, our levels of investment" in ISR, said Schwartz. For the most part, "existing ISR inventories will remain as they are," he noted.

BRACs, special ops, Army aircraft

Force structure cuts will enable the services to consolidate their infrastructures, Pentagon officials note. As a result, DOD is asking Congress to approve two more rounds of Base Realignment and Closure proceedings, one in 2013 and the other in 2015. This proposal almost certainly will run into fierce resistance on Capitol Hill.

In contrast to conventional forces, special operations will benefit markedly from the FY13 budget and those to follow. Funding for special ops will increase substantially in the face of the terrorism threat, especially in the Middle East.

"As successful as we've been in confronting [terrorism], we continue to see that

A UH-60 Blackhawk helicopter takes off for the skies from Forward Operating Base Wolverine, Shinkai, Afghanistan. Photo by Staff Sgt. Sadie E. Bleistein.

challenge, whether it's in the FATA [Federally Administered Tribal Areas] of Pakistan or Yemen or Somalia or elsewhere," Panetta said. "So we're going to have to continue to confront the threat of terrorism."

Army leaders say their service's budget shows a commitment to aircraft modernization: Proposed spending for helicopters and fixed-wing unmanned and manned aircraft totals $6.3 billion. The figure is only $158 million less than last year's request and reflects the highest demand for aviation assets since 2001, say officials.

Three helicopter production programs, for Sikorsky Black Hawks and for Boeing Chinooks and Apaches, will receive a combined $3.8 billion. The Army also proposes to spend $518 million for 19 additional Gray Eagle systems that will enable the service to equip two more companies—a total of 19—with those unmanned systems.

The defense budget for fiscal year 2013 "seeks to retain the most flexible, versatile, and technologically advanced platforms that we will need in the future," Panetta said. "That involves unmanned systems, satellites, submarines, helicopters, aircraft carriers, and fifth-generation aircraft." The Pentagon gives high priority to "multimission weaponry and technology that can support…an agile and ready force," said the defense secretary.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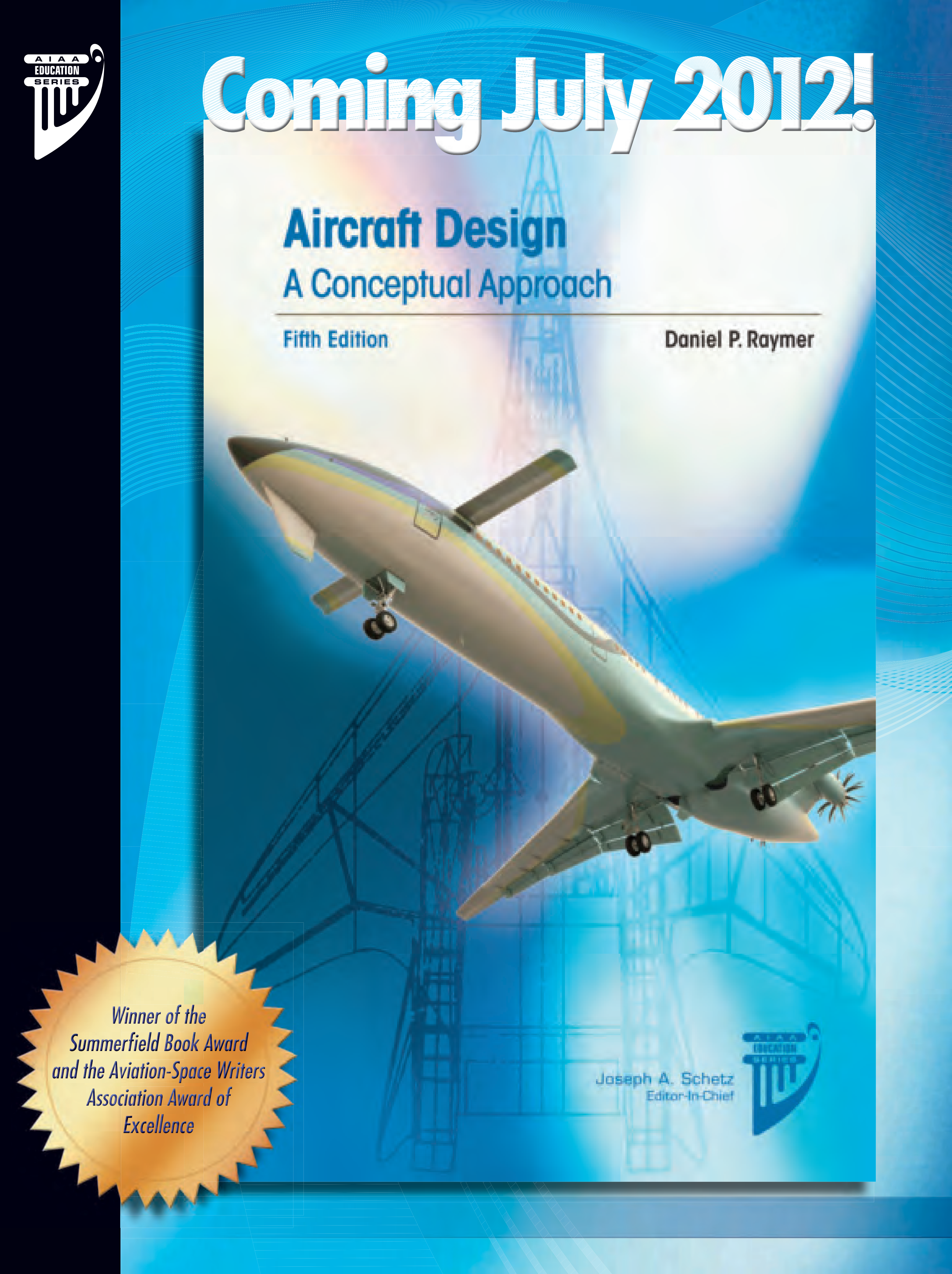
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Air-breathing propulsion technologies for hypersonic vehicles, despite inconsistent support and slow maturation, are finally within our grasp. Stable government funding for R&D to advance these technologies will be essential to developing future aerospace systems. It will also revitalize a workforce where technical expertise has eroded in recent decades and ensure preservation of the nation's critical industrial base.

National hypersonic centers: Fast track to truly fast flight

by Dora Musielak
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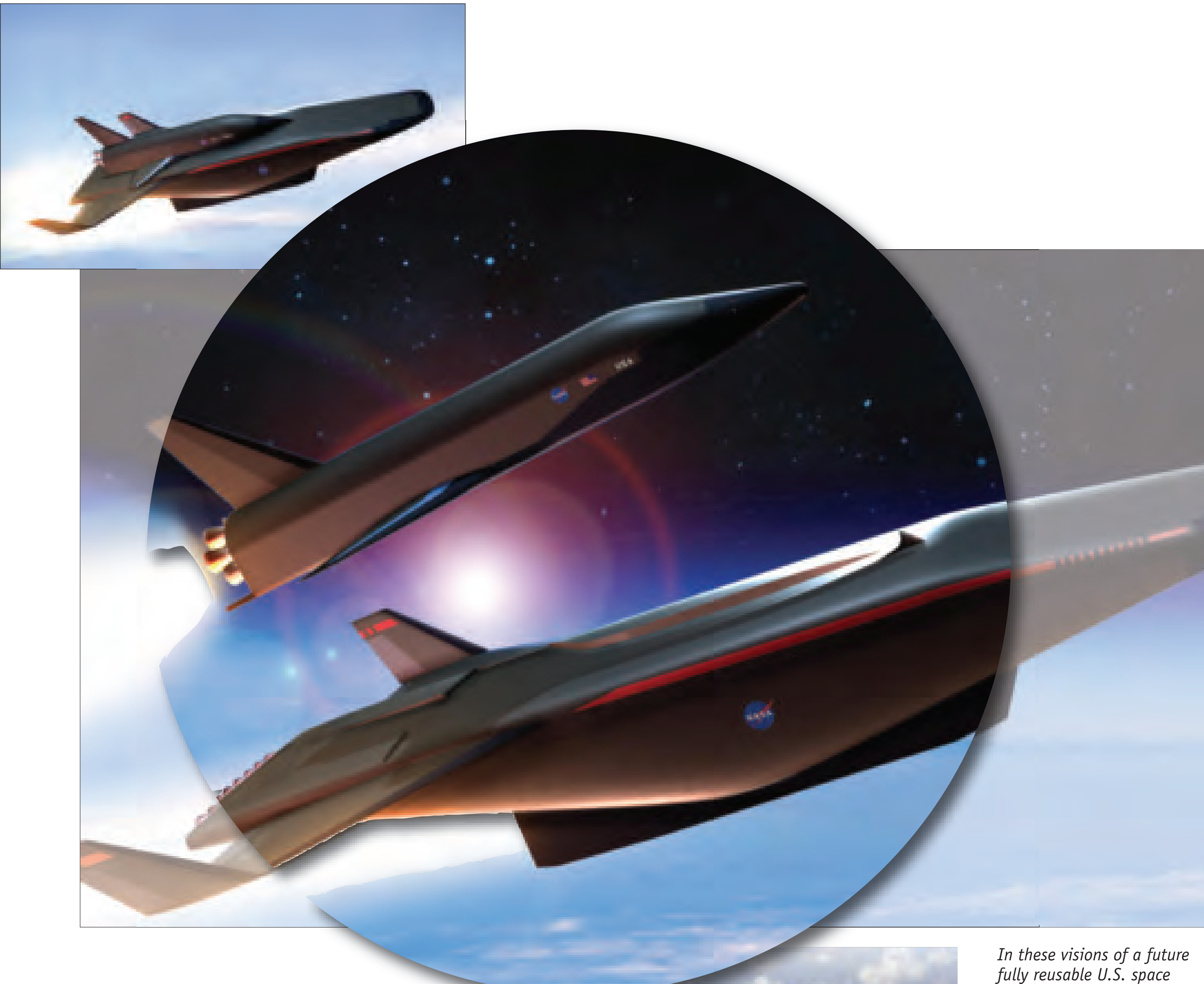
Flying across the globe in a few hours and routinely accessing space with reusable vehicles may seem like a futuristic dream, but innovative research at the three National Hypersonic Science Centers promises to bring truly fast flight closer to reality.

To hasten fundamental research in high-speed air-breathing propulsion, NASA and the Air Force funded the centers in 2008. The multiinstitution consortia are currently making strides toward improving our understanding of hypersonic flight, combining the efforts of academia and industry to facilitate greater advances. Leading researchers are confident that this work will boost technology development.

In the past few decades DOD and NASA, with industry support, have made significant progress in high-speed air-breathing propulsion. With the X-43A NASA achieved the first hypersonic flight in 2004 when the vehicle, powered by a hydrogen-fueled scramjet, zoomed to Mach 6.8; months later it soared at Mach 9.8 for 12 sec. In May 2010, the X-51A Waverider flew at Mach 5 for over 3 min, propelled by a JP-7-fueled SJY61 scramjet engine built by Pratt & Whitney Rocketdyne. A second flight did not reach its test goal. The X-51A is a hypersonic flight test demonstrator for the Air Force, intended as a fighter aircraft.

The scramjet must be integrated with a low-speed propulsion cycle to build a truly revolutionary air-breathing engine. Building such a complex, fast vehicle, be it a reusable spaceplane or an aircraft that can circle the globe in a few hours, requires solving very difficult technology challenges. In 2008, the Air Force Laboratory's Office of Scientific Research (AFOSR), NASA, and the National Nuclear Security Administration



In these visions of a future fully reusable U.S. space transportation system, the first stage is a hypersonic aircraft that uses air-breathing scramjet propulsion. The second stage uses conventional rocket propulsion to achieve orbital velocities. Courtesy NASA Langley.

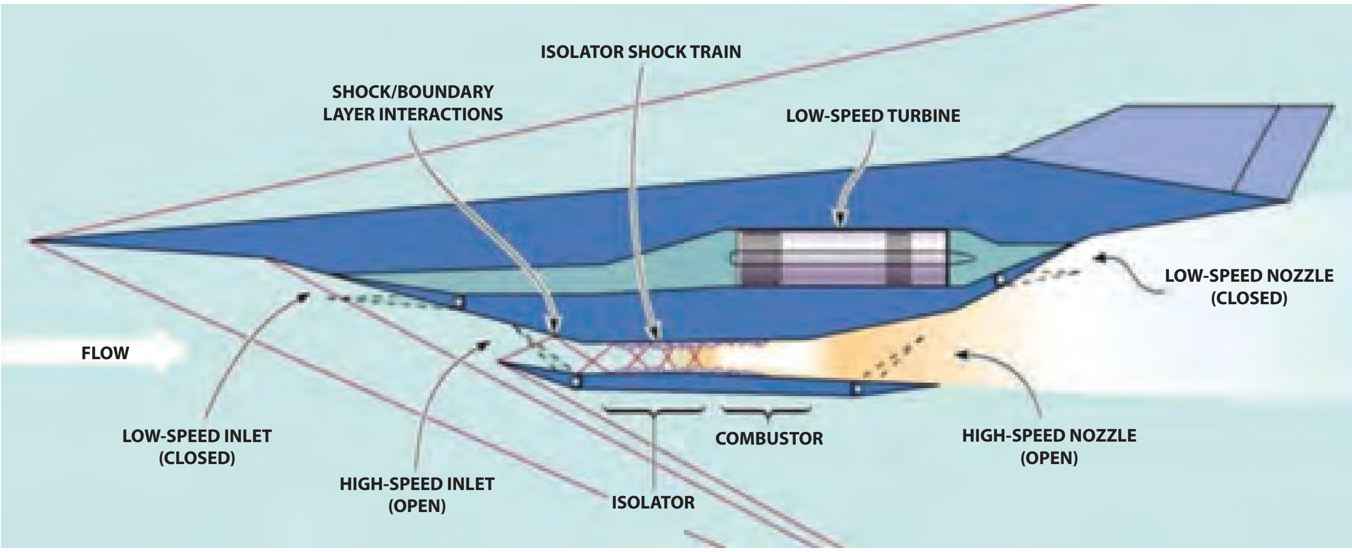
conceived the National Hypersonic Foundational Research Plan (NHFRP) to facilitate coordination of research across agencies.

The plan identified critical technologies that must be matured to technical readiness level, or TRL, 6-7 (meaning there has been a system/subsystems prototype evaluation in a relevant/operating environment). Critical technologies include high-speed air-breathing engines able to withstand repeated cycles of severe temperatures, and materials and structures capable of surviving extreme flight environments.

As part of the NHFRP, three university/industry groups in California, Texas, and Virginia were established to advance research in those critical areas. According to James L. Pittman, NASA Hypersonics project manager, "NASA's partnership with AFOSR for the National Hypersonic Science Centers is important to the future of the nation's hypersonic research. Investments in high-speed technologies, including high-temperature materials, boundary-layer transition, and air-breathing propulsion, are crucial to the future of space access and air transportation." A total of $30 million was set aside to fund the centers for five years.

Key enabling technology

Combined-cycle propulsion is an enabling technology that will facilitate low-cost access to space and revolutionize long-range cruise, high-speed flight. Why combined cycles? No propulsion concept alone can provide efficient performance over the range of Mach numbers from takeoff to hypersonic flight. Although rockets alone can



One concept is the turbine-based combined-cycle engine. Source: NASA Langley.

propel a vehicle to space, their specific impulse is considerably lower than that of any air-breathing propulsion concept and requires heavy oxidizer tanks.

On the other hand, air-breathing engines are better for flight through the atmosphere. At Mach 3 the ramjet becomes more efficient in comparison with turbine engines, but beyond Mach 5 its specific impulse decays rapidly. In the Mach 5-12 range, the scramjet delivers a higher specific impulse, and can function as ramjet/scramjet and seamlessly make the transition between the two. As the Mach number increases beyond Mach 15, an engine can switch to rocket mode.

Two basic concepts are rocket-based combined-cycle (RBCC) and turbine-based combined-cycle (TBCC) propulsion. Both configurations can switch between different modes to achieve maximum performance. The RBCC engine can operate in ramjet, scramjet, and rocket-only modes. The TBCC engine integrates a turbojet and ramjet/scramjet that share parts of the flowpath. Most TBCC designs use variable geometry inlet and nozzles that can fully close to seal off either engine. The TBCC is intended primarily for missions involving high-speed cruise in the atmosphere, while the RBCC is for Earth-to-orbit (ETO) applications.

The primary objective of the National Center for Hypersonic Combined Cycle Propulsion (NCHCCP), located at the University of Virginia (UVa), is to advance understanding of the critical mode transitions of combined-cycle propulsion. Under the direction of James C. McDaniel Jr., professor at UVa, the NCHCCP leads teams at seven universities, ATK GASL, the National Institute of Standards and Technology, and Boeing. "Both the RBCC and the TBCC could provide the first stage of a two-stage-to-orbit vehicle, so either combined-cycle engine could be used for ETO vehicles," says McDaniel.

A challenge for TBCC concepts is the transition from one engine to the other. This requires large ground-based test facilities that can accommodate a dual propulsion flowpath vehicle, and longer test times than scramjet-only tests to allow time for the turbine hardware to spool up and/or down. According to James Edwards, professor at North Carolina State University and leading researcher at NCHCCP, "Next-generation hypersonic vehicles will be much larger in size and will be very difficult to test in existing wind tunnels." He believes computational methods will play a more important role in the design and analysis of these vehicles, requiring development and validation of highly accurate techniques to simulate the complex flows as well as to gather comprehensive experimental databases to anchor the models.

Critical mode transitions

"Conducting a scientifically based approach to achieving optimal design and performance is an essential first step to develop a rational design strategy for combined-cycle engines," says McDaniel. He emphasizes that research is vital to resolving these critical mode transitions of combined-cycle propulsion:

• ***Turbine/ramjet transition.*** One design challenge is to transition seamlessly between

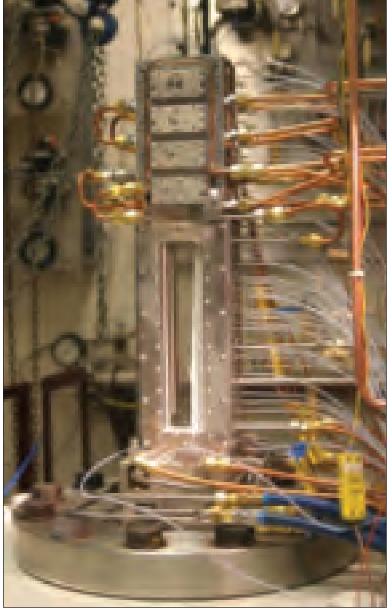
IMPORTANT HYPERSONIC TECHNOLOGY PROGRAMS WORLDWIDE

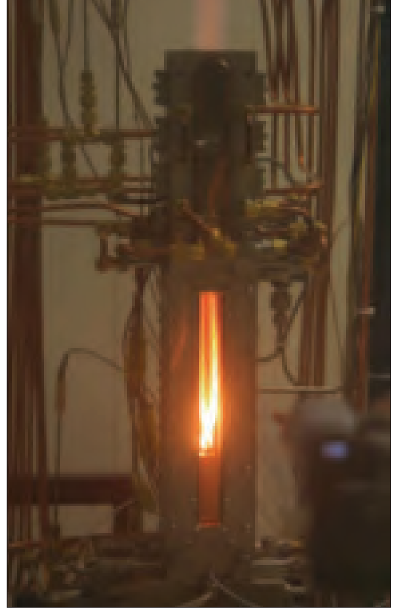
Nation	*Program*	*Emphasis*	*Status*
Australia/U.S.	HIFiRE	Flight test of a scramjet using a Terrier-Orion sounding rocket to develop and validate scramjet technologies.	Second HIFiRE hypersonic test flight was on March 22, 2010.
Brazil	14X	Mach-6 hypersonic UAV propelled by H2 scramjet engine. Intended for access to space.	Being tested in T3 Brazilian air force hypersonic wind tunnel.
England	SABRE	Precooled air-breathing/rocket combined-cycle engine for Mach 5-25 [SSTO].	Proof-of-concept. Ground test of subscale engine to demonstrate engine cycle for entire flight regime.
France	LEA	Development of experimental vehicle propelled by dual-mode ram/scramjet engine to fly at Mach 10-12.	Scheduled to terminate in 2015 after four flight tests.
U.S.	X-51	Unmanned Mach-7, JP-7-fueled scramjet demonstrator. Second attempt in 2011.	First successful flight test May 2010. Two more flights are planned.

the low- and high-speed engines as the vehicle accelerates. A key component is the inlet, which must function in a true combined cycle, allowing smooth transition from low- to high-speed operation through the flight, as if the aircraft had one engine. Unstart of the inlet can occur and, during transition, can cause unstart of the high-speed inlet. Such unstart can be controlled by wall bleeding, but modeling bleed is difficult. An immersed boundary technique was developed to simulate the flow through bleed passages in the inlet. Researchers will use data from NASA Glenn's dual inlet mode transition rigs to advance understanding of this important mode transition.

• *Ramjet/scramjet transition.* In the Mach 4-6 regime, when the TBCC engine switches from ram to scramjet operation, it transitions from subsonic to supersonic combustion. The isolator flow field contains multiple shock reflections, with complex shock/boundary-layer interactions. As the flight Mach number increases beyond 6, the precombustion shock train moves out of the isolator and the engine operates in the full supersonic combustion scramjet mode. To study these flow processes, researchers conduct experiments in a direct connect scramjet operated at Mach 5 enthalpy using the UVa Supersonic Combustion Facility, a dual-mode combustion wind tunnel. Hydrogen-air combustion tests are performed at conditions in which the reaction transi-

A combined-cycle engine inlet was tested in the NASA Glenn 10x10-ft Supersonic Wind Tunnel. Source: NASA.





The UVa Supersonic Combustion Facility is a dual-mode combustion wind tunnel built for research at the National Center for Hypersonic Combined Cycle Propulsion.

tions from ram to scramjet mode. Advanced laser-based flow-field diagnostics provide data to benchmark computational models.

• ***Hypervelocity regime.*** The hypervelocity regime features intense shock-boundary-layer interactions and mixing that is diffusion-limited due to the very high freestream velocities. Researchers at the NCHCCP conduct experiments in the NASA HYPULSE shock tunnel at ATK GASL to study supersonic combustion and provide data for CFD validation over a range of enthalpy levels (Mach 5, 7, and 10) in which the flow physics is better quantified.

To advance computational tools, Edwards envisions the eventual replacement of Generation I modeling strategies (RANS, or Reynolds-averaged Navier-Stokes), first with Generation II LES (large-eddy simulation)/RANS methods (with RANS modeling used to account for near-surface turbulence) and eventually with LES as computer power increases. "Our work," he explains, "is directed toward developing a tip-to-tail Generation II simulation strategy, augmented with advanced closures for turbulence/chemistry interactions."

Hypersonic materials and structures

At hypersonic speeds exceeding Mach 5, the friction created by air resistance can literally destroy a structure, as the high surface temperatures cause large thermal stresses and rapid ablation of the materials. Heating is most severe at the inlet cowl lip, vehicle nose, and wing leading edges. This heat transfer is magnified inside the engine because of combustion.

A hypersonic vehicle must operate in this stressing aerothermal environment for prolonged periods, exposed to both oxidizing and reducing conditions. At the same time it must be capable of surviving flight vibration. According to NASA Langley scientist David E. Glass, sustained hypersonic flight imposes extreme heat fluxes and heat loads that vary according to their location on the vehicle. Temperatures range from levels that can be sustained by current materials to those that cannot, even for brief times. The X-51A, a scramjet technology demonstrator not intended for long flight, is made of standard aerospace materials such as aluminum, steel, inconel, and titanium. It uses carbon/carbon composites on the leading edges and cowls, and a silica-based thermal protection system (TPS) with reusable insulation tiles.

According to Dave Marshall, leading researcher at Teledyne Scientific & Imaging, "Development of high-temperature materials and structures at affordable cost and the ability to predict their reliability are crucial for realizing future hypersonic vehicles." With its multiinstitution consortium, Teledyne is designated the National Hypersonic Science Center for Materials and Structures. The research at NHSC-MS aims to overcome the limitations of two classes of materials that could make a dramatic difference in enabling hypersonic flight: high-temperature diborides and ceramic composites. High-temperature diborides have the best combination of high melting point and high thermal conductivity needed for sharp leading edges. Development focuses on improving oxidation resistance of these materials and understanding oxidation pathways.

Researchers are developing textile-based CMCs, establishing a capability for forming integral structures that can satisfy the demands of a wide range of severe thermomechanical environments. Ceramic composites have the best combination of high strength/weight ratio at high temperature. For example, Si-Ti-C-O fiber-bonded ceramic material exhibits excellent durability at 1,500 C in air, because a protective oxide layer is formed on the surface at a high temperature.

However, Marshall states that performance is constrained: Surface temperatures remain limited to the range of about 1,400-1,600 C, whereas higher temperature capability is desirable for durability, especially in regions susceptible to heat spikes from shock interactions or combustion instabilities. He adds that high thermal gradients cause microcracking, oxidation limits life (especially at the highest use temperatures), and dimensional control, including feature shapes and surface smoothness, needs to be improved and extended to matrix materials with higher temperature capability.

Also, hypersonic vehicles will spend most of their flight at conditions where the flow will be transitional. Laminar-turbulent transition strongly affects critical aerodynamic quantities such as the drag and wall heat flux. For example, the heating rates generated by a turbulent boundary may be several times higher than those for a laminar boundary layer. At hypersonic speeds, the boundary layer tends to thicken and become more resistant to disturbances. The design goal is to maintain a laminar boundary layer for as long as possible to minimize heating and thus reduce TPS requirements. However, there are still many pathways to transition, even at very high Mach numbers. Knowing the location where transition occurs is therefore essential.

Researchers at the National Center for Hypersonic Laminar-Turbulent Transition at Texas A&M explore instability-mode competition, receptivity, and the influence of thermochemical nonequilibrium, surface chemistry, ablation, and surface roughness. These problems are interrelated, and a systemic approach to prediction and control will integrate them over time.

Ensuring future progress

Hypersonic technologies play a key role in the development of aerospace systems whether they are cruise aircraft or space launchers. The military needs to get to a target faster (global engagement) and the commercial sector desires to take payloads into space more cheaply and reliably. Not only the U.S. but also England, France, Germany, Australia, Brazil, India, Japan, and Russia are working briskly to advance air-breathing hypersonic propulsion technology. Most of the programs focus on scramjet engines. The only exception is England, where Reaction Engines is developing a hybrid air-breathing rocket engine. SABRE (synergistic air-breathing rocket engine) combines the cycles of a precooled jet engine, a ramjet, and a rocket engine to propel Skylon, a reusable single-stage-to-orbit spaceplane. (See "Hypersonic transport… 30 years and holding?" May, page 40.)

Hypersonic technology could be the deciding factor in the global competition for superior aerospace capability. By building a new market in hypersonics the U.S. can continue to look forward to larger aeronautic trade surpluses. Leading the world in hypersonics flight capability is key to maintaining aerospace competitiveness. We must stay ahead not by just a few years, but by many years more.

Hypersonic technologies have been slow to mature. The volatile history of U.S. hypersonic system development, which has resulted in a long-term erosion of the skill base, is partially to blame, but the chief stumbling block has been the lack of sustained funding to support a unified commitment to future aerospace systems.

According to Marshall, "funding in hypersonics is not adequate and is subject to fluctuations—this makes it difficult to maintain a vibrant community that will attract top students to the field." It also makes it harder to sustain the workforce and its expertise. The centers are funded at $2 million a year for five years. McDaniel believes that "this level of funding is essential to bringing together a team of experts" capable of advancing the TBCC to TRL 6-7 in the future.

It is vital that the U.S. government continue to provide stable funding for R&D to advance key areas such as combined-cycle propulsion. Such a commitment will ensure preservation of the industrial base. Phil Drummond, NASA Langley Distinguished Research Associate, emphasizes that "the centers provide two very significant contributions to the field of hypersonics. They bring innovative approaches needed for further development of hypersonic vehicles and bring an influx of new scientists and engineers into a field that has declined significantly in recent years. It's a 'win-win' situation, because these new people bring the innovative approaches with them!" he says.

The centers develop physics-based integrated multidisciplinary design tools to help mature technologies that would enable air-breathing sustained cruise aircraft and access to space. A new generation of engineers trained in hypersonic air-breathing propulsion and materials research is another important outcome.

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Development of operational hypersonic vehicles powered by air-breathing engines is now within our grasp. Thus it is imperative that the U.S. government continue to provide stable funding for R&D to advance these technologies. Such commitment will ensure the preservation of critical industrial base and ground test infrastructure for transition to future aerospace systems.

25 Years Ago

June 21 Air France pilot Patrick Fourticq and racing driver Henri Pescarolo complete a round-the-world flight in 88 hr 19 min, landing their Lockheed 18 at Le Bourget. This beats by 3 hr the record set by Howard Hughes in 1938 with almost the same type of aircraft. B. Gunston, *Aviation Year by Year*, p. 820.

50 Years Ago, June 1962

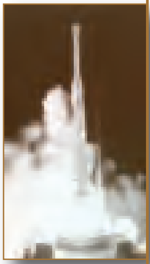
June 5 The Sikorsky S-64 Skycrane makes its first public demonstration, lifting an 8x20-ft truck-trailer. *The Aeroplane*, June 7, 1962, p. 20.

June 7 An 85-ft steerable radio telescope, built by Philco for the Office of Naval Research, is dedicated at Hat Creek, California. *Missiles and Rockets*, June 18, 1962, p. 11.

June 7 A Boeing B-52H using eight Pratt & Whitney TF33 fan engines sets a new distance record for a closed circuit without refueling. The aircraft lands at Seymour Johnson AFB, N.C., after covering a distance of 11,420 mi. in 22 hr 38 min. *Flight International*, June 14, 1962, p. 922.

June 7 A joint U.S.-Pakistan program of upper atmospheric research by sounding rockets begins with the launch of a Nike-Cajun rocket named Rehbar 1 at a site near Karachi. The rocket carries a sodium vapor experiment to measure upper atmosphere winds. *Flight International*, June 28, 1962, p. 1030.

June 9 Aerojet-General successfully static fires its 700,000-lb-thrust segmented solid-fuel rocket motor. The motor contains 159 tons of segmented propellant that is 79 ft long. This is a new record for large solid-fuel motors. *Missiles and Rockets*, June 18, 1962, pp. 10, 15.



June 10 The Telstar 1 communications satellite is launched by a Thor-Delta rocket from Cape Canaveral, Fla., and successfully relays through space the first TV pictures, telephone calls, fax images, and live transatlantic TV feed. *Interavia*, Aug. 8, 1962, p. 956.

June 15 El Al begins Boeing 720B services between Tel Aviv and Johannesburg, South Africa, via Nairobi. El Al is the second 720B operator to begin flights into South Africa since Lufthansa inaugurated its service a month earlier, on May 15. *The Aeroplane*, June 28, 1962, p. 10.

June 16 The Navy commissions its first submarine tender designed to support the Polaris fleet ballistic missile system, and the first Navy tender produced since WW II. Named the Hunley after Civil War-era submarine designer H.L. Hunley, the tender will be used to repair Polaris-firing subs and to serve and maintain their nuclear powerplants. *Missiles and Rockets*, June 25, 1962, p. 11.

June 19 A Thor-Delta places the Tiros 5 weather satellite into orbit. Launched at a higher inclination than the first four in the Tiros series, the satellite carries equipment designed to keep it operational longer. However, it operates for the same length of time as Tiros 4, 161 days. *Aviation Week*, June 25, 1962, p. 30.

June 29 The first all-solid-fuel Minuteman ICBM launched by a military crew from an underground silo takes off at Cape Canaveral, Fla., and reaches its target area 2,300 mi. downrange. D. Daso, *U.S. Air Force: A Complete History*, p. 429.

And During June 1962

—The first Pershing missile battalion of the Army is activated at Fort Sill, Okla. Called the 2nd Missile Battalion (Pershing), 44th Artillery, it consists of 615 men. The solid-fuel two-stage missile, with a range of more than 400 mi., replaces the 150-mi.-range Redstone. *Missiles and Rockets*, June 25, 1963, p. 23.

—Argentina's new turboprop airliner, the Guarani 1, begins flight testing, it is announced. Built by the state-controlled DINFIA factory at Córdoba, the 10-15-seat plane has two 850-hp Turboméca Bastan IIIA engines. *The Aeroplane*, June 7, 1962, p. 20.

75 Years Ago, June 1937

June 1 Amelia Earhart, the world's most celebrated woman pilot, begins a round-the-world flight, with Frederick J. Noonan as her navigator. They take off from Miami in a Lockheed Electra and by June 29 arrive in Lae, New Guinea. Earhart was the first woman to fly the Atlantic, having accompanied Wilmer Stultz and Louis Gordon in 1928. In 1932 she became the first woman to fly the Atlantic solo, doing so in record time, and in 1935 she

Past

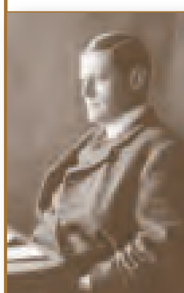
An Aerospace Chronology
by **Frank H. Winter**
and **Robert van der Linden**

was the first woman to fly the Pacific, crossing from Hawaii to California. Amelia Earhart folder, National Air and Space Museum.

June 11 Reginald Joseph Mitchell, chief designer at Britain's Supermarine Aviation Works, dies at age 42. His greatest achievement was the Spitfire, a low-wing, single-seat fighter that will see brilliant service during WW II. He joined Supermarine in 1916 and became chief designer in 1920, designing machines for the Norwegian, Swedish, and Portuguese navies and special trainers for the Japanese navy. His first great success with speed machines was the S.4, which won the Schneider Trophy for Italy in 1925. *The Aeroplane*, June 16, 1937, p. 718.

June 12 Sir Shenton Thomas, the governor of Singapore, opens the new civil airport at Kallang. Thomas arrived from Seletar in an Imperial Airways liner, making the first official landing. He is escorted by 40 planes, including three Martin bombers of the Netherlands East Indies air force, three Fokker flying boats from Surabaya, RAF planes, machines from Malayan flying clubs, and the only Autogiro in the country. *The Aeroplane*, June 16, 1937, p. 738.

June 17-20 A Soviet ANT-25, piloted by Valerie Chkalov, with Georgi Baidukov as copilot and Alexander Belyakov as navigator, lands at Vancouver, Wash., completing the first flight from the European continent to the North American continent via the North Pole. They make the nonstop 5,573-mi. trip from Moscow in 63 hr 17 min. They claim to have crossed the North Pole at 14,000 ft. *Aircraft Year Book, 1938*, p. 410.



June 22 Sir Eric Campbell Geddes dies at age 62. During WW I, his great managerial abilities were discovered by Prime Minister Lloyd George, and from then on Geddes assumed top-level governmental and military posts. He was knighted for services as deputy director general of munitions supply, a post he held in 1915-1917. In 1918 he was a member of the War Cabinet. Upon the formation of Imperial Airways, Geddes was named chairman and helped to make it one of the world's leading airlines. *The Aeroplane*, June 30, 1937, p. 789.

June 24 German pilot Ewald Rohlfs sets five helicopter records in a Focke Wulf Fw 61 VI. The records include duration with return to the departure point, 1 hr 20 min; distance in a straight line, 10 mi.; distance in a closed circuit, 50 mi.; speed over 12.4 mi., 76 mph; and altitude, 8,000 ft. A. van Hoorebeeck, *La Conquete de 1'Air*, p. 299.

June 24-25 Richard Archbold, his pilot Russell Rogers, and four others complete the first transcontinental trip in a flying boat. Departing from San Diego in a Consolidated PBY-1 Catalina, they reach New York in 17 hr 3.5 min. A. van Hoorebeeck, *La Conquete de 1'Air*, p. 299.

June 30 Britain recaptures the world altitude record when Flight Lt. Maurice James Adam climbs to 53,937 ft at South Farnborough in a Bristol 138. *Aircraft Year Book, 1938*, p. 410.

June 30 The Navy issues a contract to Martin for the XPBM-1 flying boat, the initial prototype for the PBM Mariner series used during and after WW II. E. Emme, ed., *Aeronautics and Astronautics 1915-60*, p. 35.

100 Years Ago, June 1912

June 1 Norwegian pilot Lt. Hans Dons makes Norway's first airplane flight, in a Rumpler Taube monoplane. Accompanying Dons is Capt. Tank Neilsen. R. Hallion, *Taking Flight*, p. 282.

And During June 1912

—The French navy tests Voisin hydro-aeroplanes at St. Raphael, France. At the same time, the British Royal Navy tests Henry Farman's hydro biplane. By late July, the Japanese government orders three hydroplanes from Curtiss Aeroplane and by September is also testing a French Farman hydroplane. Other countries also experiment with such planes or seek to acquire them. *Flight*, June 15, 1912, p. 543; Aug. 3, 1912, p. 711; Sept. 1912, p. 881.

Vice President Education and Outreach

The National Institute of Aerospace (NIA) is currently seeking a visionary and accomplished leader to serve as Vice President of Education and Outreach. An officer of the corporation, the Vice President of Education and Outreach (E&O) is a key contributor to the success and development of the institute, is directly responsible for the educational and outreach programs of the institute, and directs efforts to strategically map out further development of the institute's E&O programs.

The Vice President of E&O has overall responsibility for implementing the institute's graduate program, classroom operations and distance learning, continuing education program, curriculum development, post doctoral program, teacher professional development, student intern programs and competitions, and educational outreach. Will also interact and collaborate with Deans of Engineering and relevant Department Chairs at NIA member universities and is responsible for business development in area of education and outreach.

The successful candidate will have excellent executive leadership skills, solid faculty experience and strong university relations, and experience in developing new formal and informal programs and in securing grants. Prior experience in higher education administration and developing and utilizing emerging and innovative distant learning methods is desired. A PhD in engineering or the sciences or closely related field and graduate-level teaching experience is highly desired. Familiarity with government-sponsored programs at agencies including NASA, DoD, NOAA, FAA, DHS, DoE, and NSF is essential.

Interested candidates should apply via NIA's career opportunities site located at www.nianet.org under the 'About NIA' tab. Please include a letter of introduction, resume, and the names and contact information of three current references. For additional information contact Director of Human Resources at chopkins@nianet.org.

NIA, located near NASA Langley Research Center in Hampton, Virginia, is a non-profit research and graduate education institute created to perform cutting-edge aerospace and atmospheric research, develop new technologies for the nation, and help inspire the next generation of scientists and engineers. Additional information about NIA and its programs is available at www.nianet.org.

NIA is an equal opportunity/affirmative action employer. Women and members of minority groups are encouraged to apply.

Space Engineering, University of North Dakota

The Department of Space Studies in the John D. Odegard School of Aerospace Sciences at the University of North Dakota invites applications for the position of assistant/associate professor in the field of space engineering. Candidates must have an earned doctorate or must have completed all requirements for a doctoral degree before spring 2013 semester. An established record of research and ability to guide students on research, teaching and service will be considered favorably in evaluation. A broad insight into the interdisciplinary nature of space activities and significant ongoing contact or connections with the space community is highly desirable. A strong interest in, and or record of developing collaborative research projects with external funding, in those fields as they relate to use, developmental and exploration of space, particularly human space exploration, is expected. The responsibilities include guiding and mentoring graduate student research, teaching graduate and undergraduate level courses, and service. A detailed job announcement is found at www.space.edu.

Salary will be competitive and commensurate with qualifications and experience. Send a letter of application, CV, teaching and research statements, names and contact information for three references to: Dr. Santhosh Seelan, Chair, Dept. of Space Studies, University of North Dakota, 512 Clifford Hall Stop 9008, Grand Forks, ND 58202-9008. Email: seelan@space.edu. UND is an equal opportunity, affirmative action employer.

AIAA Bulletin

Space Shuttles *Discovery* (left) and *Enterprise* (right) nose to nose at the National Air and Space Museum's Udvar Hazy Center Welcome Ceremony for *Discovery* on 19 April. Space Shuttle *Enterprise* was flown up to New York City on 27 April. (*Photo credit: AIAA Fellow Tony Springer, NASA*)

JUNE 2012

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

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
2012				
4–6 Jun	**18th AIAA/CEAS Aeroacoustics Conference (33rd AIAA Aeroacoustics Conference)**	Colorado Springs, CO	*Jun 11*	**9 Nov 11**
4–6 Jun†	**19th St Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia Contact: Prof. V. Peshekhonov, +7 812 238 8210, elprib@online.ru, www.elektropribor.spb.ru		
7 Jun	**Aerospace Today…and Tomorrow: An Executive Symposium**	Williamsburg, VA (Contact: Merrie Scott; merries@aiaa.org)		
18–20 Jun†	**3rd International Air Transport and Operations Symposium (ATOS) and 6th International Meeting for Aviation Product Support Process (IMAPP)**	Delft, the Netherlands Contact: Adel Ghobbar, 31 15 27 85346, a.a.ghobbar@tudelft.nl, www.lr.tudelft.nl/atos		
19–21 Jun	**AIAA Infotech@Aerospace Conference** (Apr)	Garden Grove, CA	*Jun 11*	**6 Dec 11**
25–28 Jun	**28th Aerodynamics Measurement Technology, Ground Testing, and Flight Testing Conferences** (Mar) **including the Aerospace T&E Days Forum** **30th AIAA Applied Aerodynamics Conference** **4th AIAA Atmospheric Space Environments Conference** **6th AIAA Flow Control Conference** **42nd AIAA Fluid Dynamics Conference and Exhibit** **43rd AIAA Plasmadynamics and Lasers Conference** **43rd AIAA Thermophysics Conference**	New Orleans, LA	*Jun 11*	**17 Nov 11**
27–29 Jun†	**American Control Conference**	Montreal, Quebec, Canada Contact: Tariq Samad, 763.954.6349, tariq.samad@honeywell.com, http://a2c2.ort/conferences/acc2012		
11–14 Jul†	**ICNPAA 2012 – Mathematical Problems in Engineering, Aerospace and Sciences**	Vienna, Austria Contact: Prof. Seenith Sivasundaram, 386/761-9829, seenithi@aol.com, www.icnpaa.com		
14–22 Jul	**39th Scientific Assembly of the Committee on Space Research and Associated Events (COSPAR 2012)**	Mysore, India Contact: http://www.cospar-assembly.org		
15–19 Jul	**42nd International Conference on Environmental Systems (ICES)** (Apr)	San Diego, CA	*Jul/Aug 11*	**15 Nov 11**
30 Jul–1 Aug	**48th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit Future Propulsion: Innovative, Affordable, Sustainable** (Apr)	Atlanta, GA	*Jul/Aug 11*	**21 Nov 11**
30 Jul–1 Aug	**10th International Energy Conversion Engineering Conference** (Apr)	Atlanta, GA	*Jul/Aug 11*	**21 Nov 11**
13–16 Aug	**AIAA Guidance, Navigation, and Control Conference** (May) **AIAA Atmospheric Flight Mechanics Conference** **AIAA Modeling and Simulation Technologies Conference** **AIAA/AAS Astrodynamics Specialist Conference**	Minneapolis, MN	*Jul/Aug 11*	**19 Jan 12**
11–13 Sep	**AIAA SPACE 2012 Conference & Exposition** (Jun)	Pasadena, CA	*Sep 11*	**26 Jan 12**
11–13 Sep	**AIAA Complex Aerospace Systems Exchange Event** (Jun)	Pasadena, CA		
17–19 Sep	**12th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference** **14th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference**	Indianapolis, IN	*Oct 11*	**7 Feb 12**
23–28 Sept†	**28th Congress of the International Council of the Aeronautical Sciences**	Brisbane, Australia Contact: http://www.icas2012.com		**15 Jul 11**
24–27 Sept†	**30th AIAA International Communications Satellite Systems Conference (ICSSC) and 18th Ka and Broadband Communications, Navigation and Earth Observation Conference**	Ottawa, Ontario, Canada Contact: Frank Gargione, frankgargione3@msn.com; www.kaconf.org	*Nov 11*	**31 Mar 12**
24–28 Sep	**18th AIAA International Space Planes and Hypersonic Systems and Technologies Conference**	Tours, France	*Mar 12*	**12 Apr 12**
24–28 Sep	**7th AIAA Biennial National Forum on Weapon System Effectiveness**	Ft. Walton Beach, FL	*Nov 11*	**15 Mar 12**
1–5 Oct	**63rd International Astronautical Congress**	Naples, Italy (Contact: www. iafastro.org)		
11–12 Oct†	**Aeroacoustic Installation Effects and Novel Aircraft Architectures**	Braunschweig, Germany (Contact: Cornelia Delfs, +49 531 295 2320, cornelia.delfs@dlr.de, www.win.tue.nl/ceas-asc)		

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
5–8 Nov†	**27th Space Simulation Conference**	Annapolis, MD Contact: Harold Fox, 847.981.0100, info@spacesimcon.org, www.spacesimcon.org		
6–8 Nov†	**7th International Conference Supply on the Wings**	Frankfurt, Germany (Contact: Richard Degenhardt, +49 531 295 2232, Richard.degenhardt@dlr.de, www.airtec.aero)		
2013				
7–10 Jan	**51st AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition**	Dallas/Ft. Worth, TX	*Jan 12*	**5 Jun 12**
21–25 Jan†	**Annual Reliability and Maintainability Symposium (RAMS)**	Orlando, FL Contact: Patrick M. Dallosta, 703.805.3119, Patrick.dallosta@dau.mil, www.rams.org		
10–14 Feb†	**23rd AAS/AIAA Space Flight Mechanics Meeting**	Kauai, HI	*May 12*	**1 Oct 12**
2–9 Mar†	**2013 IEEE Aerospace Conference**	Big Sky, MT Contact: David Woerner, 626.497.8451; dwoerner@ieee.org; www.aeroconf.org		
25–28 Mar	**22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar** **AIAA Balloon Systems Conference** **20th AIAA Lighter-Than-Air Systems Technology Conference**	Daytona Beach, FL	*May 12*	**5 Sep 12**
8–11 Apr	**54th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **21st AIAA/ASME/AHS Adaptive Structures Conference** **15th AIAA Non-Deterministic Approaches Conference** **14th AIAA Dynamic Specialist Conference** **14th AIAA Gossamer Systems Forum** **9th AIAA Multidisciplinary Design Optimization Conference**	Boston, MA	*Apr 12*	**5 Sep 12**
27–29 May†	**20th 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		
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)**	Vail, CO		
12–14 Aug	**Aviation 2013**	Los Angeles, CA		
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		
10–12 Sep	**AIAA SPACE 2013 Conference & Exposition**	San Diego, CA		

To receive information on meetings listed above, write or call AIAA Customer Service, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344; 800.639.AIAA or 703.264.7500 (outside U.S.). Also accessible via Internet at www.aiaa.org/calendar.

†Meetings cosponsored by AIAA. Cosponsorship forms can be found at http://www.aiaa.org/content.cfm?pageid=292.

AIAA Courses and Training Program

DATE	COURSE	VENUE	LOCATION
2012			
1 Jul–31 Dec	**Intro to Computational Fluid Dynamics**	Home Study Course	n/a
1 Jul–31 Dec	**Advanced Computational Fluid Dynamics**	Home Study Course	n/a
1 Jul–31 Dec	**Computational Fluid Turbulence**	Home Study Course	n/a
1 Jul–31 Dec	**Introduction to Space Flight**	Home Study Course	n/a
1 Jul–31 Dec	**Fundamentals of Aircraft Performance and Design**	Home Study Course	n/a
9–10 Jul	**Optimal Design in Multidisciplinary Systems**	Ohio Aerospace Institute	Cleveland, OH
14–15 Jul	**Spacecraft Design and Systems Engineering**	ICES Conference	San Diego, CA
2–3 Aug	**Hybrid Rocket Propulsion**	Joint Propulsion Conference	Atlanta, GA
2–3 Aug	**Advanced Solid Rockets**	Joint Propulsion Conference	Atlanta, GA
2–3 Aug	**Hydrogen Safety**	Joint Propulsion Conference	Atlanta, GA
2–3 Aug	**NPSS: A Practical Introduction**	Joint Propulsion Conference	Atlanta, GA
2–3 Aug	**Missile Design and System Engineering**	Joint Propulsion Conference	Atlanta, GA
6–7 Aug	**Systems Requirements Engineering**	Ohio Aerospace Institute	Cleveland, OH
11–12 Aug	**Flight Vehicle System Identification in Time Domain**	GNC Conferences	Minneapolis, MN
11–12 Aug	**Atmospheric Flight Dynamics and Control**	GNC Conferences	Minneapolis, MN
11–12 Aug	**Recent Advances in Adaptive Control: Theory and Applications**	GNC Conferences	Minneapolis, MN
11–12 Aug	**Fundamentals of Tactical and Strategic Missile Guidance**	GNC Conferences	Minneapolis, MN
11–12 Aug	**Optimal State Estimation**	GNC Conferences	Minneapolis, MN
11–12 Aug	**Six Degrees of Freedom Modeling of Missile and Aircraft Simulations**	GNC Conferences	Minneapolis, MN
13–14 Aug	**Computational Aeroacoustics: Methods and Applications**	National Institute of Aerospace	Hampton, VA
27–29 Aug	**Space Environment and its Effects on Space Systems**	Ohio Aerospace Institute	Cleveland, OH
9–10 Sep	**Systems Engineering Verification and Validation**	SPACE Conference	Pasadena, CA
9–10 Sep	**Introduction to Space Systems**	SPACE Conference	Pasadena, CA
11–12 Sep	**Robust Aeroservoelastic Stability Analysis**	National Institute of Aerospace	Hampton, VA
15–16 Sep	**Optimal Design in Multidisciplinary Systems**	ATIO/MAO Conference	Indianapolis, IN

**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.

From the **Corner** Office

HOW TO STAY RELEVANT

Michael Griffin, AIAA President

Since assuming my duties as AIAA President-Elect and now President, I have written and spoken of the need to reverse the decline in membership characterizing our Institute in recent years. We must find ways to become more relevant to the lives and careers of aerospace professionals and we must do so without neglecting the responsibilities inherent to our core role as *the* repository of aerospace technical excellence. To fly safely in air and space, to project national power and influence abroad, to provide for the nation's defense, to send our robotic emissaries out into the solar system and beyond, to build machines that can look out and back almost to the dawn of time—these are hard tasks that remain at the frontier of human technical capability. AIAA is and must remain the professional society that is on the leading edge of how they are done.

But "how" is only part of the story in the world of today's aerospace professional. In a time of spiraling national debt and societal priorities that are—at the very least—somewhat different than those of the world in which we older members grew up, "why" is as important in aerospace today as "how", and maybe even more so. During the Cold War, "why" was not a question. The role of the aerospace profession and its professionals in achieving and maintaining strategic superiority for what we called "the free world" was obvious; "why" was not the subject of any important debate—the only real questions concerned "how" we would do it. The cessation of the Cold War has resulted in different imperatives, and today the "why" question is very much in evidence.

Any discussion at the societal level that begins with "why" inherently deals with national policy. We aerospace professionals have not been as engaged as those in, say, the medical or legal profession. We grew up in a time when national policy as it related to the aerospace and defense arena was relatively stable, and our role in meeting the goals required by those policies was clear. Today, not so much. This shift has left many of us in the aerospace profession, and certainly at AIAA, somewhat "behind the power curve" in stepping into this larger arena.

In plainer terms, when we are talking about policy, we are really talking about "what should be done". To a medical professional, the idea that national policy discussions could take place without the substantial involvement of doctors and the American Medical Association would be ridiculous—but that is exactly what happens in aerospace. AIAA as an Institute has been largely uninvolved in important national issues even as they relate to the aerospace profession. The quality of national debate on such subjects has not been improved by our absence and, importantly, our stature as the aerospace profession's leading society has suffered—we are simply not as relevant as when the primary questions of interest concerned only "how". I believe that the decline in our membership is directly related to AIAA's gradual loss of relevance in the larger world of aerospace.

How can we become more relevant? How can we engage in the important policy debates of our time without compromising our objectivity as the premier aerospace technical society? This is a challenging task. We usually cannot proceed by internally debating controversial issues and adopting an "AIAA position" on such matters. While that may occasionally be an appropriate tactic, on most significant issues our Institute's membership, both individual and corporate, will be of differing views on important subjects. The Institute generally must avoid "taking sides". We must represent the profession, not the stance taken by a particular group of professionals. In my nearly four decades of AIAA membership, this fact always has been used as the trump card to dampen any significant engagement by our Institute in national aeronautical and space policy debate. This behavior has redounded now to our detriment.

However, the Institute doesn't have to offer a plethora of "official AIAA positions" to play a significant and valuable role in aerospace policy debates. AIAA offers two key assets that, properly employed, can put our Institute front and center in the policy-making arena: our comprehensive conference and event structure, and the technical expertise that is the foundation for everything else that we are. Together these items can be the critical components of the informed debate our government relies on. There are many topics that need to be a part of the aerospace policy debate—decisions that need to be made about what to do or not do on topics that matter to society at large. Too often, by the time these topics become apparent to the general public, the opportunity may be gone.

1) What are the consequences of degradation in the quality of GPS signals from the use of broadband communications systems in neighboring frequency bands?

2) What is required to implement NextGen, and what happens to the nation's air traffic if we do not?

3) What is the market for non-government commercial human space transportation over the next generation—how should it inform the development of the next U.S. space transportation system?

4) How should the U.S. air traffic control system evolve to handle the growing number of unmanned aerial vehicles that must fly in the system? What considerations should be given to the plethora of legacy air traffic?

5) What role can hypersonic air transportation play? What development policies should be established in view of these conclusions? When?

6) What is the most appropriate next step for the U.S. human spaceflight program beyond the International Space Station? Why?

7) How should NASA's human rating standards for space vehicles inform FAA certification processes for future commercially developed human spaceflight systems?

No doubt our readers can think of many more and probably better questions whose answers affect the daily lives of those in our profession and society in general. The answers to these question will depend not only on what we might want to do, but also on what *can* be done and *how*. It is in this juncture that AIAA can thrive by creating and promoting policy forums at our many conferences, to bring together informed stakeholders from across the many disciplines that are required to reach truly productive conclusions. Generally speaking, we avoid such things. It is my observation that we have yielded the legitimacy of such forums to other groups and societies, and done so at our detriment. If AIAA is not involved in discussions relating to national aerospace issues, who should be doing this? Are they qualified?

Forums dealing with weighty topics in aerospace policy should be a regular and continuing expectation of our Institute's conference structure. The interdisciplinary nature of such events, when properly convened, will be aided by the new event model being developed under the leadership of our VP-Technical Activities, Basil Hassan. With this approach, AIAA will offer fewer, larger conferences that are more integrated across the disciplines that contribute toward air, space, and defense systems. As we shift to this model, it seems a perfect time to incorporate within these conferences the policy forums that I believe are needed to help our Institute regain the relevance we need to offer to the 21st-century aerospace professional.

DISCOVERY'S FINAL FLIGHT

Space Shuttle *Discovery*, mounted atop NASA's 747 Shuttle Carrier Aircraft, made a series of low passes—at approximately 1,500 ft—over Washington, DC area landmarks on the morning of 17 April, shortly before 10 am EDT. *Discovery*, the first orbiter retired from NASA's shuttle fleet, completed 39 missions, spent 365 days in space, orbited the Earth 5,830 times, and traveled 148,221,675 miles. *Discovery* has been transferred to the National Air and Space Museum to begin its new mission to commemorate past achievements in space and to educate and inspire future generations of explorers. This final flyover provided a rare chance in the post-Shuttle era for people to still see a Shuttle in flight. The series of low passes were approved in partnership with the Federal Aviation Administration.

Many in the Washington, DC area, including AIAA Delaware Section Vice Chair Tim Dominick and his son, took time out to view and applaud Space Shuttle *Discovery* as it made its last voyage. Some of Mr. Dominick's images are seen here.

Photo Credit: (NASA/Bill Ingalls)

(Photo Credits: AIAA Delaware Section Vice-Chair Tim Dominick)

Above: Space Shuttle *Discovery* flyover. Right: Ryne Dominick in front of Space Shuttle *Enterprise* at the National Air and Space Museum's Udvar Hazy Center. On 27 April, *Enterprise* was flown up to New York City where it will be displayed at the Intrepid Sea, Air & Space Museum. (Photo Credits: AIAA Delaware Section Vice Chair Tim Dominick)

AIAA STUDENT DESIGN/BUILD/FLY WINNERS ANNOUNCED

AIAA congratulates the winners of the 2011–2012 Cessna Aircraft Company/ Raytheon Missile Systems/ AIAA Foundation Student Design/Build/Fly (DBF) Competition, held 13–15 April at Cessna Aircraft Company's Cessna Field, Wichita, KS. A total of 68 teams submitted written reports to be judged. At least 57 teams attended the flyoff, 54 of which completed the technical inspection. Approximately 500 students, faculty, and guests were present. Attendance was down this year due to a new rule limiting universities to a single team; however, the quality of the teams, their readiness to compete, and the execution of the flights was extremely high.

The primary design objectives for this year were performance based:

First Place Winner: San Jose State University: Team PhalanX.


Second Place Winner: University of California at Irvine: Angel of Attack.

- Mission 1 was scored on the number of laps that could be flown in 4 minutes, so speed was important
- Mission 2 simulated carrying a specified passenger load for three laps, testing load-carrying ability.
- Mission 3 measured airplane time to climb with a two-liter water payload.

This year the flyoff was affected by significant weather events. Flights were suspended Saturday at 1245 hrs by high winds. That night, a severe storm cell hit southeast Wichita and a tornado passed approximately one-fourth mile from Cessna East Field. The hangar escaped damage but downed power lines forced closure of the road to the site and prevented normal access. It was determined that the flyoff could not continue and a recovery plan was implemented to provide access through the main Cessna plant for teams to recover their property. We are thankful that none of the teams experienced any property loss, and also that there weren't serious injuries to the Wichita population.

Despite this unprecedented weather event, two complete rotations through the flight queue were completed, and there were ten attempts at a third flight. Final results were based on the team's written report and the scores of each team's first two flight opportunities.

The winning team, "PhalanX" from San Jose State University, San Jose, CA, received the $2,500 first place award. Team "Angel of Attack," from The University of California, Irvine, CA, received the $1,500 second place prize. Team "H2BuffalO" from the University of Colorado, Boulder, CO, received the $1,000 third place prize.

One of the event's organizers, David W. Levy, a senior engineering specialist for aerosciences and computational fluid dynamics at Cessna Aircraft Company, stated: "The AIAA Design/Build/Fly Competition provides a real-world aircraft design experience for teams of engineering students by giving them a 'hands-on' opportunity to validate their analytic studies. This is an essential part of engineering, as the final product does not always perform as expected. Almost all engineers will learn this lesson at some point in their careers, preferably before they enter the workforce."

Now in its 16th 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. For more information about the AIAA Design/Build/Fly Competition, visit **www.aiaadbf.org**.


Third Place Winner: University of Colorado: H2BuffalO.

Award Nomination Process Streamlined!

The Honors and Awards Committee is pleased to announce that the award nomination process has been streamlined to reduce the paperwork burden upon nominators and to better communicate award guidelines.

New to the process is a limit of 7 pages for the nomination package, whether submitted online or hard copy. In addition to the nomination form, supporting materials include 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 letters of endorsement (including the 3 required letters from AIAA members) may be submitted and increase the page limit to 9 pages.

Any AIAA member in good standing is eligible to serve as a nominator. Nominators are strongly encouraged to begin using the streamlined award nomination process, and are reminded that quality of information is most important. Full implementation of the streamlined process including the 7-page limit will begin on **1 January 2013**.

AIAA members may log into **www.aiaa.org** with their user name and password to submit a nomination online or to download the nomination form. For further information, contact AIAA Honors and Awards at carols@aiaa.org or at 703.264.7623.

CALL FOR NOMINATIONS

Recognize the achievements of your colleagues by nominating them for an award! Nominations now are being accepted for the following awards.

Nomination Deadline 1 June 2012

AIAA-ASC James H. Starnes, Jr. Award is presented in honor of James H. Starnes, Jr., a leader in structures and materials, to recognize continued significant contribution to, and demonstrated promotion of, the field of structural mechanics over an extended period of time emphasizing practical solutions, to acknowledge high professionalism, and to acknowledge the strong mentoring of and influence on colleagues, especially younger colleagues.

Nominations due to AIAA by **1 June 2012**. To obtain the nomination form or further information, contact AIAA Honors and Awards at 703.264.7623 or at carols@aiaa.org.

Nomination Deadline 1 July 2012

AIAA Ashley Award for Aeroelasticity recognizes outstanding contributions to the understanding and application of aeroelastic phenomena. It commemorates the accomplishments of Prof. Holt Ashley, who dedicated his professional life to the advancement of aerospace sciences and engineering and had a profound impact on the fields of aeroelasticity, unsteady aerodynamics, aeroservoelasticity, and multidisciplinary optimization. (Presented quadrennially, next presentation 2013)

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 is presented to recognize 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 is presented to recognize 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.

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 **31 December** of the year preceding the presentation.

Losey Atmospheric Sciences Award is presented for recognition of outstanding contributions to the atmospheric sciences as applied to the advancement of aeronautics and astronautics.

Missile Systems Award

The award is presented in two categories. The *Technical Award* is presented for a significant accomplishment in developing or using technology that is required for missile systems. The *Management Award* is presented for a significant accomplishment in the management of missile systems programs.

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

Space Processing Award is presented for significant contributions in space processing or in furthering the use of microgravity for space processing. (Presented odd years)

Summerfield Book Award is named in honor of Dr. Martin Summerfield, founder and initial editor of the Progress in Astronautics and Aeronautics Series of books published by

AIAA. The 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, approved by the Board of Directors in 1999, recognizes sustained, significant service and contributions to AIAA by members of the Institute. A maximum of 20 awards are presented each year.

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

Nominations due to AIAA by **1 July 2012**. Any AIAA member in good standing may be a nominator and are highly urged to read award guidelines carefully 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**.

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

AIAA SPACE 2012 Conference & Exposition
Creating A Sustainable Vision for Space

11–13 September 2012
Pasadena Convention Center
Pasadena, CA

Creating a Sustainable Vision for Space

In today's dynamic strategic space environment, change and uncertainty abound. We are at a crossroads where numerous factors converge and where critical decisions need to be made:

- The Space Shuttle era has ended, and as we continue to plan for future human space exploration, U.S. astronauts remain dependent on Russia for near-term access to space.
- NASA's plan for human access beyond low Earth orbit will rely upon the Orion Multi-Purpose Crew Vehicle and the Space Launch System. Sustaining this path is critical not only for human exploration but also for U.S. military and economic security.
- New commercial space enterprises appear to be on the verge of being able to deliver cargo and astronauts to low Earth orbit, promising a potential game-changing capability.
- New space entrepreneurs are also on the verge of opening up new markets for suborbital space tourism and research opportunities.
- We have completed an unprecedented recapitalization of our national security space-based assets. In this post-development phase, we will need to leverage these powerful new systems, and maximize capability improvement opportunities as we continue to bring them on line.
- Space has become an increasingly congested and contested arena, giving rise to the desire for improved space situational awareness and a belief in the need for rapidly deployable space assets that can be inserted into orbit quickly and at significantly lower cost.
- Many other spacefaring nations are developing parity with U.S. space technology. While this growing international capability creates significant competitive challenges for the U.S. space industry, it also yields significant cooperative opportunities for the future exploration and utilization of space.
- The need for space-based research, commerce, and national security capability is increasing, while available resources to meet that need are decreasing. Serious budgetary pressures are limiting our options and imposing a new fiscal reality that is forcing us to make choices as to what we do, and how we fund future efforts in space.
- Maintaining a vital U.S. space industrial base is a critical, ongoing requirement. Inspiring and educating next-generation space technologists needs to be a national priority as we plot our future directions.

Given the current political, financial, and technical challenges the space industry faces, we need a cohesive and sustainable vision for the future development of space systems, to guide the intelligent integration of our commercial, civil, and military efforts, and to allow us to maximize our capabilities to better meet the future challenges of space-based exploration, science, commerce, and national security.

The AIAA SPACE 2012 Conference & Exposition will focus on many of the issues that define these challenges. Among other topics, we will look at balancing the need for affordability with the increasing demand for space-based assets; examine the relative value of new space architectures in meeting our national security needs; and explore the most effective ways to prioritize our near-term and long-term space science and exploration objectives in a cost-constrained environment. Ultimately, we want to address the fundamental question: Can we create a cohesive vision for space that will account for the needs and contributions of all stakeholders—commercial, military, and scientific—and develop a long-range framework for future space exploration and utilization that will be sustainable across the multiple political and economic cycles necessary to bring the vision to fruition?

Also this year, the AIAA Complex Aerospace Systems Exchange, or CASE, will be held in conjunction with the SPACE Conference. CASE will be a dynamic interactive event where leading aerospace managers and technologists can share their insights and best practices, and where participants will gain practical knowledge that is directly applicable to addressing the challenges we face today. CASE will be a valuable adjunct to the conference's examination of the issues affecting the future direction of space.

Exposition Hall

The AIAA SPACE 2012 Exposition Hall, located in the exhibition building at the Pasadena Convention Center, is the center of all networking and business activities at the conference. The 2012 exposition includes exhibits from industry, government, and academic organizations across the space community. Networking coffee breaks, luncheons, poster sessions, exhibitor presentations, and the opening reception are all held in the exposition hall to give attendees and exhibitors the most opportunities to meet and do business.

Exposition Hall Hours

Tuesday, 11 September 2012	0930–1630 hrs
Opening Reception	1830–2000 hrs
Wednesday, 12 September 2012	0930–1600 hrs
Thursday, 13 September 2012	0930–1400 hrs

Benefits of Attendance

Nowhere else will you get the depth and breadth of sessions on space technology, policy, programs, management, and education that you will find at the AIAA SPACE 2012 Conference & Exposition!

Why Attend?

- Find out what lies ahead as leaders in space exploration, spacecraft systems and design, space science, military space, and more discuss their programs, challenges, and solutions during plenary and panel sessions.
- Expand your knowledge as expert engineers and scientists share their latest research and development findings.
- Network, discuss challenges, and share ideas during technical sessions, luncheons, networking coffee breaks, and social activities.
- Meet and greet your current and future colleagues, business partners, and employers, and learn about the newest groundbreaking technologies in the exposition hall. Check out the presentation stage, enjoy refreshments, and network with your peers. Daily exhibit activities will attract 1,000+ participants into the hall.
- Stay at the top of your game with AIAA's Continuing Education programs. Leave with insights and solutions that you can put to immediate use.

Who Should Attend

- Industry executives
- Government and military officials
- Program managers
- Business developers
- Engineers, scientists, and researchers
- Professors, educators, and students
- Consultants
- Press/media

What to Expect

- *Discussion and interaction with aerospace leaders such as*
  — Hon. Charles F. Bolden Jr., Administrator, NASA
  — Charles Elachi, Director, NASA Jet Propulsion Laboratory
  — Lt Gen Ellen M. Pawlikowski, USAF, Commander, U.S. Air Force Space and Missile Systems Center
- *Insight into the latest and future technologies and developments in*
  — Commercial Space
  — Intelligent Systems
  — National Security Space
  — Robotic Technology and Space Architecture
  — Space and Earth Science
  — Space Colonization and Space Tethers
  — Space Economics
  — Space Exploration
  — Space History, Society, and Policy
  — Space Logistics and Supportability
  — Space Operations
  — Space Resources
  — Space Systems and Sensors
  — Space Systems Engineering
  — Space Transportation and Launch Systems
- *Networking and partnership-building with your industry peers during*
  — Opening Reception
  — Poster Sessions
  — Networking Coffee Breaks
  — Awards and Keynote Luncheons
  — Young Professional Networking Reception

Co-Chaired by
NASA Jet Propulsion Laboratory
U.S. Air Force Space and Missile Systems Center

Organized by AIAA

Opening Day Sponsored by The Boeing Company

National Security Space Day Sponsored by
Lockheed Martin Corporation

Civil Space Day Keynote Luncheon Sponsored by
Space Exploration Technologies Corp.

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			OPENING DAY
	Sunday, 9 September	Monday, 10 September	Tuesday, 11 September
			Sponsored by The Boeing Company
0700 hrs			
0730 hrs			Speakers' Briefing
0800 hrs			
0830 hrs			Opening Ceremony and
0900 hrs			Plenary Session
0930 hrs			
1000 hrs			Networking Coffee Break
1030 hrs			
1100 hrs			Technical Sessions
1130 hrs	AIAA Continuing	AIAA Continuing	
1200 hrs	Education Courses	Education Courses	
1230 hrs			
1300 hrs			Keynote Luncheon
1330 hrs			
1400 hrs			
1430 hrs			
1500 hrs			Plenary Session
1530 hrs			
1600 hrs			Networking Coffee Break
1630 hrs			
1700 hrs			Technical Sessions
1730 hrs			
1800 hrs			
1830 hrs			Opening Reception and
1900 hrs			Poster Session
1930 hrs			
2000 hrs			
2030 hrs			
2100 hrs			
2130 hrs			
2200 hrs			

Special Events

Young Professional Networking Reception

The AIAA Young Professional Committee is hosting a young professional (YP) networking reception on Monday, 10 September, 1900–2130 hrs. This is a great chance for young professional members of the Institute, professionally employed members age of 35 and under, to meet other members and make new contacts. Join the AIAA YP Committee for light hors d'oeuvres, drinks, and relaxed socializing.

Leading the STEM Charge: Illuminating the Potential in Aerospace

AIAA, in partnership with Project Lead the Way (PLTW) and the Conrad Foundation (CF), will host a one-day educational event on Wednesday, 12 September to bring together high school students who have expressed an interest in aerospace engineering. This program is sponsored by Northrop Grumman Corporation.

The event will consist of a student poster session, panel discussion, and a private networking lunch. The students will have the opportunity to showcase their work, hear from those currently working in the industry, and ask questions during the lunch and learn.

Make sure to stop by the poster session in the exposition hall and see and hear work that future leaders of the aerospace industry find exciting and challenging. They look forward to your feedback on their ideas. Conference attendees and local section members are invited to network with the students about career paths in the aerospace from undergraduate level to professional members.

For more information about this program, please contact Lisa Bacon at lisab@aiaa.org.

Report from the 1st Annual Space Generation Advisory Council (SGAC) Fusion Forum

The Space Generation Advisory Council (SGAC) completed its first ever Space Generation Fusion Forum (www.spacegenerationfusionforum.org) in conjunction with the 28th Annual National Space Symposium in April in Colorado Springs. Over two days, the Space Generation Fusion Forum offered the next generation

	NATIONAL SECURITY SPACE DAY	CIVIL SPACE DAY
	Wednesday, 12 September	Thursday, 13 September
	Sponsored by Lockheed Martin Corporation	
0700 hrs		
0730 hrs	Speakers' Briefing	Speakers' Briefing
0800 hrs		
0830 hrs	Plenary Session	Plenary Session
0900 hrs		
0930 hrs	Networking Coffee Break and Poster Session	Networking Coffee Break and Poster Session
1000 hrs		
1030 hrs	Technical Sessions	Technical Sessions
1100 hrs		
1130 hrs		
1200 hrs		
1230 hrs	Awards Luncheon	Keynote Luncheon
1300 hrs		(Sponsored by SpaceX)
1330 hrs		
1400 hrs		
1430 hrs	Plenary Session	Plenary Session
1500 hrs		
1530 hrs	Networking Coffee Break and Poster Session	Networking Break
1600 hrs		
1630 hrs	Technical Sessions	Technical Sessions
1700 hrs		
1730 hrs		
1800 hrs		
1830 hrs	William H. Pickering Lecture	
1900 hrs		
1930 hrs		
2000 hrs		
2030 hrs		
2100 hrs		
2130 hrs		
2200 hrs		

of space sector leaders from government, industry, and academia the opportunity to come together to exchange views on current, hot space topics via interactive panels moderated by today's sector leaders. The AIAA MVP Award was presented, and after an election among the selected best five participants of the Space Generation Fusion Forum, Minoo Rathnasabapathy was the winner of the award. Minoo will represent SGAC and present the report of the Space Generation Fusion Forum at AIAA's SPACE 2012 Conference & Exposition on the presentation stage in the exposition hall during the Wednesday afternoon networking coffee break.

William H. Pickering Lecture

The William H. Pickering Lecture will be held Wednesday, 12 September, 1800–1930 hrs. The lecture is named for the former NASA Jet Propulsion Laboratory Director to honor his initiation and leadership of America's unmanned scientific space program, from Explorer I in 1958 through the development of the Viking orbiters and Voyager outer planet and interstellar missions. The lecture is open to all attendees and the general public. A light dessert reception will be held prior to the lecture.

Engineers as Educators Workshop

Do you want to interact with K–12 students? Do you want to share your passion and inspire others? Are you at a loss for where to start? This workshop, held on Tuesday, 11 September, 1900–2200 hrs, will arm you with the tools, tips, and tricks to captivate your audience in a grade-level appropriate fashion by creating presentations and activities that will demonstrate the real-world applications of math and science taught in the classroom. You will learn how to construct presentations, how to use simple activities to demonstrate the engineering design process and scientific method, and how to approach educators about sharing your experiences with their students.

For more information, contact Lisa Bacon at lisab@aiaa.org.

Accompanying Persons Meet and Greet

Accompanying persons are invited to meet on Tuesday, 11 September, at 1000 hrs. Information about local attractions, activities, tours, shows, and restaurants will be available, and coffee and tea will be served.

Networking Coffee Breaks

Networking coffee breaks for all attendees will take place in the exposition hall. Coffee and other beverages will be served. Hours are as follows:

Tuesday, 11 September	1000–1030 hrs and 1600–1630 hrs
Wednesday, 12 September	0930–1000 hrs and 1530–1600 hrs
Thursday, 13 September	0930–1000 hrs and 1530–1600 hrs*

*Final coffee break is held in the conference center foyers.

Luncheons

Luncheons with keynote addresses will be held Tuesday and Thursday, 11 and 13 September. Desserts and coffee will be served in the exposition hall following each luncheon. Tickets are required and are included in the registration fee where indicated. Additional tickets may be purchased upon registration or at the AIAA Registration and Information Center.

Award Presentation

The following AIAA awards are scheduled be presented at the AIAA Awards Luncheon on Wednesday, 12 September, in the exposition hall:

- Gardner-Lasser Aerospace Literature Award
- George M. Low Space Transportation Award
- Haley Space Flight Award
- Space Science Award
- Space Systems Award
- Von Braun Award For Excellence in Space Program Management

Tickets are required and are included in the registration fee where indicated. Additional tickets may be purchased upon registration or at the AIAA Registration and Information Center.

Opening Reception and Poster Session

The opening reception and kick-off of the conference poster session will be held Tuesday, 11 September, 1830–2000 hrs, in the exposition hall. Meet and greet your current and future colleagues, business partners, and employers while enjoying cocktails and hors d'oeuvres. Tickets are required and are included in the registration fee where indicated. Additional tickets may be purchased upon registration or at the AIAA Registration and Information Center.

Poster Sessions

The conference technical program committee has organized special poster sessions to highlight high-quality technical information. All poster sessions will be held in the exposition hall during the opening reception on Tuesday evening and during the networking coffee breaks on Wednesday and Thursday. All poster session papers are included in the conference proceedings. Session times are as follows:

Tuesday, 11 September, 1830–2000 hrs
- All poster sessions

Wednesday, 12 September, 0930–1000 hrs
- Poster Session: Commercial Space
- Poster Session: National Security Space
- Poster Session: Space Transportation I and II
- Poster Session: AIAA Foundation 2011–2012 Student Space Design Competition Winners

Wednesday, 12 September, 1530–1600 hrs
- Poster Session: Robotic Technologies and Space Architecture
- Poster Session: Space Operations
- Poster Session: Space Systems Engineering and Space Economics I and II

Thursday, 13 September, 0930–1000 hrs
- Poster Session: Space and Earth Science
- Poster Session: Space Exploration I and II
- Poster Session: Space Systems and Sensors I and II

Presentation Stage

Announcements and presentations by exhibitors on their latest products and services, as well as special announcements by other conference participants, will be made on the presentation stage located in the exposition hall during the networking coffee breaks. The full schedule will be available on the conference website at **www.aiaa.org/space2012**. Exhibitors who are interested in taking advantage of this opportunity should contact Carmela Brittingham at carmelab@aiaa.org for time availability.

Cyber Café

Computers with complimentary Internet access for conference attendees will be available at the AIAA Cyber Café, located in the exposition hall. Hours of operation are as follows:

Tuesday, 11 September	0700–1700 hrs
Wednesday, 12 September	0700–1700 hrs
Thursday, 13 September	0700–1400 hrs

Conference Proceedings

Proceedings for this conference will be available in online proceedings format. The cost is included in the registration fee where indicated. The online proceedings will be available on **3 September 2012**. Attendees who register in advance for the online proceedings will be provided with instructions on how to access them. Those registering on site will be provided with instructions at that time.

AIAA Bookstore: Your First Source for Aerospace Publications

Stop by the AIAA Bookstore, located in the exposition hall, to browse new releases and best-selling titles. AIAA is dedicated to publishing the very best resources available for the aerospace community. A full selection of publications will be available for purchase at the book store throughout the event. Special discounts are offered to AIAA members.

Registration Information

AIAA is committed to sponsoring world-class conferences on current technical issues in a safe and secure environment. As such, all delegates will be required to provide proper identification prior to receiving a conference badge and associated materials. All delegates must provide a valid photo ID (driver's license or passport) when they check in. For student registrations, a valid student ID is also required. We thank you for your cooperation.

All participants are urged to register online at **www.aiaa.org/space2012**, or you may use the PDF registration form. Registering in advance saves conference attendees up to $200. A check made payable to AIAA or credit card information must be included with your registration form. A PDF registration form is also available on the AIAA website. Print, complete, and mail or fax the form with payment to AIAA. Address information is provided.

Early-bird registration forms must be received by **13 August 2012**, and standard registration forms will be accepted until **9 September 2012**. Preregistrants may pick up their materials at the advance registration desk at the conference. All those not registered by **9 September 2012** may do so at the on-site registration desk.

Cancellations must be received no later than **27 August 2012**. There is a $100 cancellation fee. Registrants who cancel beyond this date or fail to attend the conference will forfeit the entire fee.

For questions, please contact Lynne David, conference registrar, at +1 703.264.7503 or lynned@aiaa.org.

	Registration Type	Before 13-August-12	Nonmember Before 13-August-12	Conference Sessions	Exhibits	Tuesday Reception	Tuesday Luncheon	Wednesday Luncheon	Thursday Luncheon	Online Proceedings
Option 1	**Full Conference**	**$875**	**$1,030**	●	●	●	●	●	●	●
Option 2	**Government Employee Full Conference**	**$875**	**$875**	●	●	●	●	●	●	●
Option 3	**AIAA Undergraduate Student**	**$20**	**$50**	●						
Option 4	**AIAA Undergraduate Student with Networking**	**$250**	**$280**	●	●	●	●	●	●	●
Option 5	**AIAA Graduate or PH.D. Student**	**$60**	**$90**	●						
Option 6	**AIAA Graduate or PH.D. Student with Networking**	**$290**	**$320**	●	●	●	●	●	●	●
Option 7	**AIAA Retired Member**	**$40**	**n/a**	●	●	●	●	●	●	
Option 8	**Group Rate***	**$788**	**n/a**	●	●	●	●	●	●	●
Option 9	**Continuing Education Courses**	**$1,338**	**$1,343**	●	●	●	●	●	●	●
	Extra Tickets					$80	$50	$50	$50	$170

Pricing subject to change.

*Advance only. 10% discount off early bird member rate for 10 or more persons from the same organization who register and pay at the same time with a single form of payment. Includes sessions, all catered events, and single-user access to online proceedings for each registrant. A complete typed list of registrants, along with completed individual registration forms and a single payment, must be received by the preregistration deadline of 9 September 2012.

SPACE and the Complex Aerospace Systems Exchange (CASE) are colocated in 2012 and will be complementary to each other and will share some plenary sessions and networking activities such as luncheons and receptions. By registering for SPACE, you can attend CASE sessions and visit the Exposition at no extra cost.

AIAA Registration and Information Center Hours

The AIAA Registration and Information Center will be located in the exhibition building foyer at the Pasadena Convention Center. Hours are as follows:

Sunday, 9 September (*courses only; located at Hilton Pasadena*)	0730–1000 hrs
Monday, 10 September	1500–1900 hrs
Tuesday, 11 September	0700–1700 hrs
Wednesday, 12 September	0700–1700 hrs
Thursday, 13 September	0700–1700 hrs

Meeting Site

Pasadena—an Indian name that means “Crown of the Valley”—is located at the base of the San Gabriel Mountains, just 15 minutes north of downtown Los Angeles. Pasadena is home to the NASA Jet Propulsion Laboratory, the California Institute of Technology (Caltech), the Rose Bowl, and many shops, restaurants, and art galleries. Within Pasadena’s 1.5-mile downtown core, you’ll find retail areas, cobblestone courtyards, sidewalk bistros, and nightlife in three alluring entertainment districts: Old Pasadena, the Playhouse District, and South Lake Avenue. More information on Pasadena can be found at **www.visitpasadena.com**.

All conference sessions, exhibits, and special events will be held at the Pasadena Convention Center, 300 E. Green Street, Pasadena, California 91101. The Pasadena Convention center is a renovated, state-of-the-art, LEED-certified green meeting facility.

Help Keep Our Expenses Down (And Yours Too!)

AIAA group rates for hotel accommodations are negotiated as part of an overall contract that also includes meeting rooms and other conference needs. Our total event costs are based in part on meeting or exceeding our guaranteed minimum of group-rate hotel rooms booked by conference participants. If we fall short, our other event costs go up. Please help us keep the costs of presenting this conference as low as possible – reserve your room at the designated hotel listed in this Event Preview and on our website, and be sure to mention that you’re with the AIAA conference. Meeting our guaranteed minimum helps us hold the line on costs, and that helps us keep registration fees as low as possible. All of us at AIAA thank you for your help!

Hotel Reservations

AIAA has made arrangements for a block of rooms at the Sheraton Pasadena and Hilton Pasadena:

Sheraton Pasadena
300 East Cordova Street
Pasadena, California 91101
Phone: +1.626.449.4000

Continuing Education Courses

Let AIAA Continuing Education courses pave the way to your continuing and future success! As the premier association representing aeronautics and astronautics professionals, AIAA has been a conduit for continuing education for more than sixty years. AIAA offers the best instructors and courses, and is committed to keeping aerospace professionals at their technical best. On 9–10 September 2012 at the Hilton Pasadena, AIAA will offer Continuing Education courses in conjunction with the AIAA SPACE 2012 Conference. Please check the conference website for up-to-date information regarding the courses.

Register for any course and attend the SPACE Conference for FREE! (Registration fee includes full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.) See prices on the registration matrix or the website at **www.aiaa.org/space2012**.

Systems Engineering Verification and Validation
(Instructor: John Hsu, Technical/Project Manager and Principal Investigator, The Boeing Company, Cypress, CA)
This course will focus on the verification and validation process, which plays a key role from the very beginning through the final stages of the systems engineering task for a program or project. It will clarify the distinctions between verification and validation, and discuss validating requirements and generating verification requirements. The course addresses the steps to be followed, beginning with the development of verification and validation plans, and how to choose the best verification method and approach. A test and evaluation master plan then leads to test planning and analysis. Conducting the actual testing involves activities, facilities, equipments, and personnel. The evaluation process analyzes and interprets the data, and acceptance testing assures that the products meet or exceed the original requirements. There are also functional and physical audits and simulation and modeling that can provide virtual duplication of products and processes in operationally valid environments. Verification management organizes verification tasks and provides total traceability from customer requirements to verification report elements.

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

Room rates are $179 per night for single or double occupancy. For reservations, please call +1.866.716.8106. Please identify yourself as being with the AIAA conference. These rooms will be held for AIAA until **29 August 2012** or until the block is full. After 29 August 2012, any unused rooms will be released to the general public. You are encouraged to book your hotel room early. *Government Employees*—There are a limited number of sleeping rooms available at the government per-diem rate. Government I.D. is required.

Hilton Pasadena
168 South Los Robles Avenue
Pasadena, California 91101
Phone: +1.626.577.1000

Room rates are $159 per night for single or double occupancy. For reservations, please call +1.800.HILTONS. Please identify yourself as being with the AIAA conference. These rooms will be held for AIAA until **17 August 2012** or until the block is full. After 17 August 2012, any unused rooms will be released to the general public. You are encouraged to book your hotel room early. *Government Employees*—There are a limited number of sleeping rooms available at the government per-diem rate. Government I.D. is required.

Airport Information

Bob Hope Airport (BUR) – 15 miles
- Super Shuttle: $16
- Taxi: approx. $35

Los Angeles International Airport (LAX) – 32 miles
- Super Shuttle: $22
- Taxi: approx. $71

Car Rental

AIAA members can save up to 15% off your car rentals with Hertz. Your discount CDP#66135 is the key! Wherever your travel takes you, close to home or around the world, your CDP#66135 is the key to special savings. Be sure to include it in all of your reservations. Visit Hertz at www.hertz.com for the lowest rates, special offers, and information about Hertz locations, vehicles, and services. Or call Hertz at 1.800.654.2210.

"No Paper, No Podium" & "No Podium, No Paper" Policies

If a written paper is not submitted by the final manuscript deadline, authors will not be permitted to present the paper at the conference. Also, if the paper is not presented at the conference, it will be withdrawn from the conference proceedings. It is the responsibility of those authors whose papers or presentations are accepted to ensure that a representative attends the conference to present the paper. These policies are intended to improve the quality of the conference for attendees.

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.

AIAA Programs

Sessions-At-A-Glance

For the full conference program, including all paper titles, authors, and plenary and keynote speakers, visit **www.aiaa.org/space2012**.

Commercial Space
Critical Issues in Space Access
Emerging Commercial Space Markets
Emerging Commercial Space Markets: The Case for the User
Innovative Access To and Use of Space
Poster Session: Commercial Space - Innovative Access to and Use of Space
Space Entrepreneurs
Spaceports and Ranges
Suborbital Space Access and Applications
Success Practices for Technology Commercialization

Intelligent Systems
1+1=3: Human Systems Integration + Intelligent Systems Design = Enhancing Human's Space Exploration Potential
Intelligent Systems for Civil Space Applications
Intelligent Systems for National Security Space Applications I
Intelligent Systems for National Security Space Applications II

National Security Space
Advanced Concepts
Emerging Trends
Enterprise Architecting
Poster Session: National Security Space
Prototypes and Demos
Space and Technology Innovation
Technology Transition

Robotic Technology and Space Architecture
Habitation and Infrastructure
Integration of Human Systems with System Engineering
Planetary Surface Robotics
Poster Session: Robotic Technologies and Space Architecture
Space Architecture: Modular Design and Interfaces
Space Robotics
What Can Robotics Learn from Biology?

Space and Earth Science
VEGA Program
Future Space Telescopes
Poster Session: Space and Earth Science
NPOESS Preparatory Project Results & Implications for Future Observations
Earth Observing Satellites: Plans and Opportunities
NanoSat II: NanoSat Vision
NanoSat III: NanoSat Technologies and Applications

Space Colonization and Space Tethers
Space Colonization I
Space Colonization II
Space Tether Missions and Technologies

Space Exploration
Advanced Concepts for Exploration
Analysis of Exploration Architectures
Crew Mobility and EVA Systems
Cryogenic Systems for Exploration
Deep Space Habitation Systems
Demonstrating Exploration Systems
Human Exploration Beyond Earth Orbit
Nuclear Propulsion Systems for Exploration
Poster Session: Space Exploration I
Poster Session: Space Exploration II
Radiation Protection in Deep Space
Robotic Precursor Missions
Space Exploration Technologies

Space History, Society, and Policy
Delta Forum: Space Law as an Essential Ally
History and Future of Space Exploration
Poster Session: Space History, Society, and Policy
Space and Society
Space Policy
Sustaining the Vision: The Space Shuttles and Their Mission for the Next Hundred Years

Space Logistics and Supportability
Modeling and Analysis for Advanced Space Logistics and Supportability
Space Logistics and Supportability: Technology Development and Demonstration
Space Logistics Strategies: Multi-Mission Spacecraft, Reusing Flight Hardware, and Recycling Materials
Space Transportation and Logistics Infrastructures

Space Operations
New Challenges in Space Operations
Space Debris
Space Operations Best Practices
Space Operations Emerging Best Practices
Space Operations Technology

Space Resources
Stepping Stones Toward Commercial Utilization of the Natural Resources of Space
Using the Natural Resources of Space to Advance Space Exploration

Space Systems and Sensors
Designing and Building Space Sensors: Have We Lost the Recipe?
Hosted Payloads: Lessons, Challenges, and Opportunities
NanoSat I: NanoSat Mission Design
Poster Session: Space Systems and Sensors I
Poster Session: Space Systems and Sensors II - NanoSatellites
Space Sensors
Space Systems I
Space Systems II

Space Systems Engineering and Space Economics
Advances in Aerospace Concurrent Engineering
Advances in Trade Space Analysis
Cost, Risk, and Economics
Design of Systems
Poster Session: Space Systems Engineering and Space Economics I - Advances in Systems Engineering for Space Applications
Poster Session: Space Systems Engineering and Space Economics II: Selected Topics in Space Economics
Selected Papers/Presentations on Systems Engineering Topics
Trade Studies and Optimization

Space Transportation and Launch Systems
Advanced Propulsion Technologies
Commercial Crew and Cargo Transportation Development: COTS and CCDev
Current Launch Vehicles
Flight Performance of Resuable Responsive Space Access Vehicles
Launch Facilities and Operations
Launch Services
Poster Session: Space Transportation I
Poster Session: Space Transportation II
Reusable Responsive Space Access Vehicle Characteristics
Reusable Vehicles for Next Generation Responsive Space Access
Space Entrepreneurs
Space Launch Systems Update
Space Transporation Architectures II
Space Transportation Architectures I
Spaceports and Ranges

New and Forthcoming Titles

Morphing Aerospace Vehicles and Structures
John Valasek
Progress in Astronautics and Aeronautics Series, 240
2012, 300 pages, Hardback
ISBN: 978-1-60086-903-7
Member Price: $94.95
List Price: $ 134.95

Designing Unmanned Aircraft Systems: A Comprehensive Approach
Jay Gundlach
AIAA Education Series
2011, 805 pages, Hardback
ISBN: 978-1-60086-843-6
Member Price: $84.95
List Price: $109.95

Tactical and Strategic Missile Guidance, Sixth Edition
Paul Zarchan
Progress in Astronautics and Aeronautics Series, 239
2012, 900 pages, Hardback
ISBN: 978-1-60086-894-8
Member Price: $104.95
List Price: $134.95

Exergy Analysis and Design Optimization for Aerospace Vehicles and Systems
Jose Camberos and David Moorhouse
Progress in Astronautics and Aeronautics Series, 238
2011, 632 pages, Hardback
ISBN: 978-1-60086-839-9
AIAA Member Price: $89.95
List Price: $119.95

Introduction to Flight Testing and Applied Aerodynamics
Barnes W. McCormick
AIAA Education Series
2011, 148 pages, Hardback
ISBN: 978-1-60086-827-6
AIAA Member Price: $49.95
List Price: $64.95

Space Operations: Exploration, Scientific Utilization, and Technology Development
Craig A. Cruzen, Johanna M. Gunn, & Patrice J. Amadieu
Progress in Astronautics and Aeronautics Series, 236
2011, 638 pages, Hardback
ISBN: 978-1-60086-817-7
AIAA Member Price: $89.95
List Price: $119.95

Boundary Layer Analysis, Second Edition
Joseph A. Schetz and Rodney D. Bowersox
AIAA Education Series
2011, 678 pages, Hardback
ISBN: 978-1-60086-823-8
AIAA Member Price: $84.95
List Price: $114.95

Spacecraft Charging
Shu T. Lai
Progress in Astronautics and Aeronautics Series, 237
2011, 208 pages, Hardback
ISBN: 978-1-60086-836-8
AIAA Member Price: $64.95
List Price: $84.95

Engineering Computations and Modeling in MATLAB/Simulink
Oleg Yakimenko
AIAA Education Series
2011, 938 pages, Hardback
ISBN: 978-1-60086-781-1
AIAA Member Price: $79.95
List Price: $104.95

Introduction to Theoretical Aerodynamics and Hydrodynamics
William Sears
AIAA Education Series
2011, 220 pages, Hardback
ISBN: 978-1-60086-773-6
AIAA Member Price: $54.95
List Price: $69.95

Basic Helicopter Aerodynamics, Third Edition
John M. Seddon and Simon Newman
AIAA Education Series
2011, 264 pages, Hardback
ISBN: 978-1-60086-861-0
AIAA Member Price: $49.95
List Price: $74.95

Gas Turbine Propulsion Systems
Bernie MacIsaac and Roy Langton
AIAA Education Series
2011, 328 pages, Hardback
ISBN: 978-1-60086-846-7
AIAA Member Price: $84.95
List Price: $119.95

Order 24 hours a day at www.aiaa.org/books

AIAA Complex Aerospace Systems Exchange (CASE)

11–13 September 2012
Pasadena Convention Center
Pasadena, CA

CASE is a new event developed to address an imperative for the aerospace industry. AIAA leadership intends to make system-level issues and thinking a central component across the Institute's products and services. With this event, AIAA provides a forum for professionals working in complex system development to share problems and insights and bridge the gap between the technology and science of components and the integration and management skills needed to field successful aerospace systems of increasing complexity. CASE will help to articulate and shape the important issues facing this community so that future forums can continue the dialogue and effect progress in addressing real-world issues.

Message from the CASE Executive Chair

Design and development of complex systems is a central competence of our aerospace community, but it has not been the direct focus of any of our engineering disciplines or a regular topic at any of AIAA's conferences. This will change with a new event, the Complex Aerospace Systems Exchange (CASE), which is going to be held in parallel with the Space 2012 Conference in Pasadena this September. CASE will be an open discussion of the systems engineering and project management challenges we face each time we bring a new aerospace vehicle to life.

CASE is more than a new topic, it will be a new kind of meeting. We are calling it an "Exchange" because we expect the audience to generate at least half the bandwidth. Instead of paper presentations, CASE will consist of various forms of discussions, with many interactive panels and brief lightning talks. Participants will learn from each other, not just from the speakers.

I hope many of you will be able to experience this event, particularly chief engineers and project managers. I am supporting CASE as the Executive Chair, and we are fortunate to have Laura McGill as General Chair.

Mike Griffin, AIAA President

Benefits of Attendance

Why Attend

CASE addresses some of the most important system development issues facing aerospace chief engineers, program managers, and systems engineers today, such as minimizing cost overruns and delays, and mitigating late test failures. Participants will have the opportunity to hear insights, best practices, and lessons learned from recognized practitioners in each of these areas.

The structure of the event will be unlike existing AIAA conferences. With a greater emphasis on information and idea exchange among the best and brightest in the aerospace systems engineering arena than on technical paper presentations, CASE attendees can expect to leave the event with practical knowledge and ideas that are directly applicable to their daily work.

Who Should Attend

- Chief engineers and program managers of major aerospace systems, both corporate and government
- Current and aspiring system engineering practitioners
- Business managers
- Government acquisition, procurement, and oversight personnel
- System operators
- Supplier and sub-contractor project managers
- Component and subsystem design engineers looking to better understand how their work fits in a broader system context
- Academic researchers interested in state-of-the-art system engineering principles and requirements
- Mid-career professionals moving from technology into Integrated Project Team lead positions
- Early career professionals with an interest in system engineering disciplines and principles

What to Expect

- Hear multiple sides of complex issues rather than company "commercials" or one-dimensional insights.
- Be part of and shape the discussion rather than being a passive listener.
- Focus on a single track over the course of the event or mix and match the conversations in which you choose to participate.
- Leave this event with practical knowledge and ideas that you can apply to your work immediately.
- Participate in networking activities with other CASE participants, as well as SPACE 2012 participants:

— Opening Reception
— Networking Coffee Breaks
— Awards and Keynote Luncheons
— Young Professional Networking Reception
— Poster Sessions

	Sunday, 9 September	Monday, 10 September	Tuesday, 11 September	
0800 hrs	AIAA Continuing Education Courses	AIAA Continuing Education Courses	Opening Session and Keynote Address	
0830 hrs				
0900 hrs				
0930 hrs				Exposition Hall Open
1000 hrs			Networking Coffee Break	
1030 hrs			CASE Opening Plenary Session	
1100 hrs			CASE Track Panels & Presentations	
1130 hrs				
1200 hrs				
1230 hrs			Keynote Luncheon	
1300 hrs				
1330 hrs				
1400 hrs			CASE Track Panels & Presentations	
1430 hrs				
1500 hrs				
1530 hrs				
1600 hrs			Networking Coffee Break	
1630 hrs			CASE Track Panels & Presentations	
1700 hrs				
1730 hrs				
1800 hrs				
1830 hrs			Opening Reception and Poster Session	
1900 hrs				
1930 hrs				

KEY
Shared with SPACE 20012
CASE Specific

Program Overview

Track 1: Complex Systems Development

Society is challenged by the need to develop increasingly complex and critical aerospace systems successfully that meet stakeholders' needs within planned budgets and schedules. This track will focus on large system development activities from the establishment of requirements through the conceptual, preliminary, and detail design phases.

Session Topics

- Forensic Investigations I: Problems Rooted in Design
- Elegant Design and Complex Systems Development
- Forensic Investigations II: Problems Rooted in Program Direction
- New Paradigms for Complex Systems Development
- Collecting Our Thoughts: Complex Systems Development

Track 2: Integration, Test, and Verification of Complex Systems

Pressure to conduct affordable development programs requires that the integration of Complex Systems must be planned to significant detail well in advance of detailed design. This includes strategies to design and mature models, databases, simulations, and test equipment to support program needs that extend from bench testing of prototypes through flight testing on multiple ranges.

Session Topics

- Planning and Executing an Integration and Test Strategy for a Complex Aerospace System
- Integration of Modeling and Simulation, Ground Test and Flight Test
- Verification and Validation Issues
- Lessons Learned

Track 3: Program Management of Robust and Resilient Systems

Complex Aerospace systems require Program Management strategies and integrated planning tools to coordinate the activities of technical teams from multiple organizations that are physically separated but closely networked to work collaboratively and share common databases. Programs to develop and support Commercial and Military Aircraft, Spacecraft, Energy Systems, and UAVs are each

Wednesday, 12 September	
CASE Track Panels & Presentations	
Networking Coffee Break and Poster Session	Exposition Hall Open
CASE Track Panels & Presentations	
Awards Luncheon	
CASE Track Panels & Presentations	
Networking Coffee Break and Poster Session	
CASE Track Panels & Presentations	
William H. Pickering Lecture	

Thursday, 13 September	
CASE Track Panels & Presentations	
Networking Coffee Break and Poster Session	Exposition Hall Open
CASE Closing Session Track Report Outs & Closing Remarks	
Keynote Luncheon	

CASE and SPACE are colocated in 2012 and will be complementary to each other and will share some plenary sessions and networking activities such as luncheons and receptions. By registering for CASE, you can attend SPACE sessions and visit the Exposition at no extra cost. Please refer to the SPACE 2012 information on pages **B12-B19** for details about the registration, travel and accommodations, networking activities, Exposition, and special events.

subject to unique policy and regulatory issues. Managing the technical and direct support aspects in the development and operation of complex aerospace systems will be the focus of this Track. Other dimensions of managing complex systems in Track 3 will include the management and integration of business operations, logistics issues, and workforce infrastructure.

Session Topics

- Execution of Successful Programs
- New Acquisition & Regulatory Approaches
- Business Operations & Logistics
- Workforce Issues

More information: **www.aiaa.org/events/case**.

Executive Chair
Michael Griffin
King-McDonald Eminent Scholar & Professor
Director, Center for System Studies
University of Alabama in Huntsville

General Chair
Laura McGill
Chief Engineer, Air Warfare Systems
Raytheon Missile Systems

Program Chairs

Paul Collopy
UAH Center for System Studies

Allen Arrington
Sierra Lobo/NASA Glenn Research Center

Abdi Khodadoust
The Boeing Company

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

24–27 June 2013
Sheraton San Diego Hotel & Marina
San Diego, California

Abstract Deadline: 20 November 2012
Final Manuscript Deadline: 4 June 2013

Abstract Submittal Guidelines

Submittals should be at least 1,000 words and in the form of an extended abstract or draft paper; draft papers are encouraged. Submittals should clearly describe the purpose and scope of the work, the methods used, key results, contributions to the state of the art, and references to pertinent publications in the existing literature. The submittal should include figures and data that support the results and contributions asserted. Both abstracts and final papers should address adequately the accuracy of the numerical, analytical, or experimental results. Abstracts will be reviewed and selected based on technical content, originality, importance to the field, clarity of presentation, and potential to result in a quality full paper. As such, abstracts should describe clearly the work to be included in the full paper, its scope, methods used, and contributions to the state of the art. The abstract must include paper title, names, affiliations, addresses, and telephone numbers of all authors. It must also indicate on the front page the conference to which it is being submitted and the technical topic or category from the conference call for papers that best fits the paper, or mark "other" if appropriate.

Procedures for Abstract and Manuscript Submission

Abstracts will be due no later than **20 November 2012**. Authors will be notified of paper acceptance via email by **25 February 2013**. An Author's Kit, containing detailed instructions and guidelines for submitting papers to AIAA, will be made available to authors of accepted papers. Authors of accepted papers must provide a complete manuscript online to AIAA by **4 June 2013** for inclusion in the online proceedings and for the right to present at the conference. It is the responsibility of those authors whose papers or presentations are accepted to ensure that a representative attends the conference to present the paper. Sponsor and/or employer approval of each paper is the responsibility of the author. Government review, if required, is the responsibility of the author(s). Authors should determine the extent of approval necessary early in the paper presentation process to preclude paper withdrawals or late submissions.

Abstract submissions for the conference will be accepted electronically through AIAA's website at **www.aiaa.org/sandiego2013**. This website will be open for abstract submittal through **20 November 2010**.

Special Notes

1) If authors wish to revise an abstract that has already been submitted, they must go to "View Submissions" and select "Return to Draft" in order to make any corrections. This removes the abstract from the organizers' view. Authors then need to submit the abstract again for it to be considered. An abstract cannot be returned to draft if it has been reviewed.

2) Once the abstract submission deadline passes, authors will no longer be able to submit new submissions or return previous submissions to draft for revisions. Be sure that all of your submission data—authors, keywords, title, and abstract file—are accurate before finalizing your submission as no modifications can be made to this data after the submission site closes.

Authors having trouble submitting abstracts electronically should email AIAA technical support at **paper_tech_support@aiaa.org**. Questions about the abstract submission or full draft manuscript themselves should be referred to the appropriate Technical Chair.

"No Paper, No Podium" and "No Podium, No Paper" Policy

This conference has a "No Paper, No Podium" and "No Podium, No Paper" policy. Submittal of an abstract is interpreted as an intention to attend the conference and to present the final paper. If a written paper is not submitted by the final manuscript deadline, authors will not be permitted to present the paper at the conference. Also, if the paper is not presented at the conference, the paper will not be published and it will be withdrawn from the conference proceedings. Videotaped presentations will not be allowed. These policies are intended to eliminate no-shows and to improve the quality of the conference for attendees.

Warning—Technology Transfer Considerations

All authors are reminded that technology transfer guidelines have substantially extended the time required for review of abstracts and completed papers by government agencies. Internal (company) plus external (government) review can consume 16 weeks or more. Government review is the responsibility of the author. Authors should determine the extent of approval necessary early in the paper preparation process to preclude paper withdrawals and late submissions.

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.

Publication Policy

AIAA will not consider for presentation or publication any paper that has been presented or published previously or is currently under consideration for presentation or publication elsewhere. Authors will be required to sign a statement to this effect.

General inquiries concerning the program, format, or policies of the conference and suggestions for special high-interest informational presentations should be directed to the conference General Chair.

General Chair
Sergey Macheret
Lockheed Martin Corporation
Email: sergey.macheret@lmco.com

43rd AIAA Fluid Dynamics Conference and Exhibit

Papers are solicited in the areas of experimental, theoretical, and computational fluid dynamics relevant to aerospace applications, including basic research and development, applied research, and advanced technology development. Papers that present new insights into flow physics; introduce innovative applications; address emerging technical areas; or combine experimental, computational, and/or theoretical approaches are strongly encouraged. Authors who have recognized expertise in a particular area and are interested in writing a comprehensive review are encouraged to contact the track chair. Potential subject areas include, but are not limited to:

Fundamental Fluid Flows
- Hypersonic and chemically-reacting flows
- Turbomachinery, combustion and internal flows
- Cross-disciplinary fluid dynamics involving aero-optics, fluid/structure interactions, micro- and nano-fluidics, multi-material flows, and multiphase flows
- High-speed turbulent flows

Flow Control
- Active, passive, and closed-loop approaches
- Reduced-order modeling methods
- Sensors and actuators

Boundary-Layer Transition
- Low- and high-speed flows
- Roughness effects
- Control methods

Other Areas of Fluid Dynamics
In addition, sessions are planned in the following areas of interest:

- Turbulence: including free-shear, wall-bounded, and high-speed flows
- Shock-dominated flows: including shock boundary-layer interactions
- Low Reynolds-number flows: including biologically-inspired flight
- Wing Aerodynamics: including deformable wings and flapping wings

Authors should indicate under which of the above topics they prefer their paper to be included. In 2013, the Fluid Dynamics Conference and Exhibit will be held in conjunction with the Computational Fluid Dynamics Conference, among others. The technical areas of these two conferences overlap and multiple joint sessions are anticipated. Authors whose papers primarily address computational aspects of fluid mechanics are encouraged to consider the Computational Fluid Dynamics Conference for abstract submission.

Please direct questions to:

Fluid Dynamics Technical Program Chair
LaTunia Pack Melton
NASA Langley Research Center
757.864.1618
Email: latunia.p.melton@nasa.gov

44th AIAA Thermophysics Conference

The Thermophysics Technical Committee solicits abstracts of papers on topics in thermophysics and heat transfer. Papers are solicited on topics related to all aspects of thermal energy, heat transfer, and aerospace applications therein. Contributions related to analytical, numerical, and/or experimental studies are welcomed. Scientific and technical contributions are emphasized, rather than status reports on work in progress. Areas of specific interest include, but are not limited to:

- Ablation
- Aerothermodynamics
- Aircraft and spacecraft thermal management
- Computational heat transfer
- Cryogenics and cryogenic systems
- Direct simulation Monte Carlo methods
- Electronic and microelectronic thermal management
- Heat exchangers
- Heat pipes
- Heat transfer: conduction, convection, phase change, and radiation
- Heat transfer and cooling in turbomachinery
- High-speed flows
- Historical perspectives in thermophysics research
- Hypersonic and low density facilities
- Microgravity effects on thermal management systems
- Microgravity testing for aerospace applications
- Missile thermal management
- Molecular dynamics simulations
- Multiphase flows
- Nonequilibrium flows
- Nonequilibrium radiation
- Nonintrusive diagnostics
- Particle-laden flow modeling and measurement
- Plumes and combustion
- Power systems
- Propulsion
- Radiation analyses and surface properties
- Rarified flows
- Space environmental effects
- Spacecraft contamination
- Surface catalysis
- Test facility diagnostics and instrumentation
- Thermal challenges in lunar or planetary exploration
- Thermal contact conductance
- Thermal control
- Thermal protection systems
- Thermophysical properties
- Turbulent flow and heat transfer
- Others (please specify)

Emerging Topics
- Continuum methods for transition to rarefied flows
- Entropy generation minimization and the Second Law
- Integrated and multidisciplinary modeling and simulation
- MEMS and nanotechnologies
- Metamaterials
- Micro-scale heat transfer and micro-fluidics
- Wireless thermal measurements

Authors should indicate under which of the above topics they prefer their paper to be included. Abstracts should be submitted electronically to AIAA as directed in the general instructions for this call for papers. Potential authors should note that the submission of full manuscripts for consideration is encouraged. However, at a reduced chance of acceptance, authors can submit extended abstracts with a minimum word count as identified in the Abstract Submittal Guidelines that also include major results of the work backed by illustrative figures. A few succinct data figures that clearly show actual results are mandatory. Submissions not meeting these criteria will not be considered for acceptance. Authors are expected to attend the conference and present their papers.

Thermophysics Conference sessions will be coordinated with the collocated Applied Aerodynamics, Fluid Dynamics, Plasmadynamics and Lasers, and Atmospheric and Space Environments conferences. Authors with multiple submissions to these meetings are advised to alert the relevant Technical Program Chairs via email to minimize any scheduling conflicts.

Each year, the Thermophysics Technical Committee selects a best paper award for both the Professional and Student Categories (with the student receiving a monetary award).

Student submissions are strongly encouraged. Also, timely survey and review articles on the above topics are solicited. Authors are encouraged to submit their manuscripts, either before or after the meeting, to the *AIAA Journal of Thermophysics and Heat Transfer* for possible publication.

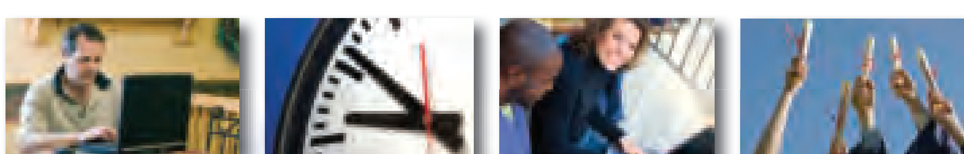
Please direct questions to:

Thermophysics Technical Program Chair
Patrick Yee
The Aerospace Corporation
310.336.0292
Email: patrick.p.yee@aero.org

44th AIAA Plasmadynamics and Lasers Conference

Papers are solicited describing basic and/or applied R&D in the areas of plasmadynamics and lasers. Contributions from theoretical, numerical, and/or experimental studies are welcomed, with special consideration given to works combing contemporary theoretical/computational analyses with experimental verification/validation. Papers reporting milestone R&D and/or engineering achievements related to the application of plasma and laser technologies in aerospace systems are of special interest. Authors interested in writing a comprehensive review of the current state of the art and/or historical perspectives are also desired. Potential topic areas include, but are not limited to:

- Plasma and Laser Physics: Including fundamental processes, laboratory plasma generation and characterization, experimental research or methods, plasma chemistry and kinetics, non-equilibrium reacting flows, and advances in theory and/or computational simulation methods
- Space Plasma Physics and Applications: Including spacecraft-plasma interactions, space laser applications, and space experiments
- Laser Devices and Systems: Including the physics, engineering, and application of high-energy lasers, chemical lasers, electric lasers, laser material interaction, laser optics, and fluid-optic interactions
- Highly Energetic Plasma Systems: Including the physics, engineering, and application of high-power gas discharge and plasma generation devices, arc-heater technology, explosively-generated plasma applications, compact pulse power, and high temperature systems and environments
- Magnetohydrodynamics (MHD): Including MHD power generation and propulsion technologies, terrestrial and aerospace systems applications, combustion plasma methods, innovative non-equilibrium plasma techniques, nuclear MHD systems, electromagnetic fluid interaction and characterization, fundamental processes, and theoretical and/or computational simulation methods
- Plasma and Laser Propulsion: Including innovative and efficient plasma formation and acceleration approaches, high power thruster concepts, electrode erosion issues, electrodeless discharge mechanisms, modeling of fundamental processes, experimental performance characterization, and beamed energy propulsion



- Plasma Materials Processing and Environmental Applications: Including exhaust gas treatment, remediation, and hazardous materials disposal
- Advanced Diagnostics: Including the development and utilization of laser-based diagnostics, flow field characterization methods, and plasma diagnostics
- Weakly Ionized Plasma Physics and Aerospace Applications: Including plasma actuators for aerodynamic flow control, and plasma-assisted combustion
- Fluid-Optics Interactions: Including the propagation of laser beams through the atmosphere and the effects of aerodynamics on the transmission of laser beams
- Fusion Energy Science: Including emerging confinement concepts for terrestrial or in-space power or propulsion, experimental programs, enabling technologies, instrumentation and diagnostic development, computational or theoretical modeling, and mission analysis

Papers concerning dual-use technologies, which address non-aerospace issues of major public concern, such as energy, environment, and medicine are strongly encouraged. Suggestions for invited papers and joint sessions are welcome also.

Students are strongly encouraged to present papers on their research at this meeting. An accepted paper whose principal author is a student and is delivered by that student will be considered for a "Best Student Paper Award." Please identify the principal author as a student (graduate or undergraduate student) at the time the abstract is submitted.

Comprehensive abstracts that state the purpose and scope of the work, outline the methods used, and identify relevant contributions, including figures and preliminary results, are recommended for accurate evaluation.

Please direct questions to:

Plasmadynamics and Lasers Technical Program Chair
Nicholas Bisek
Wright-Patterson Air Force Base
937.255.2061
Email: Nicholas.Bisek@wpafb.af.mil

31th AIAA Applied Aerodynamics Conference

The Applied Aerodynamics Technical Committee is soliciting papers on topics related to aerodynamic design, vehicle aerodynamics, and aerodynamic phenomena, including, but not limited to:

- Unsteady aerodynamics
- Vortical/vortex flow
- High angle-of-attack and high lift aerodynamics
- Transonic and supersonic aerodynamics
- Recent hypersonic vehicle and aerodynamic advances
- Sonic boom mitigation
- Low-speed, low-Reynolds number aerodynamics
- Bio-inspired aerodynamics
- Unmanned and solar powered aerial vehicle designs/tests
- Airfoil/wing/configuration aerodynamics
- Weapons aerodynamics: missile/projectile/guided-munitions, carriage and store separation
- Innovative aerodynamic concepts and designs
- Aerodynamic and multidisciplinary design and optimization methods
- Wind tunnel and flight testing aerodynamics
- Active and passive flow control
- Aerodynamic-structural dynamics interaction
- Applied CFD with correlation to experimental data
- Propeller/rotorcraft/wind turbine aerodynamics
- VSTOL/STOL aerodynamics
- Icing or roughness effects on vehicle aerodynamics
- Environmentally friendly and efficient aerodynamics and enabling technology
- Other topics in applied aerodynamics

Authors should indicate under which of the above topics they prefer their paper to be included.

Please direct questions to:

Applied Aerodynamics Technical Co-Chair
Kenrick Waithe
Gulfstream Aerospace Corporation
Email: kenrick.waithe@gulfstream.com

Applied Aerodynamics Technical Co-Chair
Chunhua Sheng
University of Toledo
Email: chunhua.sheng@utoledo.edu

Applied Aerodynamics Technical Co-Chair
Li Wang
University of Tennessee at Chattanooga
Email: Li-Wang@utc.edu

21st AIAA Computational Fluid Dynamics Conference

The 21st AIAA Computational Fluid Dynamics Conference is being held in conjunction with the 43rd AIAA Fluid Dynamics Conference to enable close synergism and interaction among a broad range of research disciplines in fluid dynamics. The CFD Conference will feature the 5th AIAA CFD Student Paper Competition (see details below).

The Fluid Dynamics and the Meshing, Visualization, and Computational Environments (MVCE) Technical Committees solicit papers covering all aspects of computational fluid dynamics particularly relevant to aerospace applications. Topics may range from basic research and development to applied and advanced technology. Contributions describing advances in the development of computational methods, in-depth reviews, and timely surveys are sought. Of particular interest are papers dealing with interdisciplinary topics in which CFD plays a predominant role. Also considered will be state-of-the-art applications that significantly challenge current CFD capabilities and give insight to algorithm and methodology characteristics. As in past conferences, the major emphasis of the conference will be on new or improved algorithms and implementations for the computational analysis of fluid dynamics problems.

Technical topics and categories include, but are not limited to, the following:

- Grid generation and geometry definition for complex configurations
- Solution adaptive grid techniques
- Numerical algorithms for inviscid and viscous flows, including both continuum approaches (finite-volume, finite-element, etc.) and particle methods (lattice-Boltzmann, direct simulation Monte Carlo, etc.)
- Numerical methods and convergence acceleration
- Effects of grid quality on solution accuracy
- Numerical error estimation and uncertainty quantification in CFD
- High-order methods
- Shock capturing schemes (including high-order methods designed to capture shocks)
- Numerical treatment of boundary conditions, including immersed boundary methods
- Lagrangian and vortex methods
- Parallel computing
- Unsteady flow computation
- Reynolds Averaged Navier-Stokes (RANS) models of turbulence

- Large-eddy simulation (LES), direct numerical simulation (DNS), and hybrid RANS/LES methods
- High-speed and chemically reacting flows
- Multi-phase flows
- Design optimization techniques that require extensive CFD and coupling/linkage methods
- Interdisciplinary methods including CFD (flow control, fluid-structure interaction, fluid-thermal interaction, etc.)
- Scientific visualization, data mining, and simulation data analysis techniques

The program will consist of invited and contributed papers. Authors interested in writing a comprehensive review are encouraged to contact the Technical Program Chair by the submission deadline to schedule a half-hour or hour-long presentation. Final manuscripts will be included in the conference proceedings.

5th AIAA CFD Student Paper Competition

The 5th AIAA CFD Student Paper Competition provides students the opportunity to share their work on CFD study and research. Participation is open to all full-time undergraduate and graduate students pursuing a degree in an engineering or scientific discipline at an accredited college or university. Each participant must be a student at the time the abstract is submitted. For an accepted abstract, a final paper is required. The student must be the major contributor and the first author of the final paper, and make the presentation of the paper at the conference. Awards are based on a combination of the extended abstract (initial screening), the final conference paper, and the presentation. Criteria for judging include the work's importance in advancing the state of the art; the technical approach; rationale; sufficient and consistent results; verification and validation; what was learned; as well as presentation and paper style, clarity, and format. The student(s) must write the paper and prepare the presentation slides themselves. A cash prize of $600 will be awarded to the first place winner, $300 to second place, and $150 to third place. The results will be announced after the CFD Conference. Certificates and checks will be mailed to the winners. All submissions must meet submission deadlines for the CFD Conference given in the general information section of this Call for Papers. Entrants should select the appropriate technical topic listed in this CFD Conference call, and must select "Student Paper Competition" as the presentation type upon submission. Please also note on the title page that the paper is a "Student Paper Competition Entry." The papers submitted to the CFD Student Paper Competition will be presented in regular technical sessions with other papers in their topic area. Student Paper Competition entries will be treated as regular AIAA conference papers in the conference proceedings and will be archived as AIAA papers.

All authors for both the CFD Conference and the CFD Student Paper Competition should indicate under which of the above topics they prefer their paper to be included. Abstracts should be submitted electronically to AIAA as directed in the general instructions for this Call for Papers. Please note that the extended abstract minimum word count is identified in the Abstract Submittal Guidelines at the beginning of this Call for Papers.

Sessions will be coordinated with the Applied Aerodynamics, Atmospheric and Space Environments, Fluid Dynamics, Plasmadynamics and Lasers, and Thermophysics conferences that are collocated with the Computational Fluid Dynamics Conference. Authors with multiple submissions to these meetings should alert the relevant technical chairs via email in order to minimize any scheduling conflicts.

Please direct questions to:

Computational Fluid Dynamics Technical Program Chair
H. T. Huynh
NASA Glenn Research Center
216.433.5852
Email: huynh@grc.nasa.gov

5th AIAA Atmospheric and Space Environments Conference

Papers are sought that provide the aerospace community (aviation, rockets, launch vehicles, and spacecraft) with scientific and technical information concerning interactions between aerospace systems and the atmospheric/space/planetary environment. In addition, new or refined information improving the basic understanding of the atmosphere, space, planets, or their applications to aviation and aerospace vehicle design and operations issues is solicited. Atmospheric and Space Environments includes the areas of:

- Aircraft Icing: Aerodynamic degradation (including rain effects, etc.); certification policies and procedures; computational modeling; flight and ground testing; techniques and facilities; ice protection systems and sensors; ice accretion physics and scaling; ground de-icing; icing education and training, icing environment characterization including in situ measurements, remote sensing, and forecasting.
- Atmospheric Environment: Development and implementation of environmental models in aviation and space vehicle design including operations within the atmosphere and orbital environment.
- Aircraft Wake Vortex Technology: Observations; modeling; atmospheric effects; operational implementation to optimize traffic rates and flight safety.
- Atmospheric Dynamics: Meso- and micro-scale modeling and observations to characterize the nature of aviation weather hazards and their expected time, location, and intensity more accurately.
- Aviation Weather Accident Prevention: Includes present safety statistics as well as improved concepts for measurement, prediction, and display systems for icing, turbulence, wind shear, wake vortices, hail, lightning, low ceiling, and visibility hazards.
- Green Aviation: Assessment of the impacts of aviation on climate and air quality; improvements in environmental observations and models to quantify and monitor environmental impact; atmospheric radiation, chemistry and contrail studies; environmental impacts of improved and alternative designs for airframes, propulsion systems, and fuels.
- Meteorological Applications to Aerospace Operations: Basic design criteria and design verification; day of launch procedures; launch commit criteria; economic impact of weather information on operations; severe storms; communication of weather information to flight crews; improved techniques for extrapolation and short-term forecasting; cloud-free line-of-sight observations, and forecasting. Additional topics include the upper atmospheric environment, space weather and atmospheric ionizing radiation, aviation weather and range meteorology, AIM Weather Integration, and impacts of aviation on climate and air quality are also sought.
- Space-, Aircraft-, and Ground-Based Measurement Systems: Earth-observing systems including measurements, monitoring, modeling, and assessment; data and information systems requirements for global climate change research; remote sensing of land and oceans; remote and in situ sensors for tropospheric, stratospheric, mesospheric, and thermospheric investigations; evaluation of advanced instrument concepts; and sensor evaluation including performance, calibration, validation, and verification.

- Environment Standards: Reference and standard atmosphere and other environment model developments for aviation and space vehicle design and operations within the Earth's atmosphere, including on-orbit environment.
- Meteoroid and Debris Environment: Description of on-orbit and deep space meteoroid and debris model developments, applications, and effects on satellites and spacecraft relative to technical, programmatic, and political issues.
- Space Environment: Plasma, neutral, and radiation environments in the magnetosphere, ionosphere, and the Van Allen radiation belts; correlation between space weather and troposphere weather; impacts of space weather on space systems and on climate; space environment ground or flight experiments. Planetary space, surface, and atmospheric environments are also of interest.
- On-Orbit Spacecraft–Environmental Interactions: Interactions of spacecraft and the on-orbit environment. Environments of interest include the environment in the absence of the spacecraft (i.e., natural) and the induced neutral and charged environments.
- Spacecraft Charging: Collection of charged particles on spacecraft surfaces and within non-conductive materials. The topic includes anomalous behavior due to induced electric fields, electrostatic discharges, material interactions, and fault mitigation strategies.
- Natural environment definitions for space vehicle design and development.
- Surface Environments of Planets, Moons, Asteroids, and Comets: Characterization of the environments of the surface of planets, moons, asteroids, and comets as well as their ground-based simulation. This includes descriptions of the dust, electrostatic fields, radiation environment, and the like. Of particular interest are effects on spacecraft, rovers, habitats, and other human and robotic exploration systems, and methods to mitigate those effects.

Other areas of atmospheric environment pertinent to aircraft and aerospace vehicle applications are also welcome.

Abstracts should be submitted electronically to AIAA as directed in the general instructions for this call for papers. An abstract of at least 1,000 words, with key figures and references to pertinent publications in the existing literature, is required. Authors must identify clearly in the abstract new or significant aspects of their work. The submission of a draft of the paper instead of an abstract is encouraged. The draft paper should include key figures that illustrate the primary intent of the author's message. Dummy figures are acceptable if final data are not available, provided that final data will be submitted with the manuscript. The review and acceptance process will be weighted in favor of those authors submitting more relevant documentation of their proposed papers. The length of the final paper should be appropriate for a conference paper—not a major project, final report, or final thesis.

Please direct questions to:

Atmospheric and Space Environments Technical Co-Chair
Marcia Politivich
National Center for Atmospheric Research
Research Applications Lab
303.497.8449
Email: marcia@ucar.edu

Atmospheric and Space Environments Technical Co-Chair
Nelson W. Green
Jet Propulsion Laboratory
818.393.6323
Email: Nelson.W.Green@jpl.nasa.gov

AIAA Ground Testing Conference

The Ground Testing Technical Committee (GTTC) solicits abstracts of proposed papers for the Ground Testing Conference. We encourage submission of paper abstracts for research related to all aspects of the science, technology, and application of ground testing and aerodynamic measurements, from basic research, to measurements for understanding complex flows, to facility development, to system test and evaluation, to sustainment and advancement of capabilities. The following are general areas where papers are sought: 1) measurement and testing technology research and development; 2) advances in ground test capability; 3) operations and policy; and 4) ground test facilities infrastructure sustainment. Papers that address the interface between measurement and testing, such as the transfer of advanced diagnostics from research laboratories to test facilities and the lessons learned, are encouraged. A more detailed description of these four general areas of interest is:

Measurement and testing technology research and development in support of ground testing
- Advances in non-intrusive methods of flow property and chemistry measurements
- Advances in surface measurement techniques for boundary-layer transition, skin friction, heat transfer, and surface temperature and pressure
- Development and application of MEMS-based measurement technology
- Miniaturization of aerodynamic probes
- Development of techniques for acquiring multiple flow properties
- Improvements in uncertainty analysis for advanced diagnostic techniques
- Development of new experimental methods
- Presentation of work in progress and/or completed work directed to new techniques
- Transition from laboratory to test facility

Advances in ground test capability
- Development of new and/or improved facilities and associated systems
- Advances in measurement techniques and calibration methodology
- Improvements in flow quality
- Projecting of requirements
- Innovations in experiment design and post-test analysis
- Development of automation sciences applications
- Integration of modeling and simulation
- Improvements in ground test support and integration
- Developments in test facility and data networking

Operations and policy
- Personnel and their skills
- Organization, economic considerations, metrics
- Transition process to new measurement techniques
- Working relationships and alliances, industry/government/academia interface
- Test process improvement, standardization
- Safety and environmental compliance issues
- Communications and data transfer, information security
- Agency policies

Ground test facilities infrastructure sustainment
- Integrated operations and maintenance
- Consolidation of existing ground test facilities
- Best practices in maintenance and capability sustainment
- Prioritization and work selection process with limited budgets
- Strategic investment planning

In keeping with the multidisciplinary nature of this call for papers, there will be several sessions held in conjunction with the other colocated conferences (e.g., Fluid Dynamics). For these sessions, papers are sought in any areas where the conferences have overlapping interests, but the following areas are of particular interest:

Fluid Dynamics

- Use of large data sets from modern measurement techniques to provide greater insight into the dynamics of fluid motion
- Survey papers describing aspects of experimental techniques important to the CFD community
- Survey papers describing aspects of computational methods important to experimentalists assessing and utilizing CFD results

Information pertaining to the above broad categories for measurement of data, testing peculiar to any speed range (low speed to hypervelocity), and for any type of ground test will be considered. Sessions will be organized within the above broad categories according to discipline and speed range, depending on the response to this call for papers. The sessions will include invited papers as well as contributed presentations. The Ground Test Technical Committee will award certificates for the best papers in the ground test sessions, based on feedback from the session chairs.

Please direct questions to:

Ground Test Technical Chair
Victor A. Canacci
Jacobs Technology, Inc.
NASA Glenn Research Center
216.433.6222 • 216.433.6414 FAX
Email: victor.a.canacci@nasa.gov

Upcoming AIAA Professional Development Courses

14–15 June 2012
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 10 May 2012	*Standard (11 May–8 Jun)*	*On-site (9–14 Jun)*
AIAA Member	$885	$1050	$1190
Nonmember	$995	$1155	$1295

The Space Environment—Implications for Spacecraft Design (Instructor: Alan Tribble)

This course provides an introduction to the subject of spacecraft-environment interactions, also known as space environments and effects or space weather effects. It addresses each of the major environments: vacuum, neutral, plasma, radiation, and micrometeoroid/orbital debris. In each section, the basic physics behind the environment is reviewed, but the emphasis is on quantifying the magnitude of the various interactions and identifying mitigation techniques and design guidelines.

1 July–31 December 2012
2012 Home Study Courses
To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**

Intro to Computational Fluid Dynamics (Instructor: Klaus Hoffmann)

This introductory course is the first of the three-part series of courses that will prepare you for a career in the rapidly expanding field of computational fluid dynamics.

Advanced Computational Fluid Dynamics (Instructor: Klaus Hoffmann)

This advanced course is the second of the three-part series of courses that will prepare you for a career in the rapidly expanding field of computational fluid dynamics.

Computational Fluid Turbulence (Instructor: Klaus Hoffmann)

This advanced course is the third of the three-part series of courses that will prepare you for a career in the rapidly expanding field of computational fluid dynamics with emphasis in fluid turbulence. Completion of these three courses will give you the equivalent of one semester of undergraduate and two semesters of graduate work.

Introduction to Space Flight (Instructor: Francis J. Hale)

By the time you finish this course, you will be able to plan a geocentric or interplanetary mission to include the determination of suitable trajectories, the approximate velocity budget (the energy required), the approximate weight (mass) and number of stages of the booster, and the problems and options associated with the terminal phase(s) of the mission.

Fundamentals of Aircraft Performance and Design

(Instructor: Francis J. Hale)

This course will give you an introduction to the major performance and design characteristics of conventional, primarily subsonic, aircraft. At the end of the course, you will be able to use the physical characteristics of an existing aircraft to determine both its performance for specified flight conditions and the flight conditions for best performance.

Introduction to Computational Fluid Dynamics		
	Early Bird by 1 Jun	*Standard (2 Jun–1 Jul)*
AIAA Member	$1140	$1250
Nonmember	$1245	$1355

Advanced Computational Fluid Dynamics		
	Early Bird by 1 Jun	*Standard (2 Jun–1 Jul)*
AIAA Member	$1185	$1295
Nonmember	$1290	$1400

Computational Fluid Turbulence		
Early Bird by 1 Jun		*Standard (2 Jun–1 Jul)*
AIAA Member	$1245	$1350
Nonmember	$1350	$1455

Introduction to Space Flight		
	Early Bird by 1 Jun	*Standard (2 Jun–1 Jul)*
AIAA Member	$1050	$1190
Nonmember	$1155	$1295

Fundamentals of Aircraft Performance and Design		
	Early Bird by 1 Jun	*Standard (2 Jun–1 Jul)*
AIAA Member	$1050	$1190
Nonmember	$1155	$1295

9–10 July 2012
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 4 Jun	*Standard (5 Jun–2 Jul)*	*On-site (3–9 Jul)*
AIAA Member	$885	$1050	$1190
Nonmember	$995	$1155	$1295

Optimal Design in Multidisciplinary Systems

(Instructors: Prabhat Hajela and J. Sobieski)

When you are designing or evaluating a complicated engineering system such as an aircraft or a launch vehicle, can you effectively reconcile the multitude of conflicting requirements, interactions, and objectives? This course discusses the underlying challenges in such an environment, and introduces you to methods and tools that have been developed over the years.

14–15 July 2012

The following Continuing Education class is being held at the 42nd International Conference on Environment Systems in San Diego, California. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

To register for the ICES course, go to **www.aiaa.org/ICES2012.**

	Early Bird by 18 Jun	*Standard (19 Jun–13 Jul)*	*On-site (14–15 Jul)*
AIAA Member	$1288	$1388	$1488
Nonmember	$1365	$1465	$1565

Spacecraft Design & Systems Engineering (Instructor: Don Edberg, Professor of Aerospace Engineering, California State Polytechnic Univ. Pomona, Redlands, CA)
This course presents an overview of factors that affect spacecraft design and operation. It begins 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. 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.

2–3 August 2012

The following Continuing Education classes are being held at the 48th AIAA/ASME/SAE/ASEE Joint Propulsion Conference in Atlanta, Georgia. 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 courses, go to **www.aiaa.org/JPC2012.**

	Early Bird by 2 Jul	*Standard (3–28 Jul)*	*On-site (29 Jul–2 Aug)*
AIAA Member	$1265	$1365	$1465
Nonmember	$1343	$1443	$1543

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

Advanced Solid Rockets (Course is sponsored and taught by the distinguished members of the AIAA Solid Rockets Technical Committee, lead by David Poe, Aerojet)
Solid propulsion is vital to tactical, space, strategic, and launch vehicles. The course examines fundamental and advanced concepts related to solid rockets. Theoretical and practical aspects of the field are covered. This course is based on the "Advanced Solid Rocket Propulsion" graduate-level mechanical engineering course taught at the University of Alabama at Huntsville (UAH). All instructors are experienced solid rocket experts and many were involved with the UAH course. The individual presentations included in this short course include broad rocket motor and system design principles, internal ballistics modeling, propellant fundamentals, component design (motor case, nozzle, and igniters), component and motor manufacturing, combustion instability, and motor failures.

Hydrogen Safety (Instructors: Steve Woods, NASA White Sands Test Facility, Las Cruces, NM; Miguel Maes, Las Cruces, NM; Stephen Mcdougle)
This course is intended to provide the student with a working knowledge of safety issues associated with the use of hydrogen. Using the aerospace industry standard, "Guide to Safety of Hydrogen and Hydrogen Systems" (AIAA G-095-2004), this course presents basic safety philosophy and principles and reviews a practical set of guidelines for safe hydrogen use. The information presented in this course is intended as a reference to hydrogen systems design and operations and handling practices; users are encouraged to assess their individual programs and develop additional requirements as needed.

NPSS: A Practical Introduction (Instructor: Paul Johnson, Wolverine Ventures, Fort Wayne, IN; Edward Butzin, Wolverine Ventures, Jupiter, FL; Dr. Ian Halliwell, Senior Research Scientist, Avetec, Heath, OH)
This course will give attendees a working knowledge of NPSS software and allow them to create and/or modify system models using this tool. The course material will discuss the object-oriented architecture and how it is used in NPSS to develop flexible yet robust models. A detailed presentation of NPSS execution options, syntax, and interfaces with external codes will be addressed. Overviews of NPSS operation (i.e., Solver, etc.) will also be included. Attendees will be interactively involved with the material by performing exercises on their personal hardware that demonstrates and clarifies the material being discussed in the lecture. All attendees will be provided with a reduced capability version of NPSS for their use during the course and will be permitted to keep it after the course is completed.

Missile Design and System Engineering (Instructor: Eugene Fleeman, International Lecturer, Lilburn, GA)
This course provides the fundamentals of missile design, development, and system engineering. A system-level, integrated method is provided for missile configuration design and analysis. It addresses the broad range of alternatives in satisfying missile performance, cost, and risk requirements. Methods are generally simple closed-form analytical expressions that are physics-based, to provide insight into the primary driving parameters. Configuration sizing examples are presented for rocket, turbojet, and ramjet-powered missiles. Systems engineering considerations include launch platform integration constraints. Typical values of missile parameters and the characteristics

of current operational missiles are discussed as well as the enabling subsystems and technologies for missiles. Sixty-six videos illustrate missile development activities and performance. Attendees will vote on the relative emphasis of types of targets, types of launch platforms, technical topics, and roundtable discussion.

6–7 August 2012
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 2 Jul	*Standard (3–30 Jul)*	*On-site (31 Jul–6 Aug)*
AIAA Member	$885	$1050	$1190
Nonmember	$995	$1155	$1295

Systems Requirements Engineering **(Instructor: John Hsu)**
Requirements analysis and specification development are the most important contribution at the onset of a program/project. It will set a corrective direction to guide the program/project preventing the later-on redesign and rework. This course will familiarize you with an effective method for defining a set of requirements of a system. The focus is on the initial problem space definition, defining user needs, concept of operations, systems, segment, subsystem requirements, and architecture. Gain an understanding of the following requirements engineering activities: elicitation of requirements, system requirements analysis, requirements integration, interface requirements and control, functional analysis and architecture, requirements management, and verification and validation of requirements. Learn about the principles and characteristics of organizing a well-written requirements and specifications.

11–12 August 2012
The following Continuing Educations courses are being held at the AIAA Guidance, Navigation, and Control et al. Conferences in Minneapolis, MN. 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 courses, go to **www.aiaa.org/GNC2012.**

	Early Bird by 16 Jul	*Standard (17 Jul–10Aug)*	*On-site (11–12 Aug)*
AIAA Member	$1243	$1343	$1443
Nonmember	$1348	$1448	$1548

Flight Vehicle System Identification in Time Domain **(Instructor: Ravindra Jategaonkar, Senior Scientist and Group Leader, German Aerospace Center, DLR-Institute of Flight Systems, Braunschweig, Germany)**
The scope of application of system identification methods has increased dramatically during the last decade. The advances in modeling and parameter estimation techniques have paved the way to address highly complex, large-scale, and high fidelity modeling problems. This two-day course will review the recent advances in the time-domain methods of system identification from flight data, both from the theoretical and practical viewpoints. Starting from the fundamentals, a systematic approach will be presented to arrive at the solution. Benefits derived from flight validated models applying system identification will be highlighted. The course will provide an overview of key methods of parameter estimation in time domain, cover many examples covering both fixed-wing and helicopter applications, and address model validation in both time and frequency domain. It will be supplemented with an overview of software tools available.

Atmospheric Flight Dynamics and Control **(Instructor: David Schmidt, Professor Emeritus, University of Colorado, Monument, CO)**
The course covers all five aspects of flight dynamics and control in an integrated format—the equations of motion; aerodynamic modeling; steady-state analysis and control power; dynamic and modal analyses including modal approximations; and synthesis of stability-augmentation and autopilot control laws. The course contains a clear, rigorous, yet practical treatment of conventional topics dealing with rigid vehicles, while also addressing the flight dynamics and control of elastic vehicles extensively. Key topics include the rigorous derivation of the equations of motion for rigid and flexible aircraft via Newton and Lagrange; a review/tutorial on lumped-mass vibrations including rigid-body degrees of freedom; modeling the effects of static and dynamic elastic deformation on the forces and moments; modal analysis of rigid and flexible vehicles; elastic effects on vehicle control (e.g., filtering, sensor, and actuator placement); a case study on active structural mode control; plus other examples involving a flexible hypersonic vehicle and large flexible aircraft. The material on flexible vehicles is presented from a "flight-dynamics" rather than a "structural-dynamics" perspective. An integrated treatment of linear dynamic models is used throughout. Typical autopilot control laws are synthesized using loop-shaping techniques, including discussions of typical sensors and gain scheduling. The student is introduced briefly to the classical "crossover" pilot model and its implications regarding flight control. MATLAB® and Simulink are used extensively in the many examples involving real aircraft.

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)**
Adaptive control is 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 reviews a number of well-established methods in MRAC. Starting with MRAC problem formulation and an overview of classical robustness and stability modifications, the course will introduce the adaptive loop recovery approach that allows the approximate retention of reference model loop properties such as relative stability margins. We 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.

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.

Fundamentals of Tactical and Strategic Missile Guidance (Instructor: Paul Zarchan, Technical Staff, MIT Lincoln Laboratory, Newton, MA)
Whether you work in the tactical world or the strategic world, this course will help you understand and appreciate the unique challenges of each. So everyone can clearly understand the principles of both tactical and strategic missile guidance, concepts are derived mathematically, explained from a heuristic perspective, and illustrated with numerical examples. Material is presented so that participants with different learning styles can benefit. The course will be of value to both novices and experts wanting to learn more about missile guidance and to understand its importance to system design.

Optimal State Estimation (Instructor: Dan Simon, Professor, Cleveland State University, Cleveland, OH)
After taking this course, the student will be able to apply state estimation techniques in a variety of fields confidently. This course includes: 1) A straightforward, bottom-up approach that begins with basic concepts, and then builds step-by-step to more advanced topics; 2) Simple examples and problems that require paper and pencil to solve, which leads to an intuitive understanding of how theory works in practice; and 3) MATLAB®-based state estimation source code for realistic engineering problems, which enables students to recreate state estimation results and experiment with other simulation setups and parameters. After being given a solid foundation in the fundamentals, students are given a careful treatment of advanced topics, including H-infinity filtering, unscented filtering, high-order nonlinear filtering, particle filtering, constrained state estimation, reduced order filtering, robust Kalman filtering, and mixed Kalman/H-infinity filtering.

Six Degrees of Freedom Modeling of Missile and Aircraft Simulations (Instructor: Peter Zipfel, University of Florida, Shalimar, FL)
This course will introduce you to modeling aerospace vehicles in six degrees of freedom (6 DoF). Starting with the modern approach of tensors, the equations of motion are derived and, after introducing coordinate systems, they are expressed in matrices for compact computer programming. Aircraft and missile prototypes will exemplify 6 DoF aerodynamic modeling, rocket and turbojet propulsion, actuating systems, autopilots, guidance, and seekers. These subsystems will be integrated step by step into full-up simulations. Typical fly-out trajectories will be run and projected on the screen. The provided source code and plotting programs lets you duplicate the trajectories on your PC (requires FORTRAN or C++ compiler). With the provided prototype simulations, you can build your own 6 DoF aerospace simulations.

13–14 August 2012
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 6 July2012	*Standard (7 Jul–3 Aug)*	*On-site (4–13 Aug)*
AIAA Member	$885	$1050	$1190
Nonmember	$995	$1155	$1295

Computational Aeroacoustics: Methods and Applications (Instructors: Christopher Tam and Sarah Parrish)
This course examines the computational issues that are unique to aeroacoustics. Course materials consist of three parts: introduction, CAA methods, and applications. The purpose of the introduction is to provide a brief review of the field of aeroacoustics; the issues and problem areas. CAA methods form the main component of the course. A number of applications are discussed to illustrate how CAA methods are used in realistic and practical problems. By definition, CAA problems are time dependent and usually contain high frequency components. Because of the nature of sound, one would like to be able to compute CAA problems with as few number of mesh points per wavelength as possible. These characteristics of CAA problems are very different from fluid flow problems, so specially developed CAA methods are needed. Students will be introduced to these methods.

27–29 August 2012
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 23 Jul	*Standard (24 Jul–20 Aug)*	*On-site (20–27 Aug)*
AIAA Member	$1085	$1250	$1390
Nonmember	$1195	$1355	$1495

Space Environment and its Effects on Space System
(Instructor: Vincent L. Piscane)
This course is intended to serve two audiences: 1) those relatively new to the design, development, and operation of spacecraft systems and 2) experts in fields other than the space environment who wish to obtain a basic knowledge of the topic. The topics and their depth are adequate for the reader to address the environmental effects on spacecraft instruments or systems to at least the conceptual design level. Topics covered include spacecraft failures, solar system overview, Earth's magnetic and electric fields, Earth's neutral environment, Earth's plasma environment, radiation interactions, contamination, and meteorites and orbital debris.

11–12 September 2012
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 7 Aug 2012	*Standard (8 Aug–4 Sep)*	*On-site (5–11 Sep)*
AIAA Member	$885	$1050	$1190
Nonmember	$995	$1155	$1295

Robust Aeroservoelastic Stability Analysis
(Instructor: Richard Lind)
This course will introduce the concept of robustness to the study of flutter and aeroservoelasticity. The models that are traditionally used for stability analysis are augmented with uncertainties to reflect potential errors and unmodeled dynamics. The mu method is developed to account directly for these uncertainties. The resulting robust stability margin is a worst-case measure of the smallest flutter speed for the system as effected by any of the uncertainty values. This course demonstrates the procedure for formulating a model in the mu framework and computing the associated robust stability margin. Furthermore, the course discusses methods to compute uncertainties in the models based on flight data analysis. Several applications from recent flight tests are presented for which the mu method was used to compute robust aeroservoelastic stability margins.

9–10 September 2012

The following Continuing Educations courses are being held at the AIAA SPACE 2012 Conference in Pasadena, 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 SPACE courses, go to **www.aiaa.org/space2012.**

	Early Bird by 13 Aug	*Standard (14 Aug–8 Sep)*	*On-site (9–10 Sep)*
AIAA Member	$1338	$1438	$1538
Nonmember	$1443	$1543	$1643

Systems Engineering Verification and Validation **(Instructor: John Hsu, Technical/Project Manager and Principal Investigator, The Boeing Company, Cypress, CA)**
This course will focus on the verification and validation process, which plays a key role from the very beginning through the final stages of the systems engineering task for a program or project. It will clarify the distinctions between verification and validation, and discuss validating requirements and generating verification requirements. The course addresses the steps to be followed, beginning with the development of verification and validation plans, and how to choose the best verification method and approach. A test and evaluation master plan then leads to test planning and analysis. Conducting the actual testing involves activities, facilities, equipments, and personnel. The evaluation process analyzes and interprets the data, and acceptance testing assures that the products meet or exceed the original requirements. There are also functional and physical audits and simulation and modeling that can provide virtual duplication of products and processes in operationally valid environments. Verification management organizes verification tasks and provides total traceability from customer requirements to verification report elements.

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

Standard Information for all AIAA Conferences

This is general conference information, except as noted in the individual conference preliminary program information to address exceptions.

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.

Conference Proceedings

This year's conference proceedings will be available in an online format only. The cost is included in the registration fee where indicated. If you register in advance for the online papers, you will be provided with instructions on how to access the conference technical papers. For those registering on-site, you will be provided with instructions at registration.

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 Web site, **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 Computing, Information, and Communication*. You may now submit your paper online at **http://mc.manuscriptcentral.com/aiaa**.

Speakers' Briefing

Authors who are presenting papers, session chairs, and co-chairs will meet for a short briefing at 0700 hrs on the mornings of the conference. Continental breakfast will be provided. Please plan to attend only on the day of your session(s). Location will be in final program.

Speakers' Practice

A speaker practice room will be available for speakers wishing to practice their presentations. A sign-up sheet will be posted on the door for half-hour increments.

Timing of Presentations

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

Committee Meetings

Meeting room locations for AIAA committees will be posted on the message board and will be available upon request in the 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 preliminary conference 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 conferees. A telephone number will be provided in the final program.

Membership

Professionals registering at the nonmember rate will receive a one-year AIAA membership. Students who are not members may apply their registration fee toward their first year's student member dues.

Nondiscriminatory Practices

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

Smoking Policy

Smoking is not permitted in the technical sessions.

Restrictions

Videotaping or audio recording of sessions or technical 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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