5 AEROSPACE AMERICA MAY 2012

May 2012

# AEROSPACE AMERICA

## Human space exploration

# A GLOBAL QUEST

Snaring a piece of the sky

Hypersonic transport...30 years and holding

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

# AEROSPACE AMERICA

**May 2012**

## DEPARTMENTS



## FEATURES



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COVER

With budgets shrinking around the world , the best hope for expanding our exploration of space may be through widespread international cooperation. Turn to page 40 for more information. Image courtesy NASA/JPL-Caltech.


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# Editorial

## Getting there together

The Global Space Exploration Conference is being held this month in Washington, D.C. This year also marks the tenth anniversary of the Second World Space Congress and the twentieth anniversary of the First World Space Congress. What has changed in two decades?

In 1992 the concept of 'international cooperation in space' focused mainly on the interaction of government programs. ESA and entities such as Intelsat, Intersputnik, and others were considered shining examples of success in linking nations together. Of these, only ESA remains intact; the remainder became private corporations. The next decade saw the consolidation of corporations into international consortia such as EADS and SES Global; in joint ventures such as Eurockot and International Launch Services; and in the expansion of commercial services into global markets.

But nation-to-nation cooperation is far from becoming extinct. The prime example of this is certainly the international space station. It is by far the largest international cooperative space program ever—the result of efforts by 16 different nations. Although it has had many designs, many names, and has spawned seemingly endless complaints about cost overruns and missed deadlines, and even whether it had any real value or purpose, the station is now widely considered to be among the most remarkable human achievements of modern times. Somehow, the will of 16 nations to be a part of this extraordinary effort pushed past domestic and international political squabbles, changes of governments and budgets, and serious economic problems.

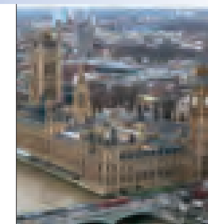
It seems reasonable to believe that the next great space endeavor, to move beyond low Earth orbit, perhaps with Mars as the ultimate goal, will also be a shared effort. Witness to this is the coalition of 14 space agencies that, in 2006, began discussions on shared interests concerning space exploration, both human and robotic. Their aspirations were articulated in a document entitled *The Global Exploration Strategy: The Framework for Coordination,* released in 2007. From this was born the International Space Exploration Coordination Group (ISECG), which has spent the years since developing a roadmap for exploring our solar system.

There have of course been many roadblocks to the goal of true international cooperation, the most recent being NASA's budget-driven withdrawal from the ExoMars mission, which ESA now appears to be pursuing with cooperation from Russia.

Nevertheless, the "Global Exploration Roadmap," released in September 2011 by the ISECG, articulates a long-range strategy that ultimately leads to human exploration of the surface of Mars. The roadmap lays out options for multilateral discussion and interaction involving both robotic and human missions, perhaps using the station, perhaps by visiting an asteroid or returning to the Moon.

Will this be the way of the future? Politics change, economies change, and alliances are made and broken. But with this roadmap, as with the development of the space station, the whole of all of these efforts will surely be greater than the sum of its parts. Getting together to get there together benefits everyone.

Elaine Camhi
Editor-in-Chief



# F-35 shows ups and downs of international partnerships

AT THE START OF MARCH 2011 THE U.K. government began a reappraisal of its 2010 decision to acquire the F-35C carrier version of Lockheed Martin's Joint Strike Fighter rather than the F-35B vertical takeoff variant. The F-35C does have a longer range, can carry more weapons, and is interoperable with the U.S. and French navies. However, it would necessitate changing the design of the U.K.'s two aircraft carriers, now under construction, to equip them with catapults and arrester gear. This would raise the cost of each carrier by more than $1 billion.

If this proceeds, the U.K. would have to renegotiate its acquisiton plan with the U.S. government. Although this would not impact the overall number of F-35s ordered by the U.K., according to one source at Lockheed Martin, it does underline the uncertainties of integrating international partners within a single long-term complex defense program.

## Counterbalancing benefits

Despite these political challenges, the benefits of such partnerships still outweigh the problems. The F-35 has been developed with the concept of international cooperation embedded in the program from the start—cooperation in industrial partnerships and in the deployment of the aircraft in theatre. The eight nations (apart from the U.S) participating in the F-35 system development and demonstration phase (U.K., Italy, Australia, Turkey, Netherlands, Canada, Denmark, and Norway) all operate within a complex network of collaborative agreements that are growing deeper and wider as economic problems put increasing pressure on national defense budgets.

Although the agreed investment in the program by the international partners is relatively small compared to the overall costs—around $4.4 billion against an estimated $30 billion-$40 billion total—the global customer base is a strategically vital part of keeping down the final production costs to the Dept. of Defense.

International customers have already placed outline orders for nearly 700 F-35s, against 2,443 orders from the U.S.

"The international nature of the program has meant partners in Europe signed up fairly early on in the development phase, and this has helped keep the program alive," says Raymond Jaworowski, senior aerospace analyst at market consultants Forecast International. "The U.S. has had to tread very carefully and understands what sort of damage could be done to the international partnerships."

## Seismic changes

Even so, few of the program's initial managers could possibly have foreseen the seismic changes in the global defense market when the first partnership arrangements were made. Over the past two years there has been a rapid decline in defense spending among European states, adding new levels of uncertainty into long-term commitments to the program.

In 2010 the governments of the EU's 26 member states spent a total of €194 billion on defense, while the U.S. spent $689 billion (the equivalent of €520 billion). "Between 2008 and 2010, there have been reductions in defense spending in at least 16 European NATO member states. In a significant proportion of these, real-term declines have exceeded 10%," according to the London-based International Institute of Strategic Stud-

ies (IISS). "The effect of these cuts across European states was brought into focus by the campaign in Libya, which highlighted existing gaps in targeting, tanker aircraft, and intelligence, surveillance, and reconnaissance."

The roles to be fulfilled by the F-35 are ground-to-air strikes and combat air operations. These, however, are currently not on the high-priority list for filling capability gaps in EU defense departments, especially compared to other urgent aviation capability requirements such as air-to-air refueling, fixed-wing transports, and transport helicopters.

## Asia rising

At the same time, defense spending in Asia is rising at more than 3% a year. As James Hackett, editor of the IISS publication *Military Balance* noted in March, "On the current trend, Asian defense spending is likely to exceed that of Europe, in nominal terms, during 2012" for the first time.

The long-term result of these changes is that Europe will probably require fewer F-35s than first planned, but new market prospects will emerge from the Middle East and Asia.

"The F-35 may not be as large a market as originally thought, but all the program partners will probably stay in place," though not with the numbers they had planned, Jaworowski points out. "The long-term prospects still suggest the F-35 will certainly be the dominant fighter in the market over the next 20-30 years. There are three different models, so anyone who currently flies F-16s, Harriers, and possibly F-18s could be potential customers."

## Gauging final figures

The key issue for all partners currently trying to plan long-term equipment strategies is what the final cost of the aircraft will be and how firm the delivery deadlines are. At the end of March the DOD planned to announce a new total program cost estimate for the F-35. Meanwhile, development delays have pushed back the end of the SDD phase until 2013 and added a reported

**MAJOR INTERNATIONAL SUPPLIERS TO THE F-35 JSF PROGRAM**

| Supplier | Country | Work package |
|---|---|---|
| Avcorp | Canada | Avcorp secured the F-35 outboard wing contract in 2009. It is currently contracted for 260 ship sets, with the opportunity to secure 340+ ship sets of outboard wings for the F-35 (CV). |
| Héroux-Devtek | Canada | In March 2006 Lockheed Martin awarded Héroux-Devtek's Progressive business unit a multiyear contract for the low-rate initial production phase of the JSF project. In particular, Progressive will build the inner wing bulkhead for all three versions. |
| Terma | Denmark | Lockheed Martin, BAE Systems, and Northrop Grumman, along with Moog, General Dynamics Armament and Technical Products, Parker Hannifin, and Marvin Engineering, have signed an MOU with Terma A/S for the Danish company to become a major strategic partner in the program. The agreement covers composite conventional edges for the aircraft horizontal tails, advanced lightweight composite components for the center fuselage, STOVL horizontal tails, missionized gun pods for STOVL and CV variants, data acquistion pods for flight test instrumentation, and radar electronics flight control components. |
| Alenia | Italy | Cameri has been chosen by the government to set up a final assembly line producing two F-35s a month and managed by Alenia Aeronautica. The latter will also be the second source supplier of the wing box. |
| Fokker Aerostructures | Netherlands | Fokker is producing the F-35's flaperons, the design and production of the doors and hatches, three electrical wiring harnesses, the wiring and structural components for the Pratt & Whitney engines, and the arresting gear. |
| Kongsberg Defense and Aerospace | Norway | Composite parts and subassemblies for the F-35 center fuselage. |
| Turkish Aerospace Industries | Turkey | Under the letter of intent, TAI becomes the second source for the F-35 center fuselage. |
| BAE Systems | U.K. | BAE Systems is responsible for the design, development, and production of the aft fuselage, empennage, and CV wing tips for each aircraft. The company is providing critical components for the vehicle and weapon systems, in particular the fuel system, crew escape, life-support system, and prognostics health management integration. BAE Systems has significant work share in autonomic logistics, primarily on the support system side, and is involved in the integrated test force, including the systems flight test and mission systems. The company is also responsible for the electronic warfare systems suite and is providing advanced affordable low observable apertures and advanced countermeasure systems. In addition, BAE Systems is supplying the vehicle management computer, the communication, navigation, and identification |

*(continued)*

**MAJOR INTERNATIONAL SUPPLIERS** *(continued)*

| Supplier | Country | Work package |
|---|---|---|
| | | modules, the active stick and throttle, and the EOTS laser subsystem. |
| General Electric U.K. | U.K. | Horizontal tail centering actuator; standby flight display system, electrical power management system, remote input/output data concentrator units; engine and debris monitoring system and airframe strain and stress models; and integrated canopy frame assembly. |
| GKN Aerospace | U.K. | The company is the supplier of a number of complex titanium structures for the airframe and engine; providing the advanced all-composite engine front fan case and embedded electro-thermal ice protection system for the F135 engine; and designing and supplying the aircraft's canopy transparency. |
| Martin Baker | U.K. | US16E ejection seat. |
| Rolls-Royce | U.K. | Rolls-Royce signed a $131-million contract with Pratt & Whitney to supply lift systems for the first six F-35Bs. |
| ***Subcomponent suppliers*** | | |
| BAE Systems Australia | Australia | Wiring boards and assemblies, cable assemblies, and selected electronic components. |
| Production Parts | Australia | High turbine supports/bearing housing supports for the Pratt & Whitney F135. |
| Barco | Belgium | Display components for L-3 Display Systems. |
| Magellan | Canada | Aft-fuselage, horizontal and vertical tails substructures for BAE Systems. |
| Terma | Denmark | Aft-fuselage, horizontal and vertical tails substructures for BAE Systems. |
| Galileo Avionica | Italy | Cables and components for BAE Systems. |
| Logic Sistemi Avionici | Italy | Display components for L-3 Display Systems. |
| Fokker | Netherlands | Titanium components for the Pratt & Whitney F135; in-flight opening doors for Northrop Grumman. |
| Philips | Netherlands | Display components for L-3 Display Systems. |
| Thales Nederland | Netherlands | Machining and casting of submodules and components, and the assembly of electronic components for BAE Systems. |
| Kongsberg | Norway | Composite components for Northrop Grumman. |
| Volvo Aero | Norway | Low-pressure turbine shaft and the intermediate case for Pratt & Whitney's F135. |
| Alp Aviation | Turkey | Landing gear components and assemblies supplied to Goodrich, rear fan hub for Pratt & Whitney. |
| Aydin Yazilim ve Elektronik Sanayii | Turkey | Display components for L-3 Display Systems |
| TAI | Turkey | Second source suppliers for composite air inlet ducts for Northrop Grumman. |
| GKN Aerospace | U.K. | Ice protection system components for the Pratt & Whitney F135. |
| Ultra Electronics | U.K. | F135 EIPS electronic controller and inter-connecting harnesses and connectors for Pratt & Whitney. |

$8.4 billion to the development costs. Lockheed Martin is aiming to sell the aircraft at a price equivalent to a Block 60 F-16 or Block 2 F/A-18E/F.

It is difficult to be sure exactly what impact the economic problems in Europe will have on the total number of aircraft ordered. The U.K. has said it could need up to 138 of the planes and ordered two F-35Bs in 2009 and one F-35C in 2010. An announcement of the final numbers of aircraft it requires is due before the next defense review in 2015.

In 2010 the Netherlands canceled its original commitment to buy 85—which version or versions was not specified—then changed its government and ordered two F-35As. A definitive agreement for orders is due in the next cabinet. In June 2011 Norway approved funding of four F-35 trainers and expects to make a decision on final numbers in 2014. Italy originally approved the purchase of 131 F-35s in 2002 for €15 billion, agreeing to build a final assembly facility at Cameri air base. However, in February of this year it announced that it would be reducing its order to 90 aircraft.

## Ripple effects

These changing acquisition plans have an impact on the global supply chain. Production contracts have been given to many non-U.S. suppliers on the basis of aircraft orders. Some of these are for major components. Turkish Aerospace Industries, for example, is a second source for the center fuselage, and the number of fuselages produced will be determined by the number of F-35s Turkey will procure.

"The production of parts by the supplier base is dependent on the orders we receive," says David Scott, director of international business development at Lockheed Martin.

"There is an expectation that international customers will meet their planned commitments for buying aircraft and we will meet our commitments to their industries. But all of this will take decades to work out as they order aircraft and we build aircraft."

At the same time that European partners and customers have dithered about delivery figures, the number of potential new customers from the Middle and Far East has been gradually increasing. The F-35 has not been cleared for export to Middle East countries apart from Israel and Turkey, despite keen interest in the aircraft from gulf states, while China's military buildup is providing a catalyst to the demand for fifth-generation fighters from several states in the region. In December 2011, Japan announced an order for 42 of the planes.

Lockheed Martin's efforts to reduce unit prices of F-35s by looking for efficiency improvements in the production process are being monitored especially closely now by international customers, many of whom have yet to determine the final number of aircraft they will buy.

**Philip Butterworth-Hayes**
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# Correspondence

**Moving beyond Earth: NASA's steps through 2020** (March, page 16) includes the section "Why send humans to deep space?" That section listed some important reasons, but it did not mention what many might consider one of the most important: Prepare for a time when a permanent human colony can be developed somewhere off Earth.

An initial colony would need support from Earth. Later, it might be economically self-supporting. Eventually, a colony that can exist with no support from Earth may be possible. Then, humanity will truly be in space to stay.

**James A. Martin**
Huntington Beach, California

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In **The ephemeral 'advanced propulsion'** (March, page 24), Jerry Grey properly addresses many options for space transportation and the propulsion they use. He is correct that combined rocket air-breathing cycles probably are not useful now, and single-stage vehicles are not a good option at present. He mentions partly reusable vehicles with subsonic airplane first stages, which may have some benefit.

One concept he did not mention is a reusable rocket booster with an expendable upper stage. For some time, I have felt that this should be the next major development in launch (see "Where Profit Drives RLV," *Aerospace America*, April 1997). Recent Air Force studies have also indicated that such vehicles are appropriate now, and the Air Force is pursuing a demonstration vehicle.

Jerry mentions tether 'slingshots' but does not give tethers much consideration. The most exciting concept I have seen lately is the reel tether, introduced in 2010 at an IAF congress ("Space Colonization, A Study of Supply and Demand," IAC-11.E5.1.8, 2010). By extending a tether down from a low Earth orbit, capturing a payload, and reeling it up, the reel tether can improve launch economics. By reeling a tether up from LEO, a reel tether can help a payload move to higher orbits. There is no need to extend the reel tether more than current materials make practical, and multiple reel tethers can be used to boost payloads as far as needed.

**James A. Martin**
Huntington Beach, California

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The two articles in the February issue deserve comment.

First, as to **China's long-range view** page 8), the article would have been much more informative if it had given some quantitative values. How much payload can it put into what orbit? What is the size and weight of the vehicle? Does it use liquid propellants or solid propellants or a combination of both? How many stages does it have? Quantitative values would make it easy to assess what capability the Chinese have. As it is, it seems not to tell us anything we don't already know.

Turning to the **Conversation with John Gedmark** (page 16), the man has good credentials, but he seems to not understand the difference between suborbital flights and going into orbit. It takes about 30 times more energy to stay in orbit as it does to fly a suborbital flight for a look around and then come back down.

He mentions he wants to get launch costs down, but none of the companies he mentions are going to do that. Many of them are into the suborbital tourist business, which only provides for those who can afford to spend a couple of hundred grand for a suborbital flight. Many of the others are capable of going into orbit but not at tourist fares. Only the government can afford the bill to take supplies and astronauts to and from the space station.

The way to reduce costs of going into orbit is to build more efficient rocket engines. Neither the commercial entities nor NASA are doing that. NASA is being mandated by an uninformed Congress insisting on development of a space launch system using inefficient and obsolete rocket engines. The Exploration Systems Development at $3.0073 billion is 16.9 % of the NASA budget.

NASA is also intending to use some space launch contractors, in the Commercial Space Flight Federation, who use inefficient kerosene-fueled rocket engines, which waste 80% of the kerosene because they operate at excessively small fuel-rich mixture ratios. That is the way you build an inexpensive rocket engine. The result is that thousands of pounds of unused kerosene, a hydrocarbon, are dumped into the atmosphere. We do not allow gasoline, a hydrocarbon, to be leaked into the atmosphere when we pump it into our automobiles, so why do we allow kerosene to become a giant oilspill in the sky? We cannot afford such inexpensive rocket engines.

Now, Mr. Gedmark does mention single-stage-to-orbit vehicles and reuseable vehicles, but we are not going to get there using inefficient rocket engines as is being done by the commercial entities and NASA.

I think the American public deserves better than this.

**Dale L. Jensen**
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**Reply by Butterworth-Hayes:** Thank you for your interest in **China's long-range view**. I must respectfully disagree with the relevant paragraph of your letter. The point was nothing to do with 'gee whiz' numbers or other bits of rocketry; it was about the psychology of the Chinese engineers and scientists involved and the trend behind their work—the 'what it all means' side of their progress.

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**The greening of satellite propulsion** (February, page 26) contains numerous misleading and, in some cases, incorrect statements. Here is why I believe this to be the case:

• The statement that the exhaust plume composition from LMP-103S is "mainly water vapor" is very hard to accept, because its composition is described as a relatively benign blend of ammonium dinitramide (ADN), water, methanol, and ammonia. What happens to the C, N, $CH_4$, $NH_4$, etc., molecules, atoms/ions? Has the thruster efflux actually been physically measured for substantiation of this claim?

• Higher performance and density for LMP-103S are stated. This may well be true, but when comparing these characteristics with those of existing flight-proven hydrazine systems, the following system performance benefits need to be considered:

Is there a spontaneous catalyst available to achieve ambient temperature rapid LMP-103S decomposition or, unlike hydrazine, is a high thrust chamber preheat temperature, at increased cost in spacecraft power, required?

What thrust chamber material is required to withstand the stated much higher operating temperature? Is this material simple and low cost like that used for hydrazine thrusters or is it a much more exotic and costly material, such as iridium-rhenium?

Are there opportunities for integrated propulsion system synergy? For instance, $N_2O_4/N_2H_2$ apogee engines can be combined with monopropellant hydrazine thrusters in a dual-mode system which combines 315 to 325 performance where it is needed most, with the flexibility and wide operating box of conventional hydrazine thrusters for ACS and other low thrust maneuvers.

Is it possible to introduce performance enhancements? For example, the Secondary Combustion Augmented Thruster (SCAT) operates bimodally as either a monopropellant thruster or as a bipropellant engine, delivering an $I_{sp}$ of 315 sec, depending on whether high performance or pulse mode operation is needed. Hydrazine can also be used as a gas generator, enabling electrothermal hydrazine thrusters ($I_{sp}$ greater than 300 sec) or for arcjets ($I_{sp}$ about 600 sec). All these enhanced thrusters are in wide use on many operational spacecraft.

Other issues include:

• This article says this propellant has been verified to be compatible with most hydrazine commercially available off-the-shelf components. However, no detailed compatibility test results are presented. Furthermore, the article does not specifically address compatibility with elastomers or other synthetic rubbers, such as those used for tank diaphragms, seals, and propellant valves, as has been demonstrated repeatedly with hydrazine.

• The statement that it takes two full days with a crew of two extra people and 20 specialists to load hydrazine propellant into a small spacecraft is ridiculous. I have personally been involved with loading hydrazine into many large U.S. spacecraft. These operations have always been accomplished with an experienced crew totaling three or four people and no other specialists. Operations are usually accomplished within a half day using modern loading equipment, not two full days.

I contacted Aerojet about their views on this article, and received the following response: "As a world premier supplier of hydrazine and hypergolic propulsion and a strong proponent of green propulsion, Aerojet understands the challenges associated with developing a new propellant. We concur with Mr. Sackheim that both the positive aspects of the High Performance Green Propulsion (HPGP) technology and the negatives and unknowns should have been discussed within the subject article.

**Robert L. Sackheim**
Sackheim Propulsion Associates
**Yvonne C. Brill**
Propulsion system consultant

## Events Calendar

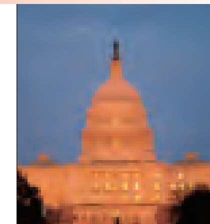
**MAY 7-11**
Reinventing Space Conference, Los Angeles, California.
***Contact: 703/264-7500***

**MAY 14-18**
Twelfth Spacecraft Charging Technology Conference, Kitakyushu, Japan.
***Contact: Mengu Cho, 81 93 884 3228; cho@ele.kyutech.ac.jp***

**MAY 22-24**
Global Space Exploration Conference, Washington, D.C.
***Contact: 703/264-7500***

**MAY 22-25**
Fifth International Conference on Research in Air Transportation, Berkeley, California.
***Contact: Andres Zellweger, 301/330-5514***

**MAY 30-31**
UAS Global Exhibition and Conference, Odense, Denmark.
***Contact: http://uasglobal.info***



# Agreeing to agree on nothing

IN FEBRUARY, CONGRESS PASSED LEGislation that requires the FAA to draw up plans by 2015 to allow for commercial drones in national airspace.

To those who work with them, these robotic aircraft are called UAVs, UASs, or remotely piloted vehicles (the latter term is used only by the Air Force), but crews and maintainers still call them drones. When they began to proliferate about a decade ago, no one envisioned that they would soon be bidding to share the sky with commercial airliners, executive jets, and private planes.

The measure was inserted into the National Defense Authorization Act, which President Barack Obama signed into law last December. It orders the FAA to set up six ranges where the military and others can evaluate technologies that will allow drones to fly safely in public airspace.

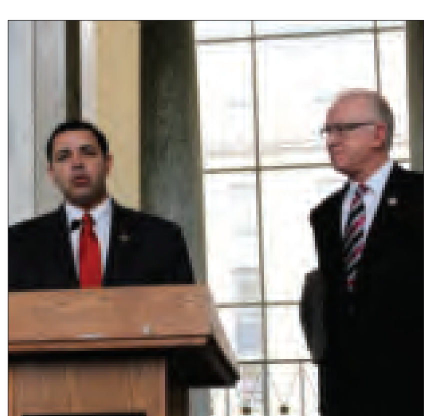
“These test sites will help us ensure that our high safety standards are maintained as use of these aircraft becomes more widespread,” said Transportation Secretary Ray LaHood in a statement. Officials in Washington see hundreds of military versions being brought home from Afghanistan, and the use of drones in the U.S. for law enforcement and commercial applications is on the increase.

Critics see the legislation as a gift to the industry that develops and manufactures drones. The mandate is primarily the work of Rep. Henry Cuellar (D-Texas) and Rep. Howard P. ‘Buck’ McKeon (R-Calif.), who cochair the bipartisan ‘drone caucus’ (officially called the Congressional Unmanned Systems Caucus). This kind of provision is known in Washington as an unfunded mandate—it directs the FAA to take action but provides no money to pay for doing so.

When the nation went to war after the attacks of Sept. 11, 2001, the U.S. military had about 50 drones. Today, it has 7,500, and drones make up about one-third of all aircraft in the Air Force. The Pentagon, which will bring drones home when the war in Afghanistan ends, wants the FAA to create regulations and procedures that will let unarmed UAVs fly routinely around the country—outside military ranges—for training, natural disaster response, and homeland security missions. Technology experts predict that drones will eventually be capable of safely flying anywhere, sharing the airways with your next commercial flight.

Until now, the FAA has banned their widespread use because of concerns that the unmanned planes cannot see other aircraft and could cause a crash. The agency currently allows such flights only under special exemptions, and it grants very few. Such certificates of authorization generally require UAV operators to use a ground observer and a chase plane to ensure their drone does not endanger civilian aircraft, essentially canceling out the benefits that unmanned aircraft offer.

“Unmanned aircraft can help us meet a number of challenges, from spotting wildfires to assessing natural disasters,” says LaHood. “These test sites will help us ensure that our high safety standards are maintained as the use of these aircraft becomes more widespread.”



*Rep. Henry Cuellar (left) and Rep. Howard P. ‘Buck’ McKeon*

Some believe things are looking better for the FAA than they have in a long time. After years of temporary funding measures, the agency finally has formal, long-term appropriations. On March 15, it signed a four-year agreement with 15,000 air traffic controllers that is expected to provide stability for the workforce. Although the agency is behind schedule on an array of issues, from NextGen ATC to establishing new pilot safety regulations, observers say they see progress and expect things to get better when a new administrator is named.

LaHood had been speaking publicly on aviation issues while the FAA awaited a replacement for its former administrator Randy Babbitt, who resigned in January. In March, the president nominated Michael P. Huerta, the acting administrator, to fill that role on a permanent basis.

## C-27J debate

The Air Force is running up against Capitol Hill resistance to its decision to retire new C-27J Spartan airlifters as part of the administration’s FY13 budget proposal. No C-27Js are being assigned to the active-duty force: All are slated for Air National Guard units, hometown wings and squadrons that enjoy tremendous support in the nation’s capital. Debate over the aircraft reflects larger concerns in Congress about administration defense plans.

Sen. Rob Portman (R-Ohio), a supporter of the Air National Guard C-27J airlift wing in Mansfield, Ohio, was polite but stern as he grilled Michael Donley, secretary of the Air Force, and Gen. Norton Schwartz, USAF chief of staff, during testimony before the Senate Armed Services Committee on March 20. The Air Force’s program of record for 38 C-27Js includes 12 aircraft now in service (including two deployed to Afghanistan from Ohio last year), five that are close to entering service, four still in production, and 17 more that, if the budget proposal is upheld, will never be built. The service had once intended to operate 78 of the planes.

The C-27J has a convoluted history. Ten copies of the earlier C-27A version entered service in 1991 and later received an upgrade but were retired in an economy move in 1999. The current C-27J began as the Army's Future Cargo Aircraft, to replace the Army National Guard's aging C-23 Sherpas. It evolved later into a bi-service program called the Joint Cargo Aircraft and still later into an Air Force-only program. Italian planemaker Alenia is on its third partner as U.S. prime contractor, L3 Communications, a company that is much respected in the defense field but has never previously managed an aircraft program.

Back in 2007, Alenia promised to build an aircraft assembly plant in Jacksonville, Florida, to turn out U.S. C-27Js. The factory never materialized because the number of aircraft was reduced from 78 to 38, too few to justify the investment. Throughout its long gestation, the Italian-built C-27J had taken brickbats from some in Washington for being 'foreign'—although the U.S. industry has not designed an airlifter in its class.

Arguing his case for the twin-engined airlifter, Portman said he had received C-27J documentation from the Air Force that is "confusing." He also called the material "inadequate" and "inconsistent." He told the leaders, "We'd love to see more than PowerPoint slides. We'd like to see some real analysis."

*On Aug. 9, 2011, deployed members of the 179th Airlift Wing and their Army counterparts assumed command of the 702nd Expeditionary Airlift Squadron at Kandahar Airfield, Afghanistan. C-27Js were selected for this mission because of their ability to use a short runway and their long flying capability, but deployment left the Mansfield Guard unit with just four of the aircraft.*

*Michael Donley (left) and Gen. Norton Schwartz*

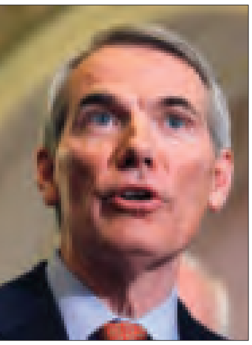
Donley countered that there are many reasons for shelving the C-27J, including the savings that will accrue from reducing the number of aircraft types in inventory: "How many fleets are we going to have to manage?," Donley asked rhetorically. He called the four-engined C-130 Hercules, already in service in large numbers, "more flexible across the broader range of tactical airlift requirements." He also pointed to what the air staff sees as a key drawback to the plane: Unlike the C-130, which is maintained by airmen in uniform, the C-27J requires contractor logistics and maintenance support.

Donley said the C-27J is "nice to have," but because it satisfies a "very narrow piece" of the Army's missions, it has to go. Ironically, he was making all of the arguments that were made at the inception of the program by those who opposed it from the start.

The plan for the C-27J has always raised questions. The Pentagon wanted to have six to eight airlift wings, all at Air National Guard bases, each with just four aircraft apiece, except for training wings, which would each have six. A combat wing typically has 1,000 or more people and more typically would operate 25-75 airplanes.

At Mansfield, 1,000 full- and part-time guardsmen belong to the wing that now has four C-27Js instead of the 10 C-130s it operated previously. "Back when we had 10 airplanes we thought we were a small unit," says retired Ohio guardsman Brig. Gen. Fred Larson. "On the one day we had all four C-27Js lined up out there, they looked awfully lonely on that big airfield," he says. At one point, the ratio of pilots to planes was such that the C-27J wing commander was not yet checked out in the C-27J.

During the hearings, lawmakers questioned Air Force figures for C-27J life-cycle costs, charging that separate Air Force assessments of these costs vary from $111 million to $308 million per aircraft. Sen. Carl Levin (D-Mich.), who chairs the committee, questioned Donley and Schwartz about the equally disparate flying-hour cost estimates. One unit slated for the planes is located in Levin's home state of Michigan.



Sen. Rob Portman

Lawmakers in both parties expressed satisfaction that manufacturer Alenia backed away from saying that it would refuse to support used C-27Js sold by the U.S. to third countries. The company hopes to sell the plane around the world and had reacted strongly when it appeared the Air Force would dump 21 of them on the market Alenia is competing in with the same plane. Now that Australia is considering a C-27J buy, CEO Giuseppi Giordo says Alenia will support the aircraft throughout the world. Whether the Air Force can really get rid of the 21 planes will depend entirely on what happens in budget deliberations this summer and in the fall.



## No room for BRAC

Capitol Hill dissatisfaction with the FY13 defense budget proposal extends far beyond C-27J issues. Many lawmakers in both parties, eager to support military installations in their home districts, regard the budget proposal as a base realignment and closure (BRAC) action in everything but name, shrinking or shutting down bases without following the complicated procedures set forth in BRAC legislation. The BRAC process was created by Congress to head off partisanship in base-closing decisions, and the term has become a verb. Now, some lawmakers say the proposal is an attempt to 'BRAC' them without the formal process being followed.

A formal BRAC process, although not currently on the horizon, is exactly what the military wants, because it would permit more sweeping cuts than any in the budget proposal. Many who follow military affairs in Washington believe the nation has too many bases, some sorely underused, and that reducing infrastructure—buildings, grounds, water, electricity, roads—is the surest way to achieve savings in a fairly quick and obvious way.

Congress has ignored the Pentagon's requests for additional rounds of BRAC, one to take place next year and another in 2015. Gen. Schwartz told senators that the Air Force simply has too much excess infrastructure and that without more BRAC rounds, "we will place the force...under more pressure to put spending into excess capacity when it should go into readiness and modernization."

BRAC is one obvious solution to what *Washington Post* columnist Walter Pincus calls "the economic 'perfect storm' looming in December" after gubernatorial, congressional, and presidential elections on November 6. But in today's Washington, BRAC is something that is not going to happen.

Sen. Claire McCaskill

Sen. Claire McCaskill (D-Mo.), the chair of the Senate Armed Services Committee panel with jurisdiction over BRAC, vowed on March 22 to block any attempts this year to prepare for a formal round of stateside base closures. Pentagon leaders have failed "to make a convincing case" that another BRAC round "would benefit American taxpayers or national security," McCaskill stated in a press release. "While I applaud the [Defense] Department's desire to find responsible places to achieve savings, there is one area where there is absolutely no room for compromise this year: BRAC," she wrote.

With Congress given a 13% approval rating in a recent ABC News/Washington Post poll—the lowest figure since polling began 40 years ago—it is easy to wonder whether leaders in Washington, in either party, are capable of compromising on anything. The unpopular defense budget proposal from the administration is part of an attempt to comply with last year's bipartisan Budget Control Act, which requires cuts of $487 billion over 10 years. If Congress cannot take the first step to achieve cuts at that level, Pincus asked in a March 22 column, "how will it ever hit the additional $1.2 trillion of overall reductions before sequestration on January 2?"

Sequestration is the lawfully mandated reduction in federal spending aimed at helping the nation's debt and deficit concerns, and the only way to prevent it from happening would be to change the law. But the timing could not possibly be worse. In this election year, a lame-duck Congress will have to act on FY13 appropriations bills in December (after the bills are due, but ahead of the sequestration deadline) and will also have to raise the debt ceiling and act on the Bush-era tax cuts, which expire on December 31.

**Robert F. Dorr**
robert.f.dorr@cox.net

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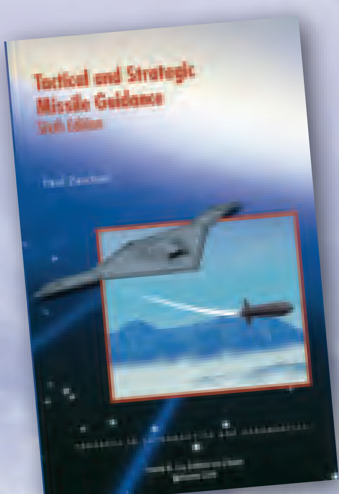


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# *Martin C. Faga*

***You have played a major role in the space arena for many years, with the Air Force, the National Reconnaissance Office, and as a top executive and now board member of MITRE. What catches your attention with regard to space today?***

The Operationally Responsive Space program, for one thing. ORS Satellite 1 was launched not long ago and is in operational service. It represents a major change in space acquisition and surveillance. The Air Force is closing the ORS office and moving its function into the Space and Missiles Systems Center in Los Angeles.

***Why is ORS 1 so interesting?***

It is the first ORS satellite built to the specifications of the users, primarily CENTCOM [Central Command], as opposed to experimenting with what seem to be useful things from the developer's point of view, which was the case with the early ORS tacsats. Those were not built to a command's requirements. CENTCOM set out the requirements for what ORS 1 should do, and they got it.

*Martin C. Faga retired as president and CEO of MITRE in 2006, having held that position for six years. Previously, he served as senior vice president and general manager of MITRE's Center for Integrated Intelligence Systems and then as MITRE's executive vice president.*

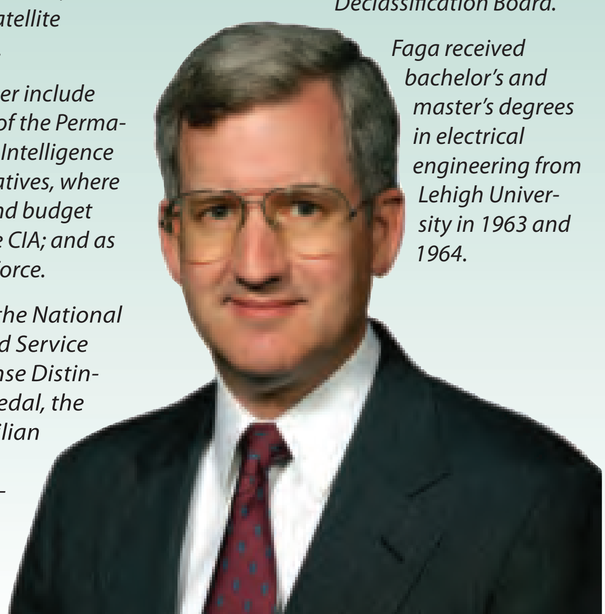
*From 1989 to 1993, before joining MITRE, Faga was assistant secretary of the Air Force for space, responsible for overall supervision of Air Force space matters. At the same time, he served as director of the National Reconnaissance Office, responsible to the secretary of defense and the director of central intelligence for the development, acquisition, and operation of all U.S. satellite reconnaissance programs.*

*Other facets of Faga's career include service as a staff member of the Permanent Select Committee on Intelligence of the House of Representatives, where he headed the program and budget staff; as an engineer at the CIA; and as an R&D officer for the Air Force.*

*Faga has been awarded the National Intelligence Distinguished Service Medal, the Dept. of Defense Distinguished Public Service Medal, the Air Force Exceptional Civilian Service Medal, and the NASA Distinguished Service Medal. In 2004, he was awarded the Intelligence Community Seal Medallion.*

*Faga has served on the Commission for the Protection and Reduction of Government Secrecy, the Jeremiah Panel to review the mission and organization of the NRO, several Defense Science Board task forces, and the National Commission for the Review of the NRO. He is a fellow of the National Academy of Public Administration and a member of the board of directors of Alliant Techsystems, GeoEye, the Association for Intelligence Officers, and the Space Foundation. He also has served on the board of directors of Electronic Data Systems, the President's Intelligence Advisory Board, and the Public Interest Declassification Board.*

*Faga received bachelor's and master's degrees in electrical engineering from Lehigh University in 1963 and 1964.*



***Tell us more about all that.***

The idea was to build a relatively inexpensive satellite, I think on the order of $150 million, maybe $200 million, including cost of launch. A high-quality commercial satellite costs $750 million. NRO's big and complex satellites go way up in cost from there, as you can imagine. There is a tradeoff in terms of performance, but the hope is that the essential performance is available in ORS 1.

First user reports are favorable. If users really like it—if they conclude that the sat's performance gives them most of what they need—then, because it is relatively inexpensive, they can have a lot more of them and have greater assurance of coverage if there are losses. Then, conceivably, satellites of that ilk could become the UAVs of the future.

***So you would call ORS 1 a small sat?***

Yes, it's a small sat for military use. It doesn't press the state of the art, and it is not highly classified.

***What does this mean for future space acquisition? Does it signal a sweeping reformation, a switch to small surveillance satellites and away from the big, very expensive satellites that NRO built and operated all through the Cold War and beyond?***

That's going too far. There is room for and need for both. The point a lot of people miss about reconnaissance and surveillance is that they

*Interview by James W. Canan*

take different forms and involve different requirements.

We need very high performing reconnaissance satellites like the traditional NRO birds to try to find things on the surface of the Earth that we never knew anything about; but once we've detected those things, we want to watch what they do and keep track of what's going on there. Watching what we already know about requires a lot less performance in a satellite. Military commanders usually know what their targets are. What they need to keep finding out is where those targets are at the moment, right now—where they may have moved.

***And this distinction ushers in small sats for surveillance?***

It changes the name of the game, from having only a relatively few, very high performance, very expensive sats to having, along with them, smaller, cheaper, less capable satellites for much more rapid, repeated surveillance of targeted areas. In this regard, I think there is too much emphasis in people's minds about the surveillance of only the immediate battlefield. In fact, commanders may want to know what's happening 100 miles or 500 miles from the battlefield area. Are other troops and equipment moving in? Is another party entering the picture? Russia? China? Iran?

***Would you say that this surveillance capability is all the more important now that the Pentagon is shifting its strategic focus to the Asia/Pacific region and the Middle East, and away from Europe?***

Yes. They are vast expanses. China is a very big country, and we are not going to be able to cover it with UAVs. They can't go there, politically. UAVs are absolutely the sensors of choice for close-in surveillance of where the combat is, but that's usually pretty limited in scope.

***In the surveillance scenarios you mention, it would seem that space assets are becoming more important than ever. This raises another issue: the prospect of adversaries attacking our satellites. Talk about that.***

It's always possible, and it would not have to be a physical attack on our satellites. It could be electronic interference or some kind of space-based or ground-based laser. There are lots of ways to screw up satellites. That said, it isn't easy to do.

***Would it constitute an act of war?***

First, we must be absolutely positive that it was an attack. If a satellite is out of commission for a period of time, was it someone sending us a message? Did something happen during that period of time? Do we need to take some action? We frequently get unintentional interference with our satellites. For example, ground communications systems can and do occasionally disrupt satellite communications on certain frequencies.

**"[Satellites are] the nervous system of our military today, and if the right nerves are blocked, even temporarily, basically the whole network can be taken down."**

Disruptions like that happen all the time. So the mere fact that we have interference of some kind does not tell us that we are under attack.

***Pretty scary stuff, though.***

Satellites are so important to us now. They're the nervous system of our military today, and if the right nerves are blocked, even temporarily, basically the whole network can be taken down. Which is to say again that an adversary might get to the satellite by electronic means and never have to do anything physical, like hitting it with a kinetic kill vehicle.

***Is all this getting almost too complicated to handle?***

Maybe, but we have to handle it, and I don't think we're working hard enough to do it. There's lots of talk about handling it, but there is not enough happening to detect and protect against attacks on space assets. We're not doing enough to put detection and self-protection mechanisms on board our satellites, for example, so we would know what's happening to them and be able to do something about it. We're not doing enough in space-based space surveillance, considering what precious strategic assets space systems are.

***A few years back, the Air Force gave high priority to space protection and space situational awareness programs. I gather it hasn't followed through well enough on all that, in your opinion?***

No. In fact, I think everybody responsible for space situational awareness would acknowledge that it isn't sufficient, and that, programmatically, it is declining now. So space protection is in jeopardy.

***Not enough money?***

Everything comes down to competition for money. But this also has to do with perception of a threat and being willing to meet it. One of the most valuable lessons I had as a young Air Force captain came from talking to a Viet Nam vet about how to protect against a particular threat. Very solemnly, he said, "Marty, that's a threat I have not yet seen, and I don't have enough money or enough program to work the threats that I actually see and know, let alone those I haven't even seen." So that's one part of it.

Another is that there may be more threats to protect against than we can adequately cover, including physical attacks, cyber threats, other means of disruption—in every arena, not just in space.

***But don't we have to meet all of them, regardless? Can we afford to ignore or slight any of them?***

The Air Force has an aging aircraft force that requires lots of money to modernize. Does it have enough to do that and everything else required to meet all possible threats? At the end of the day, our leaders say they understand that a particular threat may exist or may come to exist, but they need to see it.

I don't blame them for looking at it that way. But I think something bad will happen in space someday, and everybody will say, oh gee, now we see it, and now we have to do something about it. And then the acquisition people will say that it takes five years or so—a multiyear program—to build the means of doing something about it. So all through that period, our adversary will have the advantage. And it could be fatal.

***I have to ask: If a threat turns out to be so dire, why wouldn't our leaders have seen it coming and taken steps to counter it?***

It's like buying insurance, where you say, yeah, I can see that I'll need the insurance, but it will cost me thousands of dollars a year, and I can't afford it right now. Maybe later.

***How are our space programs in general faring now, following a bad stretch of cost overruns and technical problems?***

Air Force space acquisition seems to be doing well. My sense is that things are going better at SMC [Air Force Space and Missile Systems Center] than they had been. There are a lot fewer troubled programs. And Air Force leaders say they will fully support space as part of the new defense strategy. The director of the NRO has stated publicly that all of his programs are 'green.' The problematic period for NRO programs that you mentioned was roughly 2000-2005. We're seven years past that and doing well, and I think it's due to a lot of factors, including some good leadership.

***That stretch had a bright side, didn't it? Much was accomplished in space, it seemed.***

Even when some programs were going badly, many others were going well. Space programs are always difficult, and bad things can always happen. Chances are, in the coming cutbacks, space programs will be treated unwisely in the budgeting process. They are multiyear efforts requiring consistent multiyear funding, and if we keep changing the funding of any program from year to year, we are going to take it off track. Maybe testing and design reviews will be trimmed, or the program will be stretched, and then contractors won't be able to keep their most highly skilled and experienced 'A' teams on the programs, because their skills are required for another commercial project that needs immediate attention.

**"It's like buying insurance, where you say, yeah, I can see that I'll need the insurance, but it will cost me thousands of dollars a year, and I can't afford it right now. Maybe later."**

***Corporate personnel issues can be a big negative in all this, too, can't they?***

Yes. Funding issues and personnel issues. We have found that a voluntary 'early out' policy, for example, is very unwise—trimming the workforce by paying employees generous separation money to get them to leave. The best people—the most highly skilled and experienced people—will take the money and move on to another job, because they are still in demand. The people who are not in demand, because they do not have the most current skills and haven't demonstrated the greatest capability, do not leave.

We have learned not to do early-out, that management has to identify the lowest performers and let them go. It is painful, but that is what you have to do. You also do not want to encourage the people nearest retirement to leave earlier. When capable people get to within five or 10 years of retirement and have 30 or 35 years of experience, they are usually high performers and highly experienced, and you do not want to lose them.

***Funding problems seem to be plaguing NASA programs too. Can you talk about that?***

I don't think NASA is losing a lot of money in the budget. But they are not getting enough money to procure their total program. I don't know much about their allocations for unmanned planetary exploration, or for aeronautical research, for example. I do know that there's a lot going on in those categories, and some changes proposed in their budgets.

Where NASA is really in trouble, of course, is in space transportation and the human space program. We don't have a way to space. We have the Space Launch System in development but probably not enough money to do it. And most important, we don't have a sensible, widely accepted objective for human space activity. Some say it should be Mars, others say we should go to the Moon first, or an asteroid.

***What would you recommend?***

Once we establish a requirement for human exploration of space, we need to ask what are the sensible steps, what are the objectives, what is the time frame. What we cannot do is simply say we need to have a top-priority program to go to Mars or anywhere else, period. What we should

**"We are an increasingly short-term-oriented society, whether it's companies and their emphasis on quarterly results, or politicians measuring everything in terms of their two- or four- or six-year terms of office."**

say is we will commit to spending $5 billion or $10 billion a year on exploration, and then a combination of things will happen: Technologies to support humans in space will evolve, the means to get to space will evolve, planetary exploration and other space science programs will help identify things that we want to learn through human space exploration.

In short, we should concentrate on funding and building capabilities, as opposed to having an eight-year program that has to achieve certain goals and has to cost this or that amount of money—and having no clear idea how to do all of that.

***You are advocating the long view here, right?***

Yes—a long-term deal, 20 or 25 years, in which we continuously develop our manned space capability and continuously develop a plan to do what we decide is most important to do in space. We need to establish priorities and follow through on them.

***Will our political system and government planning and budgeting processes permit all that?***

We are an increasingly short-term-oriented society, whether it's companies and their emphasis on quarterly results, or politicians measuring everything in terms of their two- or four- or six-year terms of office.

To do what I suggest for space, maybe the most useful thing that could happen would be some really thoughtful proposals by NASA itself, not the White House or any other arm of government. Let NASA propose to the political leadership something that people are prepared to support, as opposed to NASA holding on and waiting until the political leadership tells it what to do. NASA leadership is key.

Constant change in long-term objectives from administration to administration consumes NASA and won't get us there.

***Does NASA's long history of success help guide it now, do you suppose?***

Many people in the space field want NASA to recapture the glamour of the era of Apollo. It's never going to happen. NASA can be exciting, but

**"Let NASA propose to the political leadership something that people are prepared to support, as opposed to NASA holding on and waiting until the political leadership tells it what to do."**

it is never going to be Apollo again. People who have been involved in the National Reconnaissance Office, many of them my contemporaries there, see the need to go back to the days of the 1960s and 1970s with NRO. I tell them, it is never going to happen. The world has changed.

***Go back how? In what respect?***

Back to being a covert organization with great flexibility in its use of money, and with ready support for all the appropriations it requests. That day is over.

***Why? Doesn't NRO still stand guard in space against today's threats?***

NRO was a fundamental strategic asset in the Cold War. It is still a strategic asset, but it is not seen in quite the same strategic terms as it was back then, when we were really worried about the existential threat of a large-scale nuclear war that could wipe us out. That threat came from large-scale forces, missiles and aircraft, perfect for satellite reconnaissance. We don't have that now.

***What do we have?***

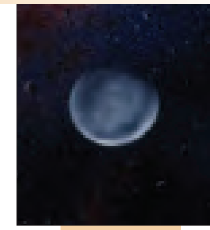
We have smaller scale threats, although perhaps more of them. NRO is still enormously productive, and its total contribution from its space constellations is greater than at any time in the past. But NRO is still regarded differently by our political and military leadership, and understandably so, in terms of its importance relative to everything else.

***Tell us more about how you see today's threats.***

I think the big risk today is when an adversary calls us up and says 'checkmate' because his cyber attack has taken out our banking system, or our municipal water systems, our electric power and telecommunications. Extreme? Yes, but increasingly plausible, because we are increasingly networked. What if our banks don't work any more because their records have been compromised in a cyber attack and no one is sure how much money they have, or if they have any at all. Banks would immediately be mobbed, and they wouldn't have the people or the physical structure or the online capability to handle it. Can you imagine the riots?

***Given all that, are you pessimistic or optimistic about the future of space, the future of our country?***

I am optimistic. There are always lots of difficulties, but I believe the country responds well to threats and problems when they are understood.



# Snaring a piece of the sky

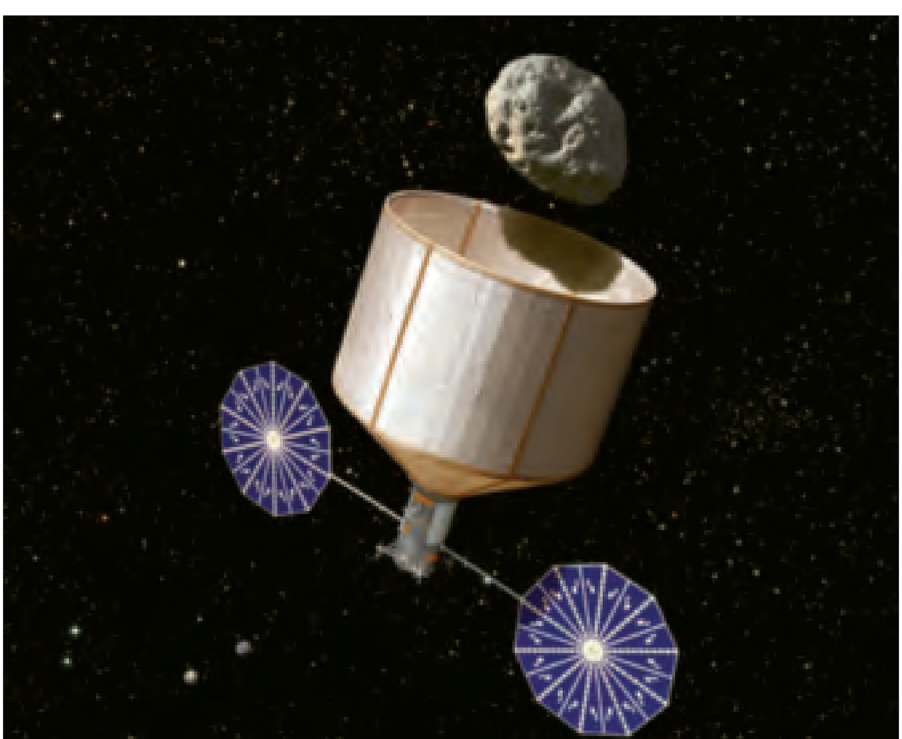
A TEAM OF EXPERTS ORGANIZED BY the Keck Institute for Space Studies (KISS) wants NASA and its partners to grab a nearby asteroid and return it to cislunar space, opening the door to astronaut operations, scientific exploration, and commercial mining of these ancient, chemically diverse bodies.

The robotic mission to retrieve a near-Earth asteroid (NEA) roughly 7 m across fits neatly into NASA's plans for human missions to larger asteroids, and would establish another science- and resource-rich destination for astronauts in cislunar space. Visits to the captured asteroid from either LEO or an Earth-Moon L2 outpost could build human spaceflight experience and reduce the risks of deep-space voyages to the Sun-Earth Lagrange points and accessible NEAs.

The seemingly quixotic idea of snaring a small asteroid has been proposed before. Science fiction writers have long been drawn to the idea of capturing a near-Earth asteroid and propelling it back to Earth orbit, there to be mined or dropped on the head of some observatory-deficient, downward-looking enemy. Space futurists contemplate capturing large asteroids into cislunar space to provide megatons of recoverable metals and volatiles. Five years ago, Constellation engineers examined the possibilities of having astronauts grapple a basketball-sized asteroid onto their Orion spacecraft and returning it to Earth.

A KISS-commissioned team examined the feasibility of an asteroid capture and retrieval mission, devoting six months of analysis and two workshops at Cal Tech to the concept. This author contributed to the study, led by JPL's John Brophy, Cal Tech's Fred Culick, and the Planetary Society's Lou Friedman. The *Asteroid Retrieval Feasibility* study had three goals:

- Determine the feasibility of robotically capturing and returning a small NEA to Earth's vicinity, using technology available *within this decade.*
- Identify the benefits of such an endeavor to NASA, the science and aerospace communities, and society.
- Identify how such a mission could aid NASA and its partners in their plans for human exploration beyond LEO.



*After matching spin rate and orientation with the asteroid target, the ACR spacecraft closes in to swallow it within the capture mechanism. Cinching cables would tighten to retain and restrain the asteroid for despin and SEP transport back to cislunar space. Artist credit: Rick Sternbach/KISS.*

### Why reach for an asteroid?

NASA is already sending robots to asteroids: Dawn is orbiting Vesta, and OSIRIS-REx launches in 2016 to the C-type NEA 1999 RQ36, aiming to return a 2-oz sample to Earth in 2023. The agency's Human Exploration and Operations Directorate (HEO) plans to conduct astronaut NEA expeditions by 2025. These missions, meant to last six months or more, will characterize, sample, and prospect objects tens to hundreds of meters in diameter.

However, proposed NASA budgets fall short of a 2025 NEO mission capability, and several major preparatory steps for such an expedition have yet to be tackled. Specifically, the agency has yet to obtain funds to launch a space-based search for smaller NEAs, which are more numerous and so statistically more likely to be accessible via the Orion/Space Launch System. Nor can HEO afford precursor asteroid missions, designed to scout the way for astronaut expeditions. These delays stack up: If it takes 10 years to conduct the search and compile a list of possible human targets, the need for subsequent robot scouting missions will force the first human NEA expedition well past 2025.

This timing opens up a window

*NASA will launch a spacecraft to an asteroid in 2016 and use a robotic arm to pluck samples that could better explain our solar system's formation and how life began. OSIRIS-REx will be the first U.S. mission to carry samples from an asteroid back to Earth. Credit: University of Arizona.*

for a robotic foray to grab a small NEA (or pluck a large boulder from a larger asteroid), then move it into a safe parking orbit around the Moon. There, robots and astronauts can literally dismantle the object in the name of science, operations experience, planetary defense engineering, and commercial prospecting.

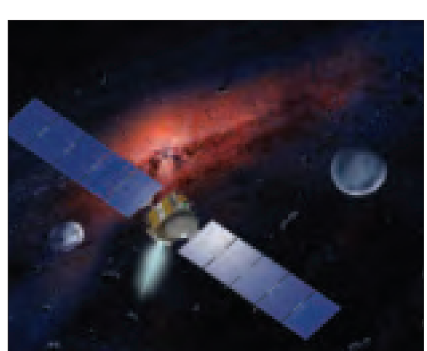
The retrieval of a sizeable, well-chosen body will enable a revolution in scientific analysis of primitive materials dating back to the solar system's origin. Equally important will be the benefits of putting astronauts, operating in the Moon's vicinity by the 2020s, in contact with bulk asteroidal material. Astronauts, perhaps operating from the EM L2 Lagrange point, would get repeated opportunities to test proximity operations, evaluate anchoring gear, repeatedly examine a two-story-tall asteroid, set up water and resource-extraction equipment, and obtain the civil engineering information needed for effective planetary defense. Follow-up missions could focus on commercial exploitation of the hundreds of tons of NEA feedstock.

## Mission overview

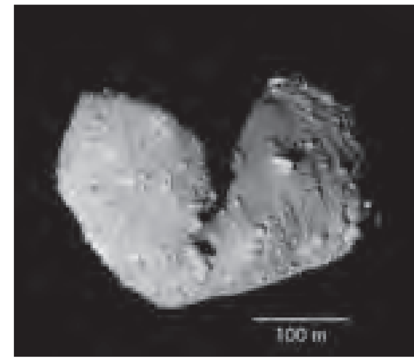
The Asteroid Capture and Return (ACR) mission would be executed by a robotic spacecraft employing solar-electric propulsion (SEP). Launched into LEO by an Atlas-V-class booster, the spacecraft deploys its 10.7-m arrays and, under ion thrust, spirals out to the Moon in about two years. Successive lunar gravity assists help the SEP execute an escape from Earth's gravity; cruise to the asteroid takes another two years.

Once rendezvous with the target is achieved, the spacecraft determines the object's spin state, diameter, and surface topography. Deploying a flexible, wide-mouthed fabric capture bag, the ACR spacecraft moves in, matches rotation, then engulfs and 'hugs' the asteroid. After capture, the spacecraft thrusters stabilize and despin the object, and the SEP system begins a 2-6-year transit to Earth.

The NEA target diameter of around 7 m was chosen to maximize the probability of finding a suitable target using ground-based telescopes, yet minimize the propellant needed to return the asteroid to cislunar space. The captured NEA would have a mass anywhere from 250,000 to 1 million kg, roughly equal to that of the ISS. (Six Apollo missions returned 382 kg of lunar samples to Earth.) Even this massive an object poses little danger to Earth: C-type asteroids possess very low physical strength and would break up upon atmospheric entry. To further ensure safety, the ACR mission will



*NASA's Dawn satellite is already orbiting the large asteroid Vesta.*




*The ACR spacecraft could snare and retrieve surface boulders on larger, easier-to-discover NEAs. These large boulders on Itokawa were imaged by Hayabusa on Oct. 23, 2005, from a distance of 4.7 km. Credit: CJAXA.*

place the NEA in a high lunar orbit. From there, an uncontrolled asteroid would be driven by gravitational perturbations to an impact on the Moon.

## Finding a target

Can we expect to find by 2020 a set of 7-m asteroids with orbits accessible to the ACR ion propulsion system? The good news is that there are many millions of NEAs smaller than 10 m across (a 10-m object has a mass of roughly 1.5 million kg). But these small objects are very faint to ground-based telescopes, visible only when close to Earth. Today only a few dozen small, suitably accessible NEAs are known, and we have no information on their spectral type or composition. A concerted search to find a set of accessible NEAs will be necessary if the ACR mission is to be launched within a decade.

The ideal asteroid target will be a C-type object, thought to be similar to carbonaceous chondrite meteorites. Such materials can yield as much as 40% by mass of recoverable volatiles, in roughly equal parts water and complex carbon compounds. The residue after volatile extraction is about 30% native iron and nickel. To identify C-type targets, the search campaign must rapidly cue follow-up observations to detect spectral features indicative of water-bearing surface minerals.

The study estimated that a low-cost ground-based telescopic campaign could sort through the 3,500 new NEA discoveries made each year and identify about five 'good' ACR candidates. These would possess the right size, mass, shape, spin state, required $C_3$ launch energy, synodic period, and water-rich composition.

### How to steal an asteroid

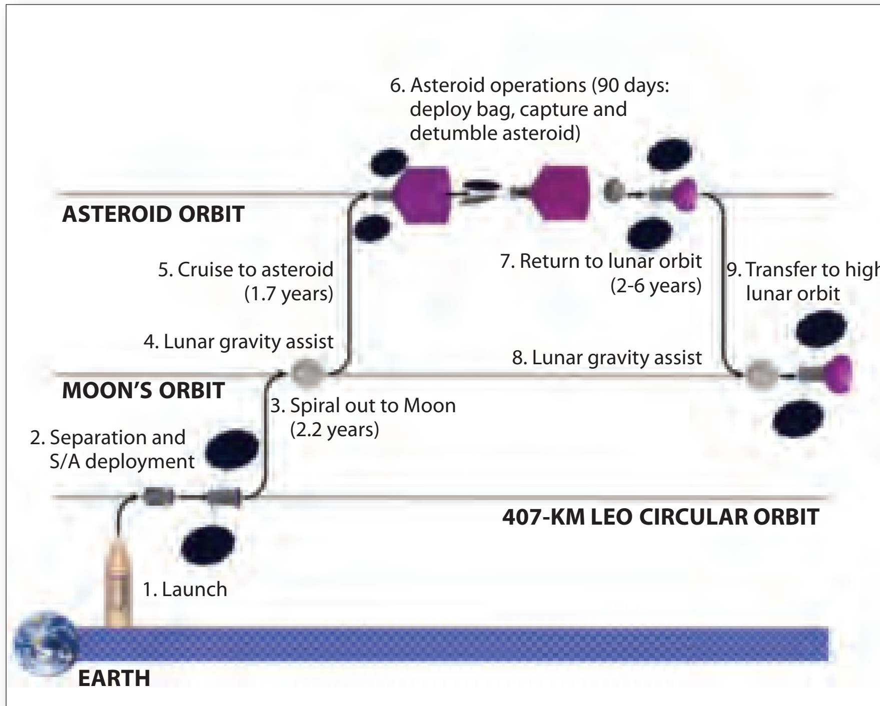
NASA Glenn's COMPASS design team, working with the KISS study staff, developed an ACR spacecraft concept based on existing space systems. The 6-m spacecraft bus is flanked by a pair of 10.7-m solar arrays to power the 40-kW SEP system. Atop the bus is stowed an inflatable, 10x15-m capture bag. The solar array wings span some 36 m, making for a large spacecraft, but it's going after big game.

The SEP system consists of five gimbaled Hall thrusters (four plus a spare) and a set of seven xenon tanks holding 12,000 kg of propellant. The system operates at a specific impulse of 3,000 sec. During NEA proximity and despin operations, ACR uses a bipropellant reaction control system employing four sets of thruster quads.

Opposite the Hall thrusters are the sensor package and capture mechanism. To characterize the NEA and provide guidance during proximity and capture operations, ACR carries four science cameras, four guidance cameras, an illumination system, a pair of LIDARs, and a pair of near-IR science spectrometers. Redundancy in the imaging systems is crucial, giving flight controllers the necessary situational awareness during approach and capture.

Once deployed, the capture mechanism resembles the open end of a funnel. The mechanism combines inflatable deployment arms, two or more inflated circumferential hoops, a high-strength fabric bag, and cinching cables. The inflatable arms and hoops hold the bag open as the spacecraft matches the asteroid spin and eases over the asteroid. The bag can contain an irregular object roughly 6x12 m in dimension, with a surface that is either solid, or weak and crumbly.

Once the asteroid is enveloped, cinching cables draw the bag closed




and snug it up against the spacecraft to provide the surface contact necessary for despinning. About 300 kg of propulsion is sufficient to detumble the roughly 500-ton asteroid. The bag fabric has the right surface thermal properties to maintain the asteroid at or below its temperature at grapple.

Should search programs fail to discover enough small, C-type NEAs to enable capture of a free-flying asteroid, the team suggested an alternate, 'pick up a rock' approach. The ACR spacecraft would rendezvous instead with a larger, roughly 100-m asteroid and target a surface boulder for retrieval. The ACR capture mechanism would be flown over a suitable boulder and the bag cinched closed. RCS thrusters would then pull the boulder free of the regolith and the asteroid's milli-*g* gravity. If a boulder won't come loose, a snow-blower-style scoop at the mouth of the capture bag could gather tons of regolith into the fabric enclosure for return to Earth.

On return to cislunar space, the ACR craft and asteroid in-tow perform a lunar gravity assist and are captured by Earth. Additional SEP thrusting puts the asteroid into a high lunar orbit, where roughly 10 m/sec of delta-V annually will suffice to maintain it there for at least 20 years. Total cost for the mission is estimated at roughly $2.6 billion over a decade (in 2012 dollars).

### Exploiting 'The Rock'

The captured asteroid, tended by its ACR spacecraft, would then be open to intensive exploration, exploitation, and dissection by both robotic and astronaut visits. NASA and its partners could sequence a series of robotic scientific missions to the object, much as cargo traffic is controlled at the ISS, conducting in-situ analysis, Earth sample return, resource extraction demonstrations, and assessment of physical and chemical properties.

As astronauts set up shop at the EM L2 'line shack' and habitat now being evaluated by NASA for the early 2020s, the captured asteroid would be a natural destination. Orion sorties to the NEA would be, in effect, human asteroid missions, reducing the risk for the full-fledged NEA missions to follow. An Orion crew could conduct multiple approaches, rehearse proximity operations, anchor, and 'dock' to the asteroid.

Astronauts would gradually peel back the capture bag, drawing back the curtain, so to speak, on an ancient, resource-rich asteroid. Close-up examination would reveal its morphology, composition, and 'topography,' and assess the physical state of its soil and bedrock. Gamma ray and neutron spectrometers would measure bulk composition before dissection begins.

Crew surface activities would progress from surface sampling to core sampling to testing anchoring strategies to extraction of water and other volatiles and finally to demonstrations of various bulk material handling and mining techniques. These activities would greatly advance asteroid science, human operations, resource extraction, and planetary defense engineering. Each Orion crew could return about 100 kg of material to Earth for analysis. After in-depth study, NASA and its partners could negotiate the handover of hundreds of tons of asteroidal material to commercial mining and resource delivery interests.

*An 8-m boulder that crashed down a hillside into an Ohio house in March is about the size of the small asteroid the ACR mission would return to high lunar orbit. Credit: G.S. Springer.*

## International exploration context

The ACR study showed that the technologies needed for the mission—SEP, high-power solar arrays, trajectory design, autonomous proximity and capture operations, and capture bag mechanisms—are all in hand or could be flight qualified by 2020. The proposed space-based IR survey mission NASA needs to identify hazardous NEAs and promising human exploration targets would also help discover the candidates for ACR.

Thus, the capture and return of a 500-ton asteroid to cislunar space could be accomplished by the middle of the next decade. This delivery date fits well into the progression of human spaceflight capabilities NASA envisions through 2030. If human NEA missions are delayed by budgetary or technical problems, the robotic ACR mission bridges the waning years of ISS operations and paves the way for true NEA expeditions.

The ACR mission seems to offer an affordable, logical step supporting human deep space expeditions in five specific ways:

• As a robotic precursor mission, ACR rehearses many of the phases of an astronaut NEA expedition and feeds that experience forward.

• ACR enables 'local' astronaut trips to an NEA lasting only a few weeks, building a bridge between LEO operations and true deep-space expeditions.

• Putting tons of bulk asteroidal material within reach of a human-tended EM L2 facility enhances the scientific, economic, and operational value of such an exploration gateway.

• The availability of hundreds of tons of asteroidal feedstock opens the door to large-scale use of extraterrestrial resources by NASA and its commercial partners, with the potential to jump-start an entire space-based industry to produce propellants and radiation shielding.

• The challenging, lengthy process of dissecting a 500-ton asteroid will engage the public and provide a steady stream of 'real-time' exploration experiences inviting community problem-solving. Imagine a televised, team competition aimed at coming up with the best and cheapest methods of extracting ores and tapping this new wealth from space.

The ACR mission also invites international cooperation in target search, hardware design and delivery, scientific study, commercial exploitation, and planetary defense engineering (by definition, ACR is an 'asteroid deflection mission').

Taken together, these benefits might entice NASA and its partners to develop ACR. The result would be a demonstrated deep-space capability that has not been seen since Apollo. The returned asteroid would put the Orion astronauts in touch with an ancient, scientifically intriguing, and commercially valuable body beyond the Moon, an achievement that would compare very favorably to missions that appear to merely repeat those Apollo landings of a half-century ago. NASA should take a good look at the ACR concept as it looks to construct an affordable path into deep space.

The *Asteroid Retrieval Feasibility* report is available via http://kiss.caltech.edu/people/contact.html.

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# Jetliner demand: The changing landscape

In the 1980s, an aircraft market forecaster could safely do his job without paying much attention to the airlines themselves. That sounds strange, but a dozen years or so after deregulation in 1978, airlines were a remarkably static industry. A few stumbled and fell, but aside from Pan Am and Eastern, for the most part nobody went away, and nobody other than Southwest successfully joined the club. Troubled legacy airlines then were like insolvent European countries today: You knew they were hurting, but you also knew that one day they would buy things again.

Through the 1990s there was a classic joke: Question: How many airlines will there be in 2025? Answer: Three—two globally merged megacarriers, and 'financially troubled TWA.' There was little to gain from paying attention to the details—all that mattered was that the airline industry had high barriers to exit and entry. The structure of the industry, therefore, did not change in ways that materially affected jetliner demand.

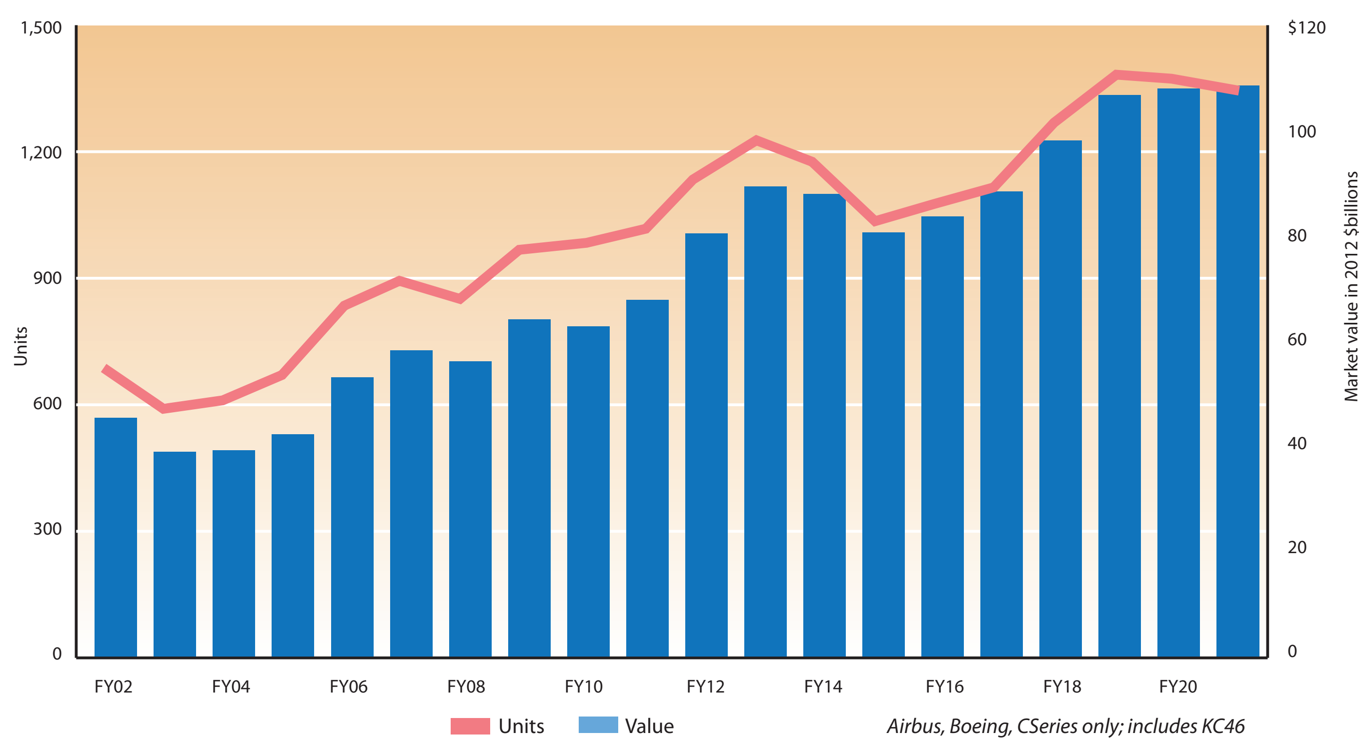
## Lower barriers for low-cost carriers

About a dozen years ago, barriers to entry got lower. Or the new entrants got smarter. Either way, more low-cost carriers (LCCs) seized domestic market share, exceeding 30% in some markets. They also began taking planes, particularly single-aisle models, helping single-aisle production reach record highs as a part of total industry output (53% last year). For the first time in decades, new airlines cropped up, such as JetBlue, easyJet, Ryanair, and Air Asia. Entry barriers probably fell too far too fast, resulting in the brief and strange lives of Independence Air and Skybus, but the industry had changed. Because of these LCCs, aided and abetted by Internet fare transparency, fares and yields came down at precipitous rates.

As a result, everyone became a low-fare carrier. The only question airlines faced was whether or not they were also a low-*cost* carrier. To put it another way, the industry had a shortage of 8 cents per seat-mile capacity and an oversupply of 13 cents per seat-mile capacity.

Carnage predictably followed. Barriers to exit had been torn down. As

**COMMERCIAL JETLINERS HISTORY AND FORECAST**
DANGEROUS WORDS: IT REALLY IS DIFFERENT THIS TIME




*When the Airbus A320Neo and Boeing 737Max become available, there will be an increase in single-aisle jet demand.*

economist Larry Summers recently commented, one hallmark of our times is that big changes take longer to happen than you would think they would, but when they start happening they happen faster than you would ever expect. In the U.S. and Europe, names are going away fast. There has been creative destruction.

Think about the names that have disappeared over the past few years (even if they survive as superficial brand identities): Swissair, Northwest, KLM, Continental, and others. Just in the past few months Spanair and Malev have followed. We'll see what becomes of American. And even the fast-growth emerging markets feel this destruction. That joke about TWA in 2025 will not be updated with 'financially troubled Kingfisher.'

As a result, almost all of the surviving carriers today are low-fare *and* low-cost airlines. As Samuel Johnson noted, there is nothing like the sight of the gallows to focus the mind. Mergers and bankruptcies have worked their magic, if you can call it that, on the landscape. It was ugly to watch —80% of airline mergers give the other 20% a bad name—but it happened.

So, increasingly over the last decade, a jet production forecaster had to look at a changing industry landscape and understand the requirements for this new airline industry.

## The technology spectrum

The first conclusion is that in a world of impressive industry-wide operational and structural improvements, it all comes down to technology. John Newhouse's timeless book, *The Sporty Game*, shows that civil jetliners were actually a more dynamic industry than their military counterparts. With warfare, however, there is a technology spectrum. At one end, technology is not so important. With guerrilla and counterinsurgency warfare, with urban or jungle warfare, technology matters less than tactics, unit cohesion, leadership, morale, doctrine, organization, and many other less tangible factors.

At the other end of the conflict spectrum you have antisubmarine warfare, antiaircraft defense, or tank battles over open terrain. There, technology is paramount. The other factors matter less. When two tank forces shoot at each other in a desert, good leadership and other 'soft' factors matter a lot less than having the best laser rangefinder and the best gun.

The airline industry is moving toward the technology end of the spectrum. Remember, everyone is a low-cost carrier. Nobody has huge lease obligations on 30-seat jets anymore. Nobody has absurdly heterogeneous fleet plans anymore. Nearly everyone has gotten rid of difficult pension obligations. They have been washed away through bankruptcy and restructuring.

And operationally, nobody has equipment sitting around at hubs for two hours any more. Legacy carriers may not have Southwest's turnaround times, but they have made a lot of progress moving in that direction. Almost everyone charges for bags, and everyone has removed every blanket from the airplane. It is no longer just Southwest that keeps costs low and domestic flight amenities minimal.

Therefore, in a world where everyone is closer to doing the right things to save money, where everyone has moved toward LCC operating procedures, the carriers are all like tanks shooting at each other in the desert. Operational concerns and procedures have been equalized. It all comes down to what technology a carrier has, and the resulting fuel bills. Equipment fuel burn is the only remaining major cost area that carriers can change.

And, of course, fuel now costs four times as much as it did in 2000. Meanwhile, domestic travel is a commodity service. Given the low margins in the airline business, carriers are running fast just to stay in the same place in relative terms.

## The refleet factor

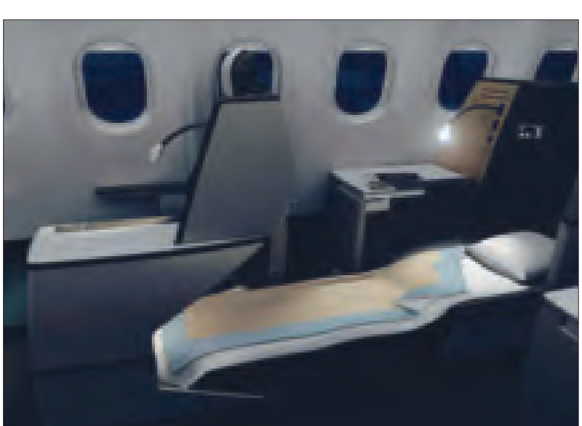
So, the U.S. is like an airline refleeting tinderbox. On the positive side, looking at opportunities, U.S. carriers can in many cases skip a generation, going from MD-80s, older 320s, and 737 classics to Neos and Maxes. On the negative side, looking at threats, if your competitor refleets with these new planes and you do not, you're toast. Since the cost savings associated with moving to new equipment exceeds airline profit margins, there is a huge cost disadvantage of being left behind in the refleet game.

We will see a considerable run-up in single-aisle jet demand after Neo and Max come on line. In the two years before they enter service, there will be a narrowbody rate dip. There is no way to avoid demand migrating from the current single-aisle models to the new ones. But the years after these two new planes enter service will see single-aisle production numbers above the very high record rates currently planned for the following year. This U.S. airline refleet factor plays a major role in driving Teal Group's commercial jetliner forecast, particularly after 2016.

*If the Bombardier CSeries is ever going to make it, now may be the time.*

The Bombardier CSeries business case may not be the soundest, but if the CSeries has a chance, this is it. Just as the MD-80 series, a marginal player, profited from its availability during the late 1980s boom market, the CSeries might conceivably benefit from a sudden North America refleet where jet availability becomes a major concern.

Twin aisles are another story. International traffic is less of a commodity product than domestic traffic, and technology is somewhat less important. For U.S. carriers, there is a lot to be said for coasting with upgrades to existing equipment. It is clear that U.S. carriers must get serious about growing their international exposure, and in particular they need to get serious about chasing international premium traffic. Everyone has to move to lie-flat business-class seating and other amenities, and to add more international routes. But this again represents another example of running just to stay in place. After all, everyone has exactly the same idea.


*U.S. carriers must get serious about growing their international exposure, and chasing international premium traffic.*

### Access to finance

Another conclusion is that looking at the past and present state of the industry, these airlines will not have much money. And what they have they will not want to spend on aircraft. However, after industry restructuring decides who will survive, and after pension overhangs are removed, the airlines will be good finance candidates. The third-party finance people's core specialty is getting access to cash at good rates.

Access to finance is the biggest risk moving forward. Right now, we are at record high jetliner production rates, but the production ramp-up is at an extraordinary angle. Output will grow 18.6% this year, with a 16% compound annual growth rate through 2014. If manufacturers' delivery plans work out, the jet industry will have grown 175% between 2003 and 2014. And that is before Neo and Max kick in and U.S. refleeting begins in earnest. Will third-party finance ramp up to meet the demand?

Given the importance of third-party financing, jetmakers must keep their products finance-friendly. That means fewer options and greater flexibility. It is all about making sure that jets are easily remarketable and that they retain their value in a changing airline industry landscape. We will see a bias in favor of known producers with strong residual-value track records. This means even greater challenges for emerging manufacturers, who already face an uphill ride.

### Government's role

Government support will be part of the answer to this challenge, for better or worse. Whether through government-owned airlines, government-owned banks and sovereign wealth funds, or government export credit agencies, the role of governments around the world in jetliner transactions has ramped up to over two-thirds of the market.

Until recently, the U.S. Export-Import Bank, which increased its backstop finance role over the past three years to about one-third of Boeing sales, had planned to ramp down as commercial finance ramped up. But the recent Obama administration decision to increase Ex-Im finance shows a move in the opposite direction. In fact, the March Ex-Im announcement implies a possible role in financing Boeing sales to domestic carriers as a retaliatory move if Bombardier gets Canadian government financing for CSeries sales to U.S. airlines.

The good news is that government finance will help make continued production increases feasible. The bad news is that government finance can also distort markets, raising the prospect of government-backed overcapacity, analogous to Fannie Mae's role in the housing market.

### Outlook for regionals

The other equipment conclusion concerns regional aircraft, on which Teal is not as bullish. Regional deliveries have declined from about 15% of the total transport market value 20 years ago to about 10% last year.

The reasons are self-evident. Airline mergers mean fewer hubs and smaller hub feed requirements. Expensive fuel means smaller aircraft look less efficient. Airlines have deemphasized market share and catchment area expansion and eagerly cut service to marginal markets. Contract renegotiations between the regionals and the majors have been painful… and it is a one-sided kind of pain. Essential Air Service subsidies have dwindled to almost nothing. Regional requirements always stayed largely North American, so the industry did not profit much from fast-growth emerging market carriers.

From a regional aircraft perspective, that is a laundry list of horror. The new 'regional' aircraft that have dominated the market over the past few years, while selling to a more global customer base, are mostly larger 90/100-seat planes flying origin and destination traffic. Almost nobody would consider them true regionals.

For the OEMs, the number-one rule is to escape from the regional market. For Bombardier, that means developing the CSeries, which is extremely risky, but at least it is not a regional aircraft. For Embraer that means business jets, KC-390 transports, and a reengined E-170/190 transport family that aims to get into mainline turf.

We can draw several conclusions from all of this:

- There will be demand for lots of next-generation single aisles, all at once. That's an opportunity.
- There will be greater emphasis on, and challenges for, third-party finance. That's a risk.
- There will be a great market for the premium seat and jet interior upgrade companies.
- There is really not much hope for regional aircraft.

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# Soyuz and Long March set the pace

THE LAUNCH SERVICES INDUSTRY CONtinued to grow last year, posting 79 attempted orbital launch missions. That total surpassed the 75 missions in each of the previous two years and represents more launches than at any time since 2000, when 87 were attempted. But although the number of launches increased, there was far less diversity in terms of the rockets used. In 2009 and again in 2010, 21 different launch vehicle models were employed, compared to only 18 in 2011.

[Note that for the sake of simplicity, we count all the Long March models as one and break out the Zenits into either land-launched or sea-launched models.]

In other words, last year's launch activities were slightly more concentrated, with 92% of all launches undertaken by the 12 most active rockets—Russia's Soyuz, China's Long March, Russia's Proton, Europe's Ariane 5, the U.S. Atlas V, the Ukraine's Zenit, the U.S. Delta IV and Delta II, Japan's H-2, the U.S. Minotaur and space shuttle, and India's PSLV. By contrast, the 12 most active vehicles accounted for 88% of all attempted launches in each of 2009 and 2010.

The rising trend in launch activity concentration is apparent for the three most active rockets, which accounted for 40% of all launches in 2009, 52% in 2010, and 53% in 2011. But it is particularly noticeable for the two most active vehicles, which accounted for 29% of launches in 2009, 36% in 2010, and 44% in 2011.

It is clear that the top two rockets are increasingly driving the launch services market. In 2009, it was Soyuz and Proton. In 2010 and again last year it was Long March and Soyuz.

In short, Soyuz and Long March have emerged as the most prolific space launch programs in the world, by far. Together they account for 34% of all the launches attempted during the past three years; we project that this dominance will continue—and probably expand—for the foreseeable future.

*Soyuz (left) and Long March are increasingly driving the launch services market.*

## Commercial expansion for Soyuz

While Soyuz has consistently ranked among the leading rockets for decades, most of its business traditionally has focused on launching civil satellites and capsules for the Rosaviakosmos, the Russian space agency, or military satellites for Russia's ministry of defense. This started to change dramatically in 1999, when the Soyuz began to be used for launching Globalstar mobile communications satellites to LEO. That year, seven Soyuz vehicles successfully launched Globalstar satellites, in batches of five.

Over the past decade, Soyuz has been used most often to launch Soyuz manned crew transport capsules to the ISS and Progress unmanned resupply capsules—increasingly so, given the drawdown of the space shuttle program. During this time, however, Arianespace has invested in helping to develop the Soyuz 2.1a and 2.1b and in marketing them commercially. In 2010, Soyuz was again being used to launch Globalstars. On October 19 of that year, a Soyuz 2.1a successfully launched six Globalstars from Tyuratam, Kazakhstan.

On July 16, 2011, a 2.1a launched six Globalstars, this time from Arianespace's main launch facilities at Kourou, French Guiana. The first Soyuz 2.1b from Kourou followed on October 21. That mission carried two Galileo navigation satellites for ESA. On December 17, another 2.1a lifted off from Kourou, carrying small French and Chilean imaging satellites, followed by a 2.1a with six Globalstars from Tyuratam.

*The Soyuz lifts off on its inaugural flight from the spaceport in French Guiana.*

Between Arianespace's investment in and commercial marketing of Soyuz and the readiness of the Globalstar program to use the vehicle for launching most of its satellites, Soyuz has grown to become the industry's most commercially successful medium-sized launch vehicle. It thoroughly dominates the medium-lift segment of the market, especially now that Boeing's Delta II is so overpriced (more than $100 million per mission) that it is essentially uncompetitive.

Soyuz's growing commercial business—along with its already substantial civil and military activity—accounts for the vehicle's 19 launches in 2011. It is hard to recall the last time any rocket posted 19 or more launches, but the feat has certainly not been matched this century. You might have to go back to the early 1990s or 1980s to the days of the Soviet Union.

**LAUNCH MISSIONS BY MONTH**

| | |
|---|---|
| January | 4 |
| February | 5 |
| March | 3 |
| April | 6 |
| May | 5 |
| June | 7 |
| July | 8 |
| August | 7 |
| September | 7 |
| October | 9 |
| November | 9 |
| December | 9 |

While more than 80% of Soyuz launches were for the Russian government last year, there is a trend toward more commercial customers, such as Globalstar. About 40% of the satellites launched by Soyuz rockets last year were commercial, including the two Galileos. A few Soyuz launchers have already been contracted by ESA to carry Galileo satellites, as well as by O3b Networks for its constellation of eight broadband communications satellites at medium Earth orbit.

We expect Soyuz to maintain its near monopoly of the medium-lift launch market for the foreseeable future. The only U.S. rockets that may eventually provide some competition are Space Exploration Technologies' medium to heavy Falcon 9 and Orbital Sciences' medium Antares (formerly known as Taurus II).

With a diverse customer base, the marketing prowess of Arianespace, and the advantage of three different launch sites (Plesetsk, Tyuratam, and Kourou), Soyuz's growth potential is considerable. The only launch vehicle program that stands to outpace Soyuz is China Great Wall Industry's Long March, which consists of just under a dozen rocket models that are either active or under development.

## Rapid rise of Long March

Although not a major player in the commercial market, Long March has been one of the most successful launch vehicle programs during the past five years. Throughout much of its history, it averaged no more than two to three missions per year.

However, Long March launch rates began growing to four to five missions annually over the past decade, as China's national space program noticeably expanded and built many more spacecraft. These included communications and scientific satellites, exploratory probes, and capsules, together with the first series of demonstration Beidou navigation satellites.

The Chinese government also began making a greater effort to market


*The Falcon 9, along with the Antares, may be the only U.S. competition for the Soyuz.*

**LAUNCH MISSIONS BY VEHICLE**

| | |
|---|---|
| Soyuz | 19 |
| Long March | 16 |
| Proton | 7 |
| Ariane 5 | 5 |
| Atlas V | 5 |
| Zenit | 4 |
| Delta IV | 3 |
| Delta II | 3 |
| H-2 | 3 |
| Minotaur | 3 |
| Space shuttle | 3 |
| PSLV | 2 |
| Dnepr | 1 |
| GSLV | 1 |
| Rockot | 1 |
| Safir | 1 |
| Sea Launch Zenit | 1 |
| Taurus | 1 |

Long March commercially to other countries with which it had developed closer political and economic ties—nations such as Venezuela and Nigeria. During 2007-2008, Long March rockets lofted Nigcomsat 1 and Simon Bolivar 1 (Venesat 1) communications satellites for Nigerian Communication Satellite and the Venezuelan Ministry of Science and Technology, respectively.

But by 2008, a much more diverse and ambitious Chinese space program and some initial success at marketing launch services abroad combined to produce a record number of missions for Long March. Seemingly overnight, the rocket posted 11 launches that year, matching Russia's heavy-lift Proton as the most prolific launch program. Suddenly, Long March had joined Soyuz, Proton, Delta II, and Ariane 5 as one of the upper-tier rockets in terms of activity level.

In less than a decade, Long March went from being a low-launch-rate program posting two to three missions a year to a medium-rate one averaging four to five, and finally to a high-rate one with 11. The growth was fueled almost entirely by the Chinese space program.

If you look at the 15 spacecraft launched by Long March rockets in 2008, all but two—the Simon Bolivar 1 for Venezuela and the Chinasat 9 direct TV broadcast satellite for China Satellite Communications—were for the Chinese government.

Tianlian 1-1 was a civil data relay spacecraft and the Tansuo 3 (Shiyan 3) and BX-1 were scientific technology development satellites. Shenzhou 7 was a manned space capsule—the first manned mission for the Shenzhou program and the first to feature a spacewalk by a Chinese taikonaut.

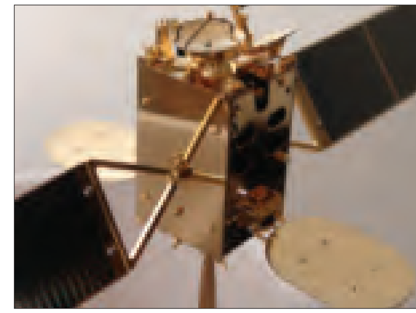
The remaining nine satellites launched by Long Marches that year were for Earth observation. At least four of those—Shijian 6E, Shijian 6F, Yaogan 4, and Yaogan 5—were designed for military imaging missions. Three were disaster monitoring satellites—Chuangxin 1-2, Huan Jing 1, and Huan Jing 2. And two were meteorological—Feng Yun 3A and 2E.

The four Long March launches in 2009 suggested that the previous year's record number of flights might have been an anomaly, but that thought was quickly put to rest in 2010 when the program successfully carried out a total of 15 missions. In fact, the slowdown was due to an extremely unusual failure (the first in 13 years) by a Long March on August 31, 2009.

The problem was attributed to a malfunction of the CZ-3B's third stage, caused by a burnthrough of one of the stage's YF-75 engine gas generators. This resulted in the placement of Indonesia's Palapa D1 commercial communications satellite in a lower than planned orbit.

The 15 launches in 2010 set another record for Long March and made it the most active of all the launch programs in the world. It surpassed both Proton and Soyuz, which had experienced one of their most successful launch years in recent memory, with 12 missions each. And again, nearly all those launches by Long March were for the Chinese government. The only exception to this was the Chinasat 6A for China Satellite Communications.

The most common types of Chinese spacecraft launched that year were civil navigation and military imaging satellites. Long Marches orbited five Beidou satellites for China's proposed Compass navigation system, which will consist of 35 satellites within the next decade. They also launched five military imaging satellites—three more Yaogans and the Tianhu 1.



*China has begun launching commercial satellites, including the Venesat 1, for foreign customers.*

In addition, these rockets launched three Shijian scientific satellites, the Chaang'e-2 Moon probe, the Feng Yun 3B meteorological satellite, and the Zhongxing 20A military communications satellite.

Had Soyuz not had such an unusually stellar year in 2011, Long March would have led the world in number of launches for the second consecutive year, with a total of 16—although one of those (on August 18) was a failure. The program continued to benefit from a full manifest of Chinese civil and military satellites, including three more Beidous, two Yaogans, a Shenzhou, a Chuangxin, and a Tianlian, but also three commercial satellites for foreign customers.

With the launch of three telecommunications/broadcasting satellites in 2011—Paksat 1R for the Pakistan Telecommunications Authority on August 11, Eutelsat W3C on October 7, and Nigcomsat-1R for Nigerian Communication Satellite on December 19—the Long March program seems finally to have made a breakthrough in the international launch market.

Combined with its captive and increasingly diverse and robust domestic market, its successful penetration of emerging markets in Africa, Central Asia, and South America, and more recently the mature and lucrative European market, the business potential is perhaps more promising for Long March than for any other launch vehicle anywhere.

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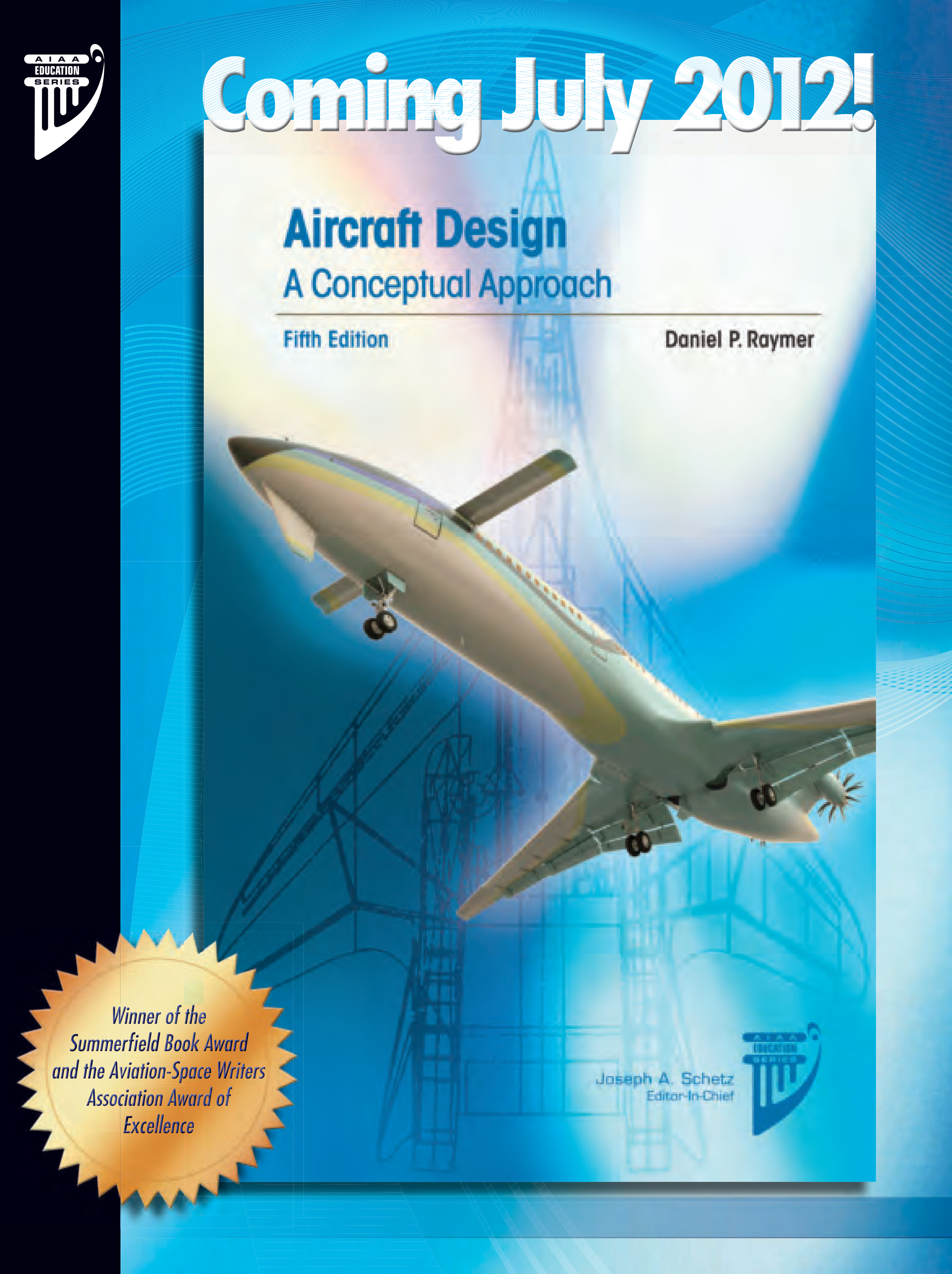
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# A global Human space exploration

*The next major step in human space exploration, going beyond LEO, will not be possible without multinational cooperation, say experts. The international space station program, despite its twists and turns, proved what countries can accomplish together and could serve as a model for a joint exploration effort. Over a dozen space agencies from around the world have begun discussions on coordinating long-range plans for such missions, which are likely to proceed in the future—with or without U.S. leadership.*

**NASA's plans for sending expeditionary crews** beyond LEO were sidetracked when President Barack Obama reset America's space agenda in April 2010, curtailing the Constellation program, which was to be an energetic plan of putting people back on the Moon, sending crews to Mars and beyond. Preparations for a human return to the Moon were halted outright. Top priority went instead to developing capabilities that would allow astronauts to visit near-Earth asteroids, orbit Mars, and ultimately make landfall on the Martian surface.

It has become increasingly apparent both to the U.S. and many other spacefaring nations that realizing any vision of sustainable space exploration beyond LEO will require greater global cooperation.

The success of the ISS project—hailed as one of the most advanced engineering achievements to date—underscores what is possible when spacefaring nations collaborate to pursue a shared strategy.

Looming large, however, is the cash-strapped condition of nations. The process of piecing together a long-term global space partnership is fraught with other challenges as well, from uncertainties regarding technical competence, to questions of interdependence and leadership acumen, to lack of political willpower.

## Nonbinding international coordination

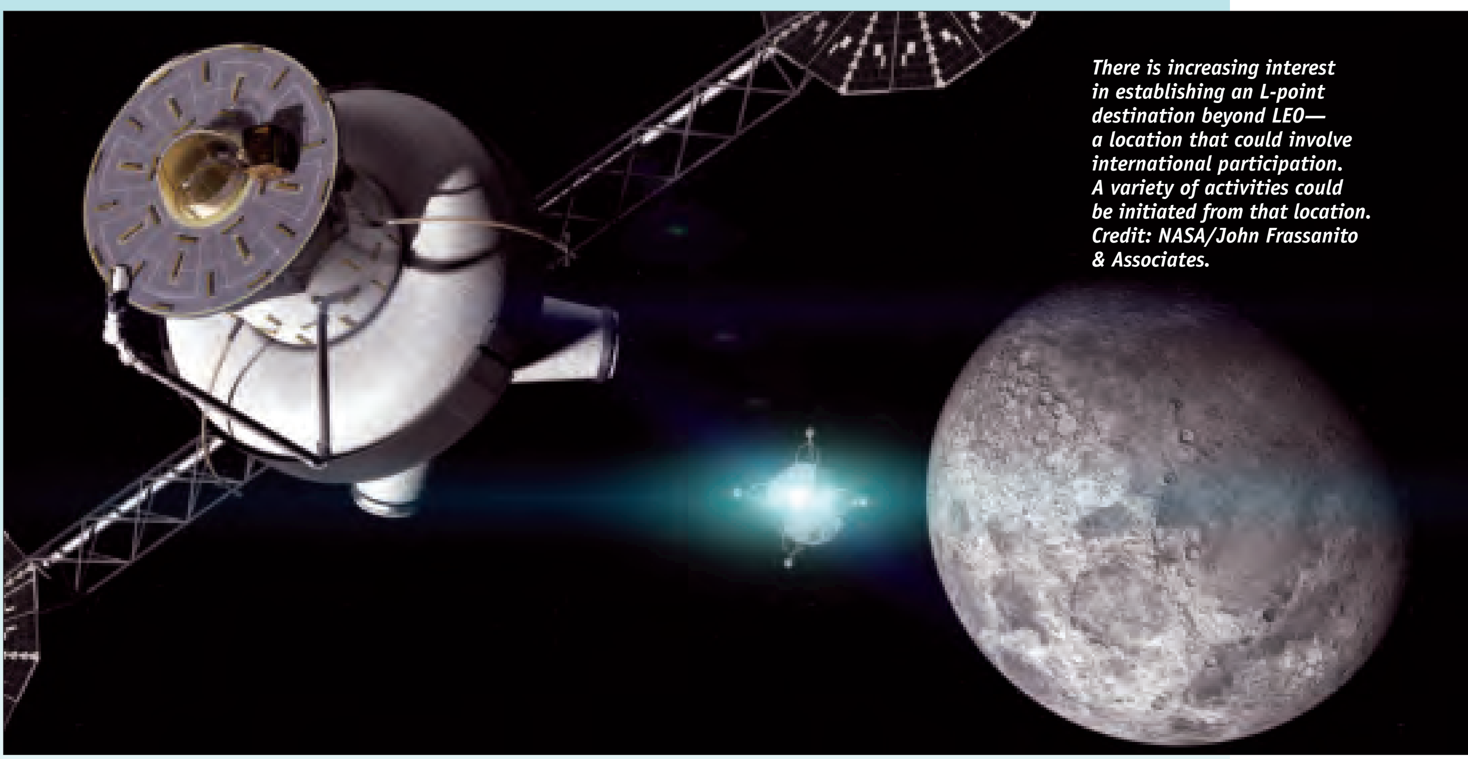
This month the Global Space Exploration Conference, organized by the International

Astronautical Federation and the AIAA, is serving as an international forum for discussions by major stakeholders in this arena—senior administrators and space exploration managers from the major space agencies, industry, governments, academia, and nongovernmental organizations.

Sure to be a major topic at the conference is a recent publication by the International Space Exploration Coordination Group (ISECG), a voluntary, nonbinding international coordination forum.

ISECG has its roots in 14 space agencies whose members sat down together in 2006 to take a hard look at global interests in space exploration. The group seeks to enable a flow of information between agencies regarding interests, objectives, and plans in space exploration. The goal is to fortify both individual exploration programs and the collective effort.

Last year ISECG released the Global Exploration Roadmap, or GLEX for short. A long-range exploration strategy, it begins



*There is increasing interest in establishing an L-point destination beyond LEO—a location that could involve international participation. A variety of activities could be initiated from that location. Credit: NASA/John Frassanito & Associates.*

# quest

**by Leonard David**
Contributing writer

### ISECG participants

| |
|---|
| ASI—Italy |
| CNES—France |
| CNSA—China |
| CSA—Canada |
| CSIRO—Australia |
| DLR—Germany |
| ESA—Europe |
| ISRO—India |
| JAXA—Japan |
| KARI—Republic of Korea |
| NASA—United States |
| NSAU—Ukraine |
| Roscosmos—Russia |
| UKSA—United Kingdom |

with the ISS and expands human presence in the solar system, leading ultimately to human missions to explore the surface of Mars. The roadmap flows from this strategy and identifies two potential pathways, Asteroid Next and Moon Next.

Each pathway is a notional mission scenario covering a 25-year period and presents a 'logical sequence' of robotic and human missions. Both were deemed realistic approaches that could address common high-level exploration goals developed by the participating agencies, recognizing that the groups' preferences regarding the pathways may vary.

The document notes that "there is much work to be done before the risks associated with such missions can be reduced to an acceptable level and the required technologies are matured to enable a sustainable approach."

The next iteration of the roadmap is expected later this year, with agencies hoping to elaborate on strategies laid out in the earlier document. There is also an eagerness to recognize additional opportunities for near-term partnerships that contribute to shaping sojourns beyond LEO.

## ISS: A key factor

"We think about a coalition or partnership for exploration beyond low Earth orbit," says Kathy Laurini, senior advisor, exploration and space operations, at NASA. She is the agency's representative to ISECG, based in The Netherlands.

"There's no question it'll start with the strong partnership that's formed by the ISS agencies. But there are a lot of other agencies out there that are emerging and have a lot of capabilities. It would be nice to bring them in," Laurini tells *Aerospace America*.

The ISS is a key ingredient, a platform to showcase research and technology and to enable innovation, she says, as well as to promote commercial cargo and crew operations. "So to the extent that ISS can drive those innovations, and make it cheaper for us to get to space, it helps governments really look beyond low Earth orbit."

Deliberations in the ISECG arrive at a bottom line, says Laurini. "Going beyond LEO is the next step; it's a question of when. Right now we're doing cooperative work so that when budgets free up there are plans that are technically feasible, programmatically implementable…but have been developed collaboratively."

Laurini says NASA cannot control the critical path of partner nations for moving beyond LEO. "It's just too expensive. It is going to take all of us and several agencies on the critical path. So just finding the right roles for those agencies, that are consistent with their capabilities and their long-term goals…is a challenge." But in the field of human spaceflight, "NASA *is* the glue. Agencies look to us for that role, frankly."

The September 2011 first iteration of ISECG's document presents a roadmap to Mars "mainly because there's a big question about the next destination," Laurini explains. "The fact is we don't really need to decide right now. The idea is to be iterative over time, to serve as a tool to help align policies and plans. The ISECG is charting a way forward, one that is a collaborative vision and respects the fact you only get money if there's a benefit to your stakeholders. Doing that and finding the common ground…that is always a challenge."

The implications of humankind moving beyond LEO are global, says Laurini. "If you're going to do it, you should do it internationally. There's no better time than now to start the planning."

## Open-ended process

Bernhard Hufenbach heads the Exploration Architecture Office in the Directorate of Human Spaceflight at the European Space Research and Technology Center (ESTEC)—the technical heart of ESA in Noordwijk, Netherlands. "Global cooperation for future space exploration is not only a necessity, due to the resources required for implementing sustained exploration, but also a common goal as stated in the Global Exploration Strategy, considering derived broader socioeconomic benefits," he says.

International partners in any future exploration must learn how to manage interdependency, notes Hufenbach. An impor-

*High-level representatives from 41 countries, including the 29 ESA and EU states, took part in a recent international conference on space exploration in Lucca, Italy. Credit: Andrea Rossi, ESA.*

tant enabler for this in an international program, he says, is a clearly defined governance scheme and overall cooperation framework.

The model applied for the ISS program can serve "as a good reference," Hufenbach believes, one that has helped to forge a strong partnership and to mitigate the consequences of various crises that arose during the project.

But there are differences between the two programs, Hufenbach stresses.

"Exploration is an open-ended process, composed of multiple missions to different destinations with potentially varying partners, driven by a very long-term vision," he says. Today, the boundaries of a particular 'international program' in this process are not defined. The governance scheme and cooperation framework for exploration must address long-term strategic planning, as well as the implementation of incremental steps through dedicated programs. "It needs to be flexible and easily adaptable to cope with change of partners and mission scenarios," he concludes.

"There is a question mark over whether the ISS model is the right one to adopt," says Ian Pryke, a senior fellow at George Mason University's Center for Aerospace Policy Research. "Whether you take an ISS model or whether you've got to evolve some different model remains to be seen."

One hurdle overcome in the ISS program, Pryke recalls, was worrying about having station partners on the critical path. Fast forward to today: As long as the station is there, he contends, "you've got a number of space agencies that are locked into working together. And they are doing it on a daily basis. That creates a positive background for whatever you do in the future."

Pryke notes that the ISECG has been careful to put the emphasis on coordination rather than cooperation. "Today, it's very hard to talk about modes of cooperation when you don't know exactly what you would be cooperating on," he says.

### Leadership vacuum?

A question raised by Max Grimard of EADS Astrium in France is: Will the U.S. remain the real leader of human space exploration? His assessment is that human space exploration is at a turning point, and should find its direction during the coming decade.

Grimard presented his personal view at the 2011 International Astronautical Congress in Cape Town, South Africa: "Today, U.S. exploration plans are sucked down into political battles, Europe and Japan are nearly nowhere, Russian plans are hazy, China's ambitions are clear and implemented, and new actors such as India are raising their profile."

*The ISS is an examplar of lessons learned for orchestrating any global program of human travel beyond LEO. Credit: NASA.*

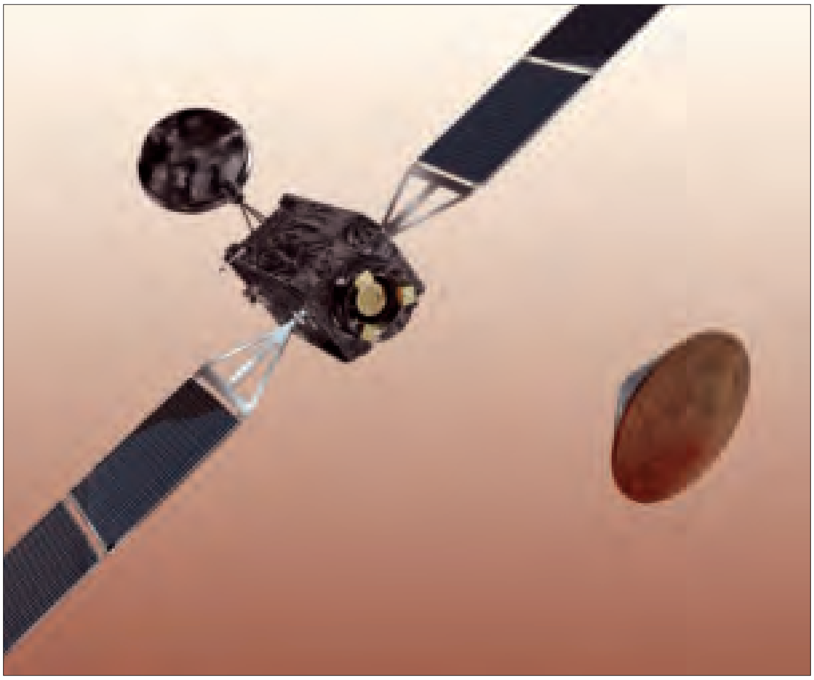
Given that appraisal and the uncertainties of the current environment, his next question is straightforward: Who will be the leaders of human space exploration 10-15 years from now?

Grimard believes four key factors are driving the dynamics of human space exploration: the general budget situation, human space exploration within a country's political agenda, budget competition for resources, and political stability during long-term exploration ventures.

There is a strong consensus that the next big step for human space exploration, such as NEOs or Mars, will necessitate huge infrastructures that are not affordable by any one country, Grimard says. Even planting new footprints on the Moon will need international cooperation.

"Three of the 'historical' spacefaring countries—the U.S., Europe, Japan—have lost political momentum for human space exploration. They are facing very strong economic constraints and have more urgent priorities," he says. Although the U.S. still has the largest civil space budget, the pressure of the debt crisis will deepen this loss of momentum, he believes. "Human space exploration is continuing more on 'DNA obligation' than on clear strategic objectives."

Grimard forecasts that the U.S. will have difficulty generating an international initiative that embraces trusting partners. That is a paradox, he observes, in that the nation remains the most powerful and



The ExoMars descent lander (above) would deliver the rover (below) to a specific location using an inflatable braking device or parachute system. Using conventional solar arrays to generate electricity, the rover will be able to travel a few kilometers over the rocky orange-red surface of Mars.

highest spending country for human space exploration, "but it can hardly appear as a leader, due to its evasiveness."

Considering the situation, Grimard advises that the booster of new initiatives in human space exploration could more likely be China rather than the U.S. in the coming decade—but not as a catalyst of an international effort. There is a high probability, he says, that China will pursue national ambitions 'à la Apollo' while the block of space station partners carry on human spaceflight in the framework of ISS and spend money trying to start a long-term initiative, without entering full-scale development.

If so, Grimard argues, this might lead to a global loss of momentum for meeting the ultimate objective: expanding the frontier of human space exploration toward the NEOs or Mars. That is, nobody is steering international partners in the structure of a worldwide endeavor. "The milestone for humans, to go outside the Earth-Moon system, might shift very far in the future," he concludes.

### Grace and goodwill

Dispatching an expedition to Mars has long been a drawing card, as the ISECG document demonstrates. Still, getting a lasting pledge between NASA and ESA to pull together the robotic ExoMars mission turned sour earlier this year.

ESA, in cooperation with NASA, had pieced together the ExoMars program to investigate the Martian environment and demonstrate new technologies paving the way for a future Mars sample return mission in the 2020s. But NASA's 2013 budget spelled out the disappointing news: The agency pulled out of a 2016 ExoMars mission and signaled a no-go on a follow-on 2018 mission. Meanwhile, ESA officials have begun looking at Russian support.

"The recent situation with Mars exploration demonstrates that even having an international cooperation agreement is no guarantee of success," says Marcia Smith, president of Space and Technology Policy Group. Smith is also founder and editor of the informative SpacePolicyOnline.com.

"Perhaps the most regrettable aspect of the revised Mars plans is that we are reneging on that 2009 agreement with ESA. After all, we are awash in Mars probes—already there, on their way, and to be launched—so I personally am not that concerned about possibly missing a Mars opportunity. But we did sign an agreement with ESA and now have to back off because of budget realities," says Smith.

With so many unpredictable factors, Smith says she does not know of a solution. "I credit our international partners around the globe for being so flexible in working with us despite the twists and turns" in the station program, for example, and in use of the shuttle for ISS operations as promised.

"So, yes, international cooperation is critical, and I hope that our partners continue to show the grace and goodwill that they have in the past as our plans constantly shift," says Smith.

### Lack of coherence

"The upcoming GLEX conference is an important part of creating a broader international consensus on human explorations beyond low Earth orbit," says Scott Pace, director of the Space Policy Institute at George Washington University's Elliott School of International Affairs in Washington, D.C. "The United States will not be engaging in exploration without international partners, so realistic plans need to be developed in consultation with prospective partners."

Pace's survey article on this subject was published in the *Harvard International Review*. Organizing a broad international approach to space exploration and space security will not be easy, says the article, not least because of the errors and confusion in recent U.S. space policy statements, strategies, and programs.

Pace notes also that the U.S. has diminished its global influence by omitting the Moon as a focus for near-term human space exploration efforts, and by failing to cooperate with Europe on the next stage of robotic missions to Mars.

Moreover, there is a lack of general coherence regarding civil space exploration in the Obama administration's 2010 National Space Policy. It directed the NASA administrator to set "far-reaching exploration milestones"—specifically, by 2025, to begin missions beyond the Moon, including flying humans to an asteroid.

As later technical work has shown, says Pace, there are few scientifically attractive, technically feasible asteroids that can be reached on this schedule. Even worse, the international space community, which had been focusing its expectations on the Moon as the next U.S. target of exploration, "felt blindsided," he notes.

Asian countries like Japan, India, China, and South Korea had seen the Moon as a challenging but feasible destination for robotic systems, and a practical focus for human space exploration, Pace continues. The choice of an asteroid mission was, perhaps mistakenly, taken as an indication that the U.S. was not interested in broad international cooperation but would focus instead on partnerships with the most capable players—Russia, and perhaps European countries. As a result, spacefaring nations are increasingly making their own plans, separately from the U.S., he writes.

Pace explains that Asian space agencies have shown an interest in lunar missions as the logical next step beyond LEO. These missions are viewed as "ambitious but achievable" and hence more practical than trips to Mars or more distant locales. He believes that a program of multilateral exploration of the Moon would also be a symbolic and practical means of building a framework for peaceful space cooperation, in concert with dual-use discussions of space transparency and confidence-building measures, known in diplomatic shorthand as TCBMs.

### Conditions for cooperation

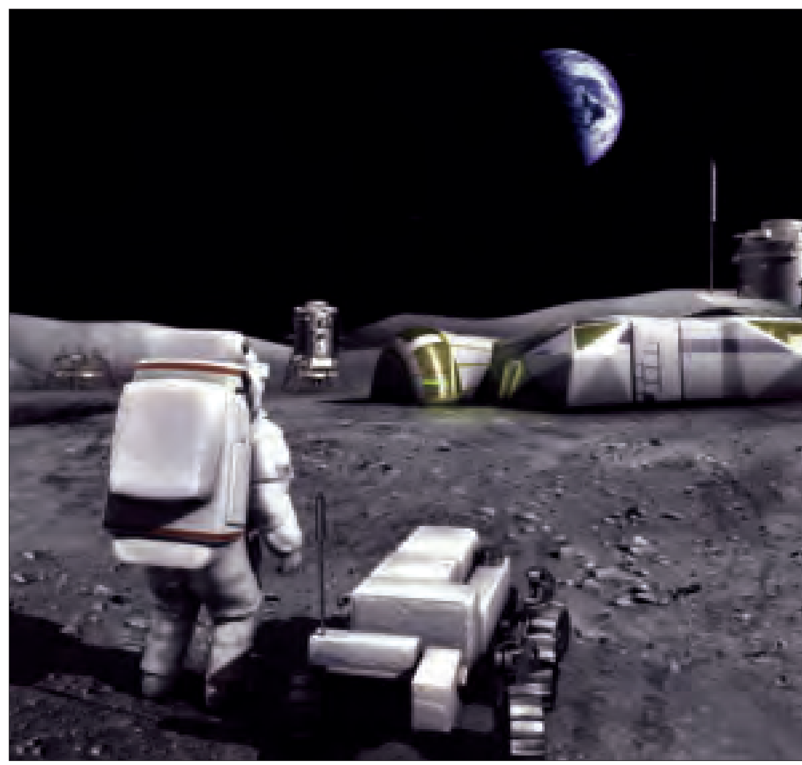
John Logsdon, professor emeritus of political science and international affairs at the Space Policy Institute, agrees that a space exploration program can take place only through multilateral cooperation. "No country is going to do this on its own, as the U.S. did during Apollo," he says,

Logsdon adds, however, that the desire for a program of human exploration "is not shared by everybody in the world." Convincing governments to invest public resources in a long-term, expensive proposition "is far from a slam dunk," he says.

First, when you start listing the conditions for cooperation, one is that the project must make a meaningful contribution (a provision that a number of countries can now meet). Another is financial necessity; but "the tricky one is political will," he says.

"The heads of space agencies can talk themselves blue in the face about how to do this…but until they can convince, both collectively and individually, their political and budget masters to commit to this kind of enterprise, it's not going to amount to anything," says Logsdon. "Cooperation is a political *and* budgetary act," he emphasizes, "and space agencies by themselves cannot make this happen."

Logsdon is among those who view ISS as a success story. The project shows that difficulties can be overcome and partnerships can work, he says. Nonetheless, the station program "hasn't all been sweetness and light. But the benefits of working together are so substantial," he says, "that they allow a partnership to persist over troubled times. No marriage is without its rough spots…nor is any large-scale cooperative project."



*The Moon is seen as one of the likeliest targets of the Aurora program, a European long-term plan for the robotic and human exploration of the solar system. Credits: ESA - AOES Medialab.*

*The joint U.S./USSR Apollo Soyuz Test Project was a key first step in international human spaceflight. This 1975 mission brought together in Earth orbit U.S. astronauts Thomas Stafford, Vance Brand, and Donald K. Slayton and Soviet cosmonauts Aleksey Leonov and Valeriy Kubasov. Slayton and Leonov pose together in the Soyuz orbital module during the docking mission.*

The ISS is there. It works. And it works in a way that creates interdependence, most of all between the U.S., Russia, and Canada, Logsdon observes. "Japan and Europe are very much aware that they are less-than-equal partners," he notes. "That's because if their modules went away tomorrow, the station could still function. That puts them in a weaker bargaining position…and [is] why those countries say in future cooperation they want interdependence, not one-way dependence."

And what about China? "It takes two to tango…and I know that's a cliché," Logsdon responds. "A partnership takes willing partners. It's not clear that China, at its current stage of space development, gives high priority to collaboration in human spaceflight." He suggests that Chinese cooperation is almost a separate issue, in view of the burgeoning cooperation among current ISS partners and emerging space-capable states. "Also, people don't talk a lot about this, but what are Russia's desires for the next several decades? I think that's an important element of this too."

In the broader scheme of things, says Logsdon, orchestrating a sign-on-the-dotted-line global space adventure is a fragile exercise. "I'm not sure you can sneak up on this and wake up one day saying, 'oh my heavens, we're committed to sending people to Mars.' There have to be specific point decisions to undertake voyages of exploration. The fundamental question is, are there enough governments interested in doing this to create a critical mass?" 

# Hypersonic transport...

## 30 years and holding?

*X43C concept. Credit: NASA.*

**The 1960s saw development of several major aerospace technology** programs, including America's Apollo and the Anglo-French Concorde, the world's first supersonic passenger aircraft. In 1968, Stanley Kubrick's seminal movie, *2001: A Space Odyssey*, showed a dart-like spaceplane approaching a huge, wheel-like space station. Given the optimism of the times, and the proven track record of success in this arena, it was perhaps inevitable that ideas for combining spacecraft and airliner technology to enable travel 'from London to Tokyo in 90 minutes' appeared regularly in the popular press. In a decade obsessed with speed, hypersonics seemed set to replace supersonics.

As we settle into the second decade of the 21st century, research into hypersonics is alive and well in some parts of the globe. But are we really any closer to that 90-minute flight?

### Learning to fly faster

As every plane-spotting child of the 1960s knew, very high speeds are measured in terms of Mach number—named after Austrian physicist Ernst Mach—with Mach 1 corresponding to the speed of sound and Mach 5 or more said to be hypersonic.

The first serious attempt to design what we would call today a hypersonic aerospace vehicle was undertaken by Eugen Sänger and Irene Bredt in the 1940s. Their 'orbital bomber' was effectively a rocket-powered vehicle launched from a rocket sled. Later in the decade a similar vehicle, though incorporating ramjet engines, was proposed by Mstislav V. Keldysh in the Soviet Union. The ramjet and its sister technology, the scramjet, remain among the best hopes for hypersonic propulsion.

***The goal of hypersonic passenger transport has been a source of excitement to aerospace engineers for more than five decades, not least because of the significant technical challenges it presents. Unfortunately, it appears to have something in common with another advanced technology—that of nuclear fusion—in always seeming to be 30 years in the future.***

America's rocket-propelled aircraft program, which has been well documented, also began in the 1940s. It produced the first aircraft to break the 'sound barrier'—the supersonic XS-1 flown by Chuck Yeager in October 1947.

NASA's most famous hypersonics demonstrator remains the X-15, which was designed to reach speeds up to Mach 6 in horizontal flight. In fact, one of the three flight models—which together performed 199 flights between September 1959 and October 1968—set a record of Mach 6.7 in October 1967, and an altitude record of some 108 km (exceeding the notional 100-km ceiling for spaceflight).

Plans were made to fly the X-15 into orbit, but this became the goal of the Mercury program instead, and the X-15 quickly receded from the limelight. Nevertheless, it did lead to further research into winged lifting bodies, and eventually to the space shuttle. One could say it also begat NASA's ill-fated X-30/National Aero-Space Plane, the X-33/VentureStar (a joint NASA/Lockheed Martin development), and the more recent and more successful X-43A variant of the Hyper-X program.

As Curtis Peebles explains in *Eleven Seconds into the Unknown: A History of the Hyper-X Program*, the idea of building "a small, simple scramjet-powered vehicle" did not arise until *after* the failure of the overambitious X-30 program. That 'idea' became the Hyper-X project. Unfortunately, the first flight-test attempt, in June 2001, ended even before the vehicle reached supersonic speed, because of a control system malfunction. However, a second flight showed that the scramjet worked, and a third extended the flight envelope to an engine burn-time of

***X-51 Waverider***

**by Mark Williamson**
Contributing writer

X-37B

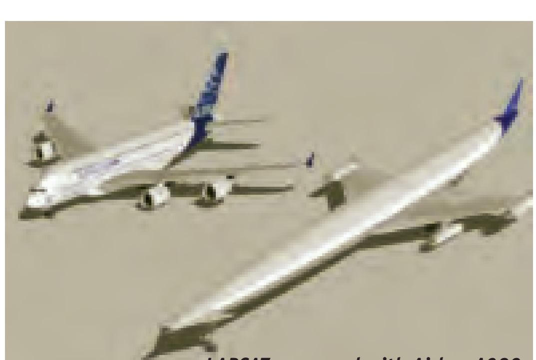
almost 11 sec and a velocity of Mach 9.8. In 2010, the follow-on X-51 Waverider extended the operating time to some 200 sec, but only to about Mach 5. (A waverider is a hypersonic vehicle that enhances its lift-to-drag ratio by riding the shock waves it generates in flight.)

More recently, in November 2011, the Army successfully tested its advanced hypersonic weapon, or AHW. Effectively a cruise missile using waverider techniques, it was carried by a suborbital rocket and made an unpowered Mach-10 glide to hit a target 4,000 km from the launch point.

Given its investments in space and military hardware, it would be surprising if China were not making similar developments. It is difficult, however, from material available in the West, to detect a significant push: Recent papers from China appear to concentrate on academic research into basic structures, materials, and methods of fuel injection and ignition.

Other nations have shown varying levels of interest in hypersonics research. For example, France was particularly active in the late 1980s, most notably with its PREPHA R&D program, but that folded in 1999. And recently there has been a resurgence of interest. According to François Falempin of MBDA Missile Systems, France is currently working on the development and demonstration of combustion chamber technologies, fuel-cooled structures, and other materials technologies, and plans an air-breathing flight demonstrator similar to the X-43, called LEA, though its funding and schedule are unclear.

And the Australian Defence Science and Technology Organisation is working with the USAF Research Laboratory on the HIFiRE (hypersonic international flight research experimentation) program. The second of up to 10 planned hypersonic flight tests from central Australia's Woomera Test Range was completed in 2010.



LAPCAT compared with Airbus A380

Interesting though these developments are from a technical standpoint, the demonstration vehicles are only a few meters long and therefore have nothing like the size and capability of an operational passenger vehicle. The notable exception, though the vehicle is based on existing technologies, is the USAF's X-37B, an unmanned minishuttle that may have carried a military imaging payload to LEO in March 2011.

It should come as no surprise that hypersonic passenger travel has taken a back seat to military applications, especially considering the technical and safety issues. Indeed, much of the hypersonics research is focused on defense applications, because that is where the near-term applications lie. In fact, the first practical hypersonics problem in need of a solution was the high-speed reentry vehicle, designed to protect warheads delivered by ballistic missiles.

## Defying gravity

Beyond the hypersonic air-breathers that remain in the atmosphere, the long-term vision of high-speed passenger flight involves developing an aerospace vehicle that can make the transition from atmospheric flight to spaceflight and back, and also lift off and land at an airport or spaceport facility. However, the technical challenges involved in engineering that vision are significant.

Arguably, the greatest challenge is the development of an air-breathing engine that can also be used at higher altitudes in some designs incorporating a rocket engine. The requirement for this dual operation is based on limitations in the vehicle's mass budget and the fundamental need to overcome gravity. The payload mass of conventional rockets is severely limited by their need to carry both fuel and oxidizer in tanks that themselves add to the mass that must be lifted. Indeed, conventional rockets are only viable in the first place because they use stages that jettison when their propellant is depleted, thus reducing the mass carried to a higher altitude. This is wasteful, of course, as most of the hardware is discarded after a single use.

The 'aerospace vehicle' removes much of the need for oxidizer and associated tankage, because its engine extracts oxygen from the atmosphere and uses that to burn its fuel. If the vehicle is also required to operate in 'rocket mode,' onboard oxidizer will be used for the exoatmospheric portion of its flightpath.

## The thermal challenge

Because friction between high-speed objects and atmospheric molecules generates large amounts of heat that must be dispersed if the vehicle is to survive, the development of a thermal protection system (TPS) is another significant challenge. So, although much of the focus has been on the propulsion elements, the arguably less glamorous matter of materials development is also high on the agenda, because aerodynamic heating becomes the dominant technical issue at hypersonic speeds.

Remember, even the Concorde, which flew at 'only' Mach 2, grew several centimeters longer during supersonic flight because of thermal expansion. The Lockheed SR-71 Blackbird was designed to exceed Mach 3, but could do so only by ditching aluminum for the more heat-resistant titanium—and even then experienced surface heating up to 260 C. Imagine the effects at Mach 5 and above, even assuming the same materials could be used.

Because of the heat generated by hypersonic vehicles, NASA Langley's David E. Glass considers them "a thermal-structural nightmare." He explains, "In addition to the tremendous aerodynamic heating on the outside…you have a large heat source inside the vehicle." This internal heat source is a feature of the X-43 and X-51 designs with their body-integrated engines, he adds, but is addressed in other concepts by "placing the engines away from the fuselage, on the wings."

Ultimately, Glass says, the thermal problem will be solved by materials technology, specifically ceramic matrix composites: "In my opinion, CMCs are one, if not *the*, enabling class of materials for hypersonic vehicles due to their high temperature capability and high specific strength (low density and high strength)." CMCs comprise a ceramic matrix reinforced by threads or fibers of a carbon or ceramic material (such as silicon carbide), which, Glass explains, offers "high-temperature resistance without the inherent low fracture toughness of ceramics."

As Glass points out, "Different thermal management techniques are applied to different flight vehicles," because the heat flux (instantaneous heating) and heat load (heat flux integrated over time) depend on a specific vehicle's trajectory. Put simply, a short burst of very high heating might be easier to withstand than a long period of relatively low thermal input, thus requiring a different design and different materials.

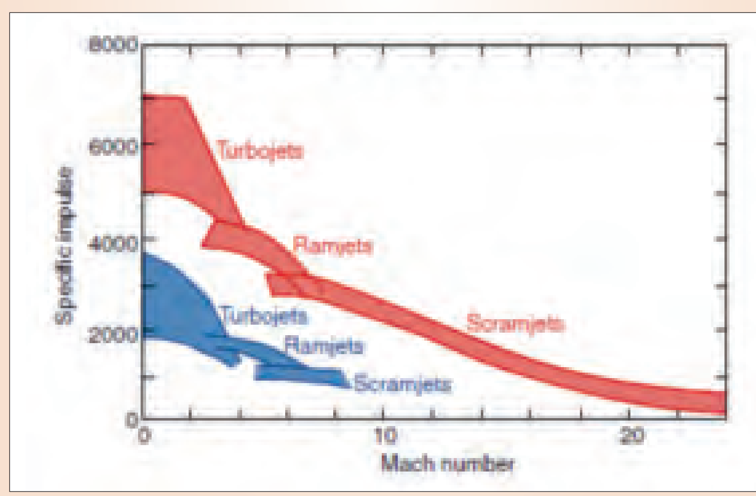
### *Propulsion options*

*According to an analysis by aerospace engineer David Van Wie of the Johns Hopkins Applied Physics Lab, although hypersonic propulsion systems can utilize liquid- and solid-fueled rockets and turbojets, air-breathing systems offer the most promising solution for a new class of vehicles "capable of achieving hypersonic cruise within the atmosphere." These include ramjets, scramjets, and dual-combustion ramjets.*

*As its name suggests, a ramjet is a type of jet engine in which propellant is combusted using air compressed by the forward motion of the aircraft—the air is effectively 'rammed into' the intake duct. This compression is necessary to decrease the velocity of the supersonic airflow to prepare it for combustion. The compressed subsonic airflow is mixed with fuel in the combustor and ignited to raise the temperature and pressure. Then, in common with the operation of a rocket, the flow leaves the engine through a convergent/divergent nozzle (again at supersonic speeds), thus producing thrust.*

*As speeds increase, the losses associated with slowing the airstream become greater, so in a supersonic combustion ramjet, or scramjet, although the air entering the engine is slowed it remains supersonic. The problem is that, while ramjets are inefficient at speeds above about Mach 5 (because they slow the air to subsonic velocities), scramjets are inefficient below that speed (as the airstream is too slow for efficient combustion).*

*The solution is a combined-cycle engine such as the dual-combustion ramjet, which incorporates a subsonic combustion ramjet as a 'pilot' to a scramjet engine and offers performance and operability over a wide range of flight conditions.*




*A comparison of efficiency of turbojets, ramjets, and scramjets (in terms of propellant specific impulse) can be made across the speed range (blue depicts hydrocarbon fuels, red depicts hydrogen).Courtesy Johns Hopkins APL.*

Of course, the choice of a TPS that does not require substantial rework after every flight, as did the space shuttle's, relates directly to the fundamental requirement for a true aerospace vehicle—that of reusability. It must be reusable to be operationally cost effective. In commercial jargon, reus-ability closes the business case.

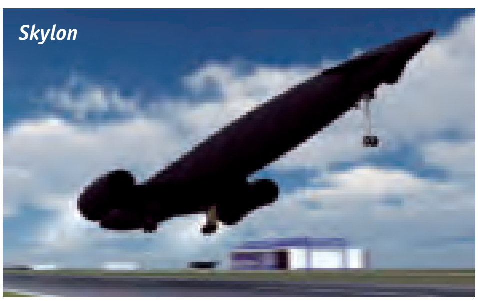
## Routine transportation?

Anyone who has attended aerospace engineering conferences and exhibits in the last 20 years will have seen the plastic models of sleek-looking spaceplanes purporting to represent the latest line of aerospace

research. They may be more eye-catching than inlet valves and composite panels, but in the final analysis they are only models.

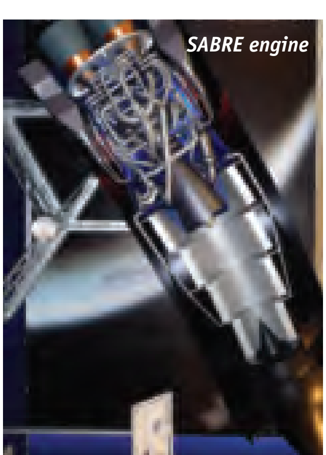
Nevertheless, behind the scenes, aerospace companies are pursuing research projects that they hope will one day result in an operational hypersonic vehicle. Japan and Europe are particularly active in the field, and both have experience with human-rated minishuttles—Japan's H-II orbiting plane and the French-backed Hermes—which, unfortunately, went nowhere.

Research by the Japan Aerospace Exploration Agency, or JAXA, currently centers on a small precooled turbojet engine (S-engine), which it intends to develop in parallel with a hypersonic turbojet experimental, or HYTEX, vehicle. It would operate at Mach 5, which one could say is 'borderline hypersonic.'


Skylon

As part of this push, JAXA intends to pursue a 'proof of concept' for a Mach-5-class hypersonic passenger transport as part of its long-term vision, JAXA 2025. A small version of the S-engine was built in 2008 and has been undergoing ground-based testing since then. The plan is to install the engine on an experimental vehicle and flight test it to Mach 5, perhaps in 2015.

Europe is currently pinning its hopes on the EU-sponsored LAPCAT (long-term advanced propulsion concepts and technologies) project, which involves the definition of a 'generic reference vehicle' for hypersonic flight. The EU's 6th Framework Program of 2005 included the objective of evaluating two advanced air-breathing concepts "capable of achieving the ultimate goal to reduce long-distance flights, e.g. from Brussels to Sydney, to less than 2 to 4 hours." The 7th Framework Program progressed this by funding two multinational collaborative research projects: LAPCAT2 and FAST20XX (future high-altitude high-speed transport 20XX). Note the temporally vague nature of 20XX.


SABRE engine

As a result, Germany's national aerospace research center and space agency, DLR, has been working on concepts such as the 50-seat SpaceLiner, which utilizes the familiar vertical ascent trajectory and rocket propulsion of the space shuttle. Thus it appears to have avoided new and unproven technologies, considering the state of ramjet/scramjet technology to be too immature for such a vehicle. According to Martin Sippel, head of DLR's Space Launcher Systems Analysis Division, its research concentrates on advanced thermal protection and "improving the safety and reliability of all major subsystems."

Taking a different tack is Reaction Engines Ltd. (REL), the U.K. firm that has proposed a precooled engine concept known as Scimitar and a compatible 300-seat vehicle configuration that, the company says, "attains the necessary subsonic and supersonic lift/drag ratio for efficient commercial operation." In common with the other concepts, the resulting vehicle would be capable of sustained flight at Mach 5 and thus, like the others, would also be limited to suborbital trajectories.

In fact, REL's philosophy is based on its work to develop Skylon, a fully reusable spaceplane capable of delivering a 10-tonne payload to the ISS in LEO. Moreover, according to REL's technical director, Richard Varvill, it could be "readied for another mission within a matter of hours"—surely the holy grail of launch vehicle developers.

Skylon's hydrogen-fueled combined-cycle engine will use atmospheric oxygen up to 30 km and Mach 5, and then use on-board liquid oxygen. In REL's words, the SABRE (synergetic air-breathing and rocket engine) combines "the best features of jet and rocket engines in a single power plant," its effectiveness being based on extremely efficient heat exchangers.

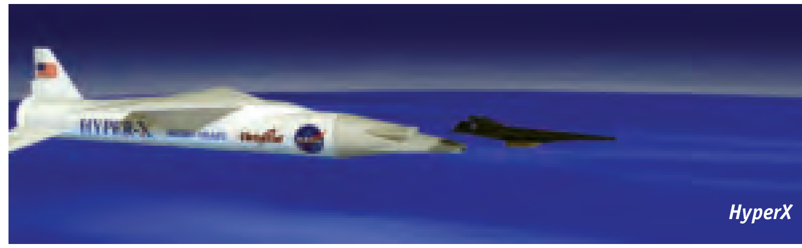
Fast-moving air is compressed as it enters an engine and thus increases in temperature. This produces one of the fundamental design challenges of high-velocity flight: heat rejection. According to Mark Hempsell, REL's future programs director, the SABRE's innovative precooler "transfers about 400 MW of heat energy from the air to a helium loop which uses it to power the propellant pumps and compressors." The vehicle's liquid hydrogen fuel then reduces the air temperature to cryogenic levels (in this case around -140 C), which allows the same engine components to be used for both air-breathing and rocket cycles, and saves mass. Interestingly, the design also allows the same engine to be used at takeoff and during initial low-velocity flight, unlike ramjets and scramjets.

Although SABRE development, in part funded by ESA and the U.K. Space Agency, has intentionally been low profile, it appears to be well ahead of the competition—if that is the right word in the currently noncommercial environment—because of its concentration on hardware development. Reduced-scale heat exchanger sections have already undergone cryogenic wind tunnel testing, and a frost control system designed to prevent moisture in the air from freezing as it enters the engine has been developed and demonstrated. Not surprisingly, Varvill considers REL to have "the only credible near-term solution to sustained cruise at Mach 5." It is fair to note that some do not share that opinion.

It is also fair to note that, despite its considerable contributions to supersonic flight and spaceflight, the U.S. seems content to stand back when it comes to commercial hypersonic transportation. In fact, NASA's latest budget request zeroes hypersonics funding.

### Not so fast

Most researchers in the field would agree that the hypersonic environment is harsh and unforgiving, with the result that systems are complex, difficult to design, and expensive to build. So progress is slow. As E.H. Hirschel of the University of Stuttgart puts it, some "70 years of theorizing and re-



HyperX

search into hypersonic flight has produced only one operational flight vehicle, the U.S. space shuttle." And even considering the progress in designing, building, and flying hypersonic reentry vehicles, the fatal flight of Columbia in February 2003 underscores the severity of the environment they face.

Technology development, testing, and flight demonstrations are exciting, and unarguably encourage young people to enter the field, but the bottom line is always the one on the balance sheet. If we are ever to see a spaceplane like the one in *2001: A Space Odyssey*, it will be but one part of an expensive commercial undertaking.

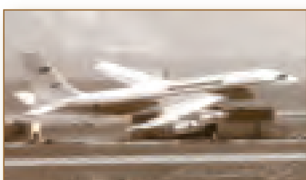
The question is, after over half a century of development, are we any closer to that childhood dream of the hypersonic passenger aircraft, or is it still 30 years away? ▲

# Out of the

## 25 Years Ago, May 1987

**May 15** The Soviet Union launches its new giant Energia booster rocket, said to be more powerful than the U.S. space shuttle, from the Baikonur test site in central Asia. However, the mock satellite carried by the rocket fails to orbit. Energia can place 100 tons into orbit, vs. 75 tons for the shuttle. NASA, *Astronautics and Aeronautics, 1986-90*, p. 114.

## 50 Years Ago, May 1962



**May 1** The first Boeing C-135B becomes operational with the USAF Military Air Transport Service. The aircraft, which closely resembles the KC-135 tanker but without refueling boom and cabin windows, has about 40% more thrust than the C-135A. *Aviation Week*, April 9, 1962, p. 98.

**May 1** The liquid-fueled Black Knight, the U.K.'s first indigenous rocketry project, is fired from the Woomera test range in Australia to a height of 480 mi. The test objective is to obtain reentry data. *Flight International*, May 10, 1962, p. 750.

**May 2** Britain's J.C. Wimpenny wins a £50 prize offered by an anonymous donor of the Royal Aeronautical Society for being the first person to fly a man-powered aircraft half a mile. Wimpenny averages 19.5 mph and flies for 993 yards at an average height of 8 ft. *Flight International*, May 10, 1962, p. 720.

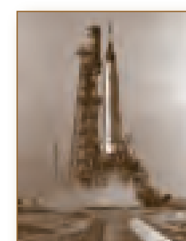
**May 3** For the first time, Soviet cosmonaut Gherman Titov discloses the total thrust of the launch vehicle that placed him into orbit on August 6, 1961. Speaking at the Third International Space Science Symposium in Washington, D.C., Titov says the thrust of his booster, using six liquid-fueled engines of the Vostok type, was 1,323,000 lb. This makes it comparable to the U.S. Saturn launch vehicle. *Flight International*, May 10, 1962, p. 749.

**May 5** Cunard Eagle Airways becomes the first British independent airline to put jets into service, introducing the Boeing 707 on its route from London to Bermuda, Nassau, Miami, and Jamaica. The airline will work with the parent corporation, Cunard Steamship, to promote its 'one-way sea and one-way air' transatlantic package. *Aviation Week*, April 16, 1962, p. 39.

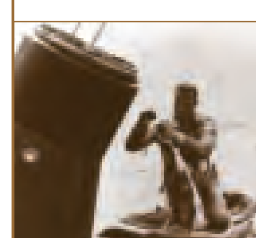
**May 8** NASA announces the selection of three contractors for major components of the Apollo spacecraft guidance and navigation system. They are the AC Spark Plug Div. of General Motors, for fabrication of the inertial gyroscope stabilization platform and other components; Raytheon, for the digital computer aboard the spacecraft; and Kollsman Instrument, for the optical subsystems, including a space sextant, Sun-finders, and navigation display equipment. I. Ertel and M. Morse, *The Apollo Spacecraft, Vol. I*, p. 160.

**May 9** The Sikorsky S-64 Flying Crane heavy-lift helicopter, powered by two Pratt & Whitney turbine engines, achieves its first flight. Designed to carry a useful load of 20,760 lb, the giant helicopter has a gross weight of 38,000 lb and a cruise speed of 110 mph. *Aviation Week*, April 16, 1962, p. 32.

**May 10** An air-to-air radar-guided Sparrow III missile, fired from a Navy McDonnell F4H-1 Phantom aircraft, scores a direct hit against a Regulus II missile at the Naval Air Missile Center at Point Mugu, Calif. The hit is the first successful head-on attack by an air-launched weapon on a surface-launched guided missile. *United States Naval Aviation 1910-1980*, p. 245.



**May 24** Project Mercury's Aurora 7 spacecraft, with astronaut Scott Carpenter on board, is launched successfully by an Atlas booster from Cape Canaveral, Fla. Carpenter makes a three-orbit flight and reenters the atmosphere. However, a yaw error and late retrofire cause him to land over 200 mi. beyond the planned impact area, out of radio range. After three hours in a life raft he is safely recovered by a Navy helicopter from the USS Intrepid. I. Ertel and M. Morse, *The Apollo Spacecraft, Vol. I*, pp. 160-161; *United States Naval Aviation 1910-1980*, p. 245.



**May 26** The F-1 rocket engine of 1.5 million lb thrust is successfully fired at full power for the first time for 2.5 min, from the Edwards Rocket Site at Edwards AFB, Calif. I. Ertel and M. Morse, *The Apollo Spacecraft, Vol. I*, p. 161.

**May 29** Vice Adm. Patrick N.L. Bellinger, the Navy aviation pioneer

# Past

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

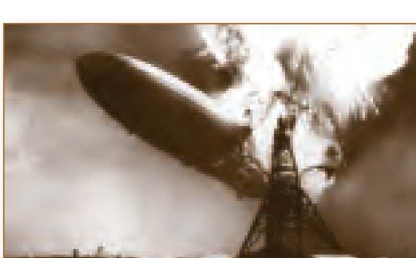
who began his career in 1912 as Naval Aviator No. 8, dies at Clifton Forge, Pa. His career included being the first Navy pilot to return home with a bullet hole in his plane, which was h during the occupation of Vera Cruz, Mexico, in 1914. In 1941, as a rear admiral, Bellinger was the senior officer at Pearl Harbor during the bombing by the Japanese and personally sent out the first radio alert: "Air Raid. Pearl Harbor—this is no drill." By 1943, he was given command of the Atlantic Fleet Air Force. He retired in 1949. *United States Naval Aviation 1910-1980*, p. 245; Patrick N.L. Bellinger file, NASM.

### And During May 1962

—The first Piper Aztec B light aircraft sold in Britain is ferried across the Atlantic by famed U.S. pilot Max Conrad, who thereby completes his 88th Atlantic crossing and 40,000 hr of flight. The Aztec is delivered to Whitbread for eventual use by another firm, Air Couriers. *Flight International*, May 10, 1962, p. 721; Max Conrad file, NASM.

## 75 Years Ago, May 1937

**May 6** The German dirigible Hindenburg bursts into flames and is



completely destroyed while being moored at Lakehurst, N.J., following the end of its first transatlantic voyage. Of 33 passengers, 16 are killed, as are 17 of 61 crewmembers, including the captain, Ernst Lehmann. This is considered one of the greatest disasters in aviation history and brings an end to the era of large dirigibles. There are many theories about why the hydrogen-filled craft exploded, from sabotage to igniting of the hydrogen by St. Elmo's fire. *The Aeroplane*, May 12, 1937, p. 556.

**May 8** Italy claims the world's flight altitude record when Col. Mario Pezzi flies to 51,361 ft in his Caproni 161 at Montecelio, Italy. He exceeds the previous record by 1,417 ft, set by England's Sqn. Ldr. F.R.D. Swain in September 1936. *Flight*, May 13, 1937, p. 483; *Flight*, May 20, 1937, p. 502.

**May 9** Hugh F. Pierce launches his independently built liquid-fuel rocket to an altitude of about 250 ft, from Old Ferris Point in the Bronx, N.Y. In 1941, with three others, Pierce founded Reaction Motors, America's first commercial liquid-fuel rocket company. E. Emme, ed., *Aeronautics and Astronautics 1915-60*, p. 35.

### And During May 1937

—The German army opens its Versuchsstelle Peenemunde (Experimental Station) on the Baltic. The work leads to the creation of missiles that eventually include the infamous V-2 rocket of WW II. Army Ordnance Capt. Walter R. Dornberger moves his staff of about 90 into the facility from their previous research and test site of Kummersdorf, outside Berlin. Civilian Wernher von Braun heads the research and design group. G. Kennedy, *Vengeance Weapon 2*, p. 12.

## 100 Years Ago, May 1912

**May 30** Wilbur Wright dies of typhoid fever. Co-inventor of the airplane with his brother Orville, he is also considered the first pilot. The Wrights followed the experiments of the German Otto Lilienthal in the 1890s and later those of Octave Chanute, with whom they corresponded. The brothers started their own systematic experiments with a manned glider in 1900. The key to their eventual success was wing warping. After about 1,000 glides, they built a suitable four-cylinder engine and on December 17, 1903, succeeded in making the first heavier-than-air flights. By 1904, they made the first complete circles and landing at the starting point, fully establishing controlled flight. Wilbur became ill after lengthy travels throughout Europe and the U.S., where he filed lawsuits protecting the Wrights' patent on the invention of the heavier-than-air craft. *Flight*, June 1, 1912, pp. 488-489 and June 8, 1912, p. 519.

### And During May 1912

—The Chinese military organize a flying corps of five biplanes, headquartered at Nanking. But the planes are to be transferred to Canton, where there is a more suitable flying field. *Flight*, May 11, 1912, p. 426.

# Mechanical, Automotive and Materials Engineering

## *Two Assistant Professor Tenure-Track Positions in Aerospace*

The University of Windsor, Faculty of Engineering, Department of Mechanical, Automotive and Materials Engineering Department (MAME) invites applications for two tenure-track faculty positions. Both positions will be at the rank of Assistant Professor in a newly established Aerospace Option in the Mechanical Engineering Program. These positions are subject to final budgetary approval.

Located at one of Canada's major international intersections, the University of Windsor plays a leading role in the future of the region and the province of Ontario. With approximately 16,000 students, including 1,700 students in a broad range of masters and doctoral programs, the University of Windsor is Canada's most personal comprehensive university.

The successful candidates are expected to engage in establishing and leading an exciting and innovative undergraduate option in Aerospace Engineering that is focused on airplanes and related systems manufacturing, repair, overhaul, and maintenance. In particular, consideration will be given to applicants with teaching experience and expertise in areas including, but not limited to Aerospace Engineering Fundamentals, Flightworthiness, and Aerospace Controls and Avionics.

Concurrently, we are interested in candidates whose research interests align with the above specified teaching need areas. It is expected that the successful candidates will establish a dynamic externally funded research program that complements existing Mechanical and Materials Graduate programs, offer graduate courses, supervise graduate students and engage in department and university service activities.

The MAME Department is the largest department in the Faculty of Engineering. It offers a multi-faceted program that tackles real-world problems, interacts with local industry, and provides students ample opportunities for hands-on experience. Major research areas are in design and optimization of energy conversion systems focusing on automotive applications; light-weight and low-wear materials; and design of innovative mechanical structures; and manufacturing processes. The Phase 2 move of the Faculty of Engineering into one of the most advanced engineering facilities in Canada, the Centre for Engineering Innovation (CEI), www.uwindsor.ca/cei, is expected for Fall 2012. Refer to www.uwindsor.ca/mame for more information about MAME.

Applicants must have a doctoral degree, preferably from an aerospace engineering program; eligibility for a PEng registration; and a strong commitment to both teaching and research. Selection will be primarily based on applicants' potential for excellence in teaching and research. Applications should include:

- letter of application, including a statement of citizenship/immigration status;
- a detailed curriculum vitae,
- a concise statement of teaching (one page) and research interest (three pages) and how this relates to the needs of the Aerospace Engineering at the University of Windsor,
- career objectives and accomplishments,
- examples of material relevant to teaching experience, and
- most significant research publications, and
- three current letters of reference forwarded directly by the referees to the Department Head.

Applications should be submitted to:


**Professor A. Sobiesiak, Department Head**
**Faculty of Engineering, Department of Mechanical, Automotive & Materials Engineering**
**University of Windsor, 401 Sunset Ave, Windsor, Ontario, Canada N9B 3P4**
**Phone: 519-253-3000 Ext. 2616, Email: asobies@uwindsor.ca**


Applications will be accepted until the positions are filled. The University of Windsor is committed to equity in its academic policies, practices, and programs; supports diversity in its teaching, learning, and work environments; and ensures that applications from members of traditionally marginalized groups are seriously considered under its employment equity policy. Those who would contribute to the further diversification of our faculty and its scholarship include, but are not limited to, women, Aboriginal peoples, persons with disabilities, members of visible minorities, and members of sexual minority groups. The University of Windsor invites you to apply to our welcoming community and to self-identify as a member of one of these groups. International candidates are encouraged to apply; however Canadians and permanent residents will be given priority. To ensure that you are considered within the priorities of the Employment Equity Program, you may self identify in your letter of application or in a separate letter to the Presidential Commission on Employment Equity, c/o Gerri Pacecca, The Office of the Provost and Vice-President Academic, 511 Chrysler Hall Tower, 401 Sunset Avenue, University of Windsor, Windsor, Ontario, N9B 3P4. The University of Windsor, one of Ontario's leading academic institutions, provides a learning-centred approach which prepares its graduates for the challenges of tomorrow. Information about the University of Windsor and its programs may be found at http://www.uwindsor.ca. For more information on living and working at the University of Windsor, visit the Faculty Recruitment and Retention website at http://www.uwindsor.ca/facultyrecruitment, or contact Ms. Gerri Pacecca (Email: recruit@uwindsor.ca), Coordinator, Faculty Recruitment and Retention, Office of the Provost and Vice-President Academic toll- free at 1-877- 665-6608 within North America or call collect outside of North America at 001-519-561-1432.

University of Windsor
*thinking forward*

# AIAA Bulletin

AIAA members Hannah Thoreson, Danny Riley, and Tracey Dodrill with Arizona Congressman Ben Quayle at the 2012 Congressional Visits Day. They were among the 176 AIAA members from 44 AIAA sections who met with their elected representatives and discussed matters of vital importance to the U.S. aerospace community. For the full article, go to pages **B8–B9**.

## MAY 2012



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

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

# **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** | | | | |
| 14–18 May† | **12th Spacecraft Charging Technology Conference** | Kitakyushu, Japan<br>Contact: Mengu Cho, +81 93 884 3228, cho@ele.kyutech.ac.jp, http://laseine.ele.kyutech.ac.jp/12thsctc.html | | |
| 22–24 May | **Global Space Exploration Conference (GLEX)** (Apr) | Washington, DC | *Oct 11* | **1 Dec 11** |
| 22–25 May† | **5th International Conference on Research in Air Transportation (ICRAT 2012)** | Berkeley, CA (Contact: Andres Zellweger, 301.330.5514, dres.z@comcast.net, www.icrat.org) | | |
| 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<br>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<br>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**<br>**30th AIAA Applied Aerodynamics Conference**<br>**4th AIAA Atmospheric Space Environments Conference**<br>**6th AIAA Flow Control Conference**<br>**42nd AIAA Fluid Dynamics Conference and Exhibit**<br>**43rd AIAA Plasmadynamics and Lasers Conference**<br>**43rd AIAA Thermophysics Conference** | New Orleans, LA | *Jun 11* | **17 Nov 11** |
| 27–29 Jun† | **American Control Conference** | Montreal, Quebec, Canada<br>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<br>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<br>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)<br>**AIAA Atmospheric Flight Mechanics Conference**<br>**AIAA Modeling and Simulation Technologies Conference**<br>**AIAA/AAS Astrodynamics Specialist Conference** | Minneapolis, MN | *Jul/Aug 11* | **19 Jan 12** |
| 11–13 Sep | **AIAA SPACE 2012 Conference & Exposition** | Pasadena, CA | *Sep 11* | **26 Jan 12** |
| 11–13 Sep | **AIAA Complex Aerospace Systems Exchange Event** | Pasadena, CA | | |
| 17–19 Sep | **12th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference**<br>**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<br>Contact: http://www.icas2012.com | | **15 Jul 11** |
| 24–27 Sept† | **30th AIAA International Communications Satellite Systems Conference (ICSSC) and**<br>**18th Ka and Broadband Communications, Navigation and Earth Observation Conference** | Ottawa, Ontario, Canada<br>Contact: Frank Gargione, frankgargione3@msn.com; www.kaconf.org | *Nov 11* | **31 Mar 12** |

| DATE | MEETING (Issue of *AIAA Bulletin* in which program appears) | LOCATION | CALL FOR PAPERS (*Bulletin* in which Call for Papers appears) | ABSTRACT DEADLINE |
|---|---|---|---|---|
| 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) | | |
| 5–8 Nov† | **27th Space Simulation Conference** | Annapolis, MD<br>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<br>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<br>Contact: David Woerner, 626.497.8451; dwoerner@ieee.org; www.aeroconf.org | | |
| 25–28 Mar | **22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar**<br>**AIAA Balloon Systems Conference**<br>**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**<br>**21st AIAA/ASME/AHS Adaptive Structures Conference**<br>**15th AIAA Non-Deterministic Approaches Conference**<br>**14th AIAA Dynamic Specialist Conference**<br>**14th AIAA Gossamer Systems Forum**<br>**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<br>Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru | | |
| 14–18 Jul | **43rd International Conference on Environmental Systems (ICES)** | Vail, CO | | |
| 12–13 Aug | Aviation 2013 | Los Angeles, CA | | |
| 19–22 Aug | **AIAA Guidance, Navigation, and Control Conference**<br>**AIAA Atmospheric Flight Mechanics Conference**<br>**AIAA Modeling and Simulation Technologies Conference**<br>**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** | | | |
| 2–3 Jun | **Phased Array Beamforming for Aeroacoustics** | Aeroacoustics Conference | Colorado Springs, CO |
| 14–15 Jun | **The Space Environment—Implications for Spacecraft Design** | National Institute of Aerospace | Hampton, VA |
| 23–24 Jun | **Perturbation Methods in Science and Engineering** | Fluids Conferences | New Orleans, LA |
| 23–24 Jun | **Space Environment and Its Effects on Space Systems** | Fluids Conferences | New Orleans, LA |
| 23–24 Jun | **Turbine Engine Ground Test and Evaluation** | Fluids Conferences | New Orleans, LA |
| 23–24 Jun | **Stability and Transition: Theory, Experiment and Modeling** | Fluids Conferences | New Orleans, LA |
| 23–24 Jun | **Computational Heat Transfer and Thermal Modeling** | Fluids Conferences | New Orleans, LA |
| 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 |
| 11–12 Sep | **Robust Aeroservoelastic Stability Analysis** | National Institute of Aerospace | Hampton, VA |

**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

## CELEBRATING OUR INDUSTRY'S ACHIEVEMENTS

Each May, the AIAA community gathers for several important and enjoyable events. This year on 8 May, our new Fellows and Honorary Fellows will be recognized at "their" dinner. Among the gathering are astronauts, test pilots, NASA administrators, government aerospace professionals, professors, researchers from around the world—and any other background from among our membership. The only requirement to attend is that everyone there has been elected by the AIAA Board as a "person of distinction in aeronautics and astronautics…." As one Fellow explained "the dinner is the one event during the year that I will NOT miss." It's a reminder that election to AIAA Fellow is much more than achieving a Membership Upgrade or even recognition for a long, productive career. Around the world, being an AIAA Fellow is regarded as among the most distinguished honors in our profession. When only one tenth of one percent of our members can be selected each year, it's only fitting that we should honor those selected at the Fellows Dinner and at our Awards Gala.

The following evening, 9 May, is the Annual AIAA Aerospace Spotlight Awards Gala—this year again at the Reagan Building. It's our opportunity to recognize the best in our profession: the new Fellows and Honorary Fellows, the winners of our premier awards: the Reed Aeronautics and Goddard Astronautics, the Public Service, Distinguished Service and International Cooperation Awards, the Guggenheim Medal, and the AIAA Foundation's Award for Excellence. This black-tie dinner is attended by over 500 people, many of whom seem to spend much of the night walking around catching up with colleagues.

The next day your leadership participate in several important meetings. The outgoing Board members are recognized at their final meeting and any remaining old business is closed out. Then AIAA's Annual Business meeting is held and the newly-elected officers and Board members take their positions. Finally, the new Board meets for its first full business meeting. Preceding these meetings are two days of committee meetings. To say that it is a full three days is an understatement, but it is also very enjoyable to see the best of the best recognized and the orderly transition of our leadership take place.

I described the Awards Gala above, but I want to return to this year's event because it is special. For the first time we will be honoring two "programs"—one looking back to an incredible past and the other looking forward to a very bright future. The overall theme for the Gala will be a "Celebration of the Shuttle." The invitation list reads like a who's who of the civil space program from the 1970s to the present—astronauts, program managers, members of Congress, NASA and industry leadership, and countless others that worked to make the program the most remarkable capability in the fairly young "space age." As various aspects of the program appear on the screens and elsewhere throughout the evening, what I expect (and hope) will happen is that the normal "catching up" that we see every year will be magnified many times over as story after story is told by those that lived them. It's just too bad that we can't equip everyone there with a recorder! When we ask who has been "touched" by some aspect of the Shuttle program to stand, I'll be surprised if there's anyone still seated. Who wasn't touched by some aspect of that wonderful program?

The 2012 winner of the AIAA Foundation Award for Excellence is the Boeing 787, which entered commercial service in October. Early in my tenure at AIAA, I visited Boeing Commercial Aircraft in Seattle and had the opportunity to spend time with the leadership, the engineering staff, and also in the mock-up of the 787 passenger compartment. I wrote in this column that I thought the 787 would be a game-changer for commercial air—design, fabrication, economy, and the passenger experience. It took longer to get into service than anyone expected, but everything I've read and heard seems to affirm that it will, indeed, be a "game-changer." At our Aerospace Sciences Meeting in January, we learned that the 787 had just set a new record for unrefueled distance for its weight class, and had flown around the world with one stop for fuel, on the ground for less than two hours. I'm not sure I'd look forward to back-to-back 12-hour flights in any aircraft, but with the improvements in so many aspects of the passenger experience, I'm positive that I want to fly on a 787 as soon as I can.

So, at the Gala we will look back and honor the Shuttle and look forward as we honor the 787. One of the hardest parts of deciding who to honor—whether program or the individual awards I mentioned earlier—is that there are so many truly outstanding people, programs, and accomplishments. We receive many great nomination packages, and I'm sure that for every nomination there are many accomplishments that go unrecognized. That's where you can help: when you know of someone or something that deserves to be recognized, or a member that deserves to be selected for Associate Fellow, Fellow, or even Honorary Fellow, take the time to do the nomination. It's easier to do on our new website!

Finally, congratulations to our newly elected members of your Board of Directors and a big "Thank You" to those who have completed their terms.

## 2012 BOARD OF DIRECTORS ELECTION RESULTS

AIAA proudly announces the results of the 2012 Board of Directors election. The newly elected officers and directors are:

**Vice President-Elect, Education**—Steven Gorrell, Brigham Young University

**Vice President-Elect, Public Policy**—Mary Snitch, Lockheed Martin Corporation

**Director–at-Large**—Robert Lindberg, National Institute of Aerospace

**Director–International**—Kevin Massey, Royal Melbourne Institute of Technology, Australia

**Director–Technical, Aerospace Design and Structures**—Kathleen Atkins, Lockheed Martin Corporation

**Director–Technical, Aerospace Sciences**—James Keenan, U.S. Army Aviation and Missile Research Development and Engineering Center

**Director–Region 2**—Alan Lowrey, Lockheed Martin Corporation

**Director–Region 3**—Sivaram Gogineni, Spectral Energies LLC

**Director–Region 6**—Jane Hansen, HRP Systems, Inc.

The newly elected board members will begin their term of office on 10 May 2012. Incoming President Michael Griffin will succeed Brian Dailey at that time. The amendment to the AIAA Constitution did not pass as there were an insufficient total number of votes cast.

## SPERRY AWARD NOMINATIONS ARE NOW OPEN!

Each year, AIAA presents the prestigious Lawrence Sperry Award to a Young Professional Member for notable achievement in the advancement of aeronautics and astronautics. Many distinguished individuals in the industry started out as AIAA young professionals:

- **1937**: *Clarence L. (Kelly) Johnson*, recognized for important improvements of aeronautical design of high-speed commercial aircraft for developing the Fowler flap on the Lockheed Model 14.
- **1972**: *Sheila E. Widnall*, recognized for aerodynamic research, later became Secretary of the Air Force and President of AIAA.
- **1980**: *William F. Ballhous Jr.*, recognized for significant contributions to Computational Fluid Dynamics as Director of Astronautics at NASA Ames Research Center.
- **1984**: *Sally Ride*, recognized for being the first U.S. woman in space at age 32.
- **1990**: *Ilan M. Kroo*, recognized for outstanding research in aerodynamics and multidisciplinary design optimization.
- **1999**: *Robert Braun*, recognized for contributions enabling the descent and landing of the Mars Pathfinder.
- **2008**: *Ryan Starkey*, recognized for outstanding contributions in multidisciplinary hypersonic vehicle design and propulsion/airframe integration/optimization for both access to space and hypersonic cruise vehicles, and computational chemistry for combustion and plasma analysis.
- **2011**: *M. Brett McMickell*, recognized for proven leadership in the area of small satellite technology with focus on the advancement of momentum and structural control systems.

We know that young professionals are out there today doing amazing things, and we need your help to find and recognize them. Please take a few moments to consider if you know a young engineer (under the age of 35) who has made outstanding contributions to the field of aeronautics and astronautics. The small amount of effort it takes to nominate and recognize the efforts of a young professional will bring both you and the candidate a great feeling of satisfaction!

Act now! Nominations are due **1 July**! AIAA members may place an online nomination by logging into **www.aiaa.org**, My AIAA. To obtain a nomination form, or submit an online nomination, login to **http://www.aiaa.org/HonorsAndAwards.aspx?id=4635**. Please contact Carol Stewart, carols@aiaa.org, if you have questions.

### NEW STANDARD AVAILABLE: AIAA GUIDE TO NOMENCLATURE AND AXIS SYSTEMS FOR AERODYNAMIC WIND TUNNEL TESTING (AIAA G-129-2012E)

The latest standard in the AIAA collection is a guide that provides a recommended test nomenclature for steady-state wind tunnel testing involving force, moment, and pressure data. Some of the benefits that may be achieved by using a standard set of nomenclature for testing includes increased customer understanding, increased portability of experimental data, increased usefulness of archived data, increased workforce flexibility, and reduced data reduction development and support costs. This guide is intended to increase the understanding of test nomenclature and axis systems between wind tunnel facilities and customers throughout the world.

Download a copy at **http://mailview.custombriefings.com/mailview.aspx?m=2010111801aiaa&r=3875063-2d37&l=006-79b&t=c** (free for AIAA Members).

## AIAA FOUNDATION SELECTED TO ADMINISTER IRIDIUM NEXT SCHOLARSHIP FUND

From left to right: S. Scott Smith, EVP, Iridium; Matt Desch, CEO, Iridium; and Bob Dickman, Executive Director, AIAA.

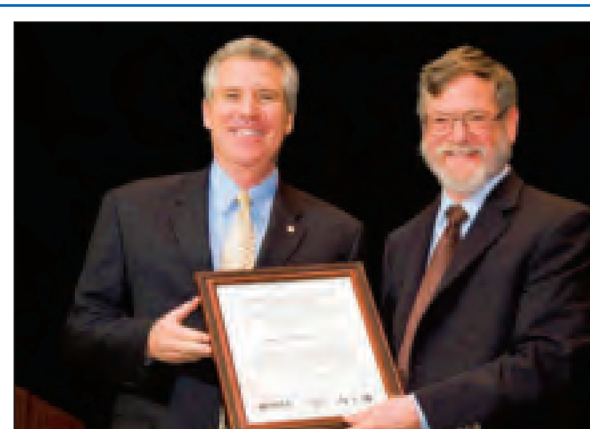
The AIAA Foundation has been selected to administer the Iridium NEXT Scholarship Fund, which will award scholarships of up to $25,000, out of a pool initially funded at $250,000, to students who have demonstrated high standards of academic excellence in the "STEM" fields of science, technology, engineering, and mathematics.

The scholarship fund aims to help create a workforce that will further the mission of Iridium NEXT, a bold vision for a second-generation satellite constellation to expand Iridium's capability to meet rapidly expanding demand for truly global mobile communications on land, at sea, and in the sky. For more information on the scholarships, eligibility criteria, and application procedures, please visit **www.aiaafoundation.org**.

AIAA Executive Director Robert S. Dickman stated: "The Iridium NEXT Mission Team Scholarship program will be one of the most significant educational opportunities in the aerospace industry. The contributions of these leading innovators will help support students, and the program is a great complement to the AIAA Foundation's commitment to investing in the future of aerospace. Together we will make a lasting impact on the future of our industry."

Iridium's Executive Director of Marketing, Don Thoma, explained: "Iridium prides itself on being both innovative and enabling of the innovations of others. The Iridium NEXT team of partners is an unmatched group of technology leaders from around the world. Collectively, we are not only working toward the successful launch of Iridium NEXT, but also as a catalyst for the future of the communication landscape and recognizing that the contributions of these students is an essential part of that." He added: "We're doing things today that we never thought we would 10 years ago. These students will be at the forefront of technology, developing new things and concepts that will change the world—just as Iridium NEXT will change the way we people and organizations connect, operate and live."


AIAA Associate Fellow Tom Fagan, P.E., was awarded the Grade of Fellow from the Society of Reliability Engineers (SRE) on 24 January 2012 at the AIAA Co-Sponsored Annual Reliability & Maintainability Symposium in Reno, NV. The citation reads: "For contributions to, and leadership in, the field of Reliability Engineering." From left to right: Dr Robert Loomis, Ph.D., retired NASA and United Space Alliance Executive and Jack Dalton, current President of SRE. Mr. Fagan is also a Fellow of IEEE.


James P. Elwood, Airport Director of the Aspen-Pitkin/County Airport, (left) receives the 2012 AIAA/ACC/AAAE Jay Hollingsworth Speas Airport Award from Dirk Speas (right). The award was presented to recognize Elwood's leadership in developing a cooperative relationship with the community surrounding the Aspen-Pitkin/County Airport by designing and implementing aggressive environmental protection programs while achieving airport expansion.


AIAA Vice President Carol Cash and AIAA Team Ohio with Ohio Senator Sherrod Brown.

## AIAA MEMBERS VISIT CAPITOL HILL TO ADVOCATE FOR AEROSPACE

*Duane Hyland*

The 15th annual Congressional Visits Day program was held on 20–21 March, drawing 176 AIAA members from 44 AIAA sections, representing 34 states and the District of Columbia to Washington, D.C., to meet with their elected representatives and discuss matters of vital importance to the U.S. aerospace community. Through 165 meetings with congressional decision makers, AIAA members discussed:

- Assuring the viability of the U.S. aerospace and defense industrial base
- Dealing with counterfeit and malicious hardware
- Supporting and evolving and adaptive cybersecurity policy
- Lessening the impact of export controls on the U.S. aerospace industry
- Sharing stewardship of the federal aeronautics RDT&E infrastructure
- Developing a robust next-generation air transportation system
- Facilitating assured, cost-effective human access to space
- Recruiting, retaining, and developing a world-class aerospace workforce
- Increasing emphasis and funding for technology and engineering in STEM.

When asked about the value of CVD to AIAA, and why she feels members should attend, Carol Cash, Vice President of Public Policy, and chair of the Public Policy Committee stated: “Congressional Visits Day provides an opportunity for AIAA members to meet with their elected officials and staff to stress the importance of ensuring that the aerospace enterprise remains robust and continues to advance. Our collective input gives government leaders important insights necessary to enable them to craft sound policies regarding aerospace. CVD allows our members to share personal experiences and anecdotal information that help illustrate why Congress should care about and protect aerospace.

This year’s Congressional Visits Day program saw the trend of increasing student participation continue, reflecting student concerns about the future of the U.S. aerospace community. When asked about the value of CVD to students, Chelsey Robinson, a student attendee from Southern Illinois University –Edwardsville, stated: “The CVD experience has been a wonderful one on many levels. It has encouraged me to learn more about the legislative process and its role in the scientific field and has left me with a greater understanding and appreciation of the process. It has also provided me with the wonderful opportunity to meet others in my field who have experience in the field of aerospace and can speak to the employment and work environment I will face after graduation.”

The Congressional Visits Day program is one of many AIAA public policy outreach activities. AIAA's grassroots public policy program give members input into the policy decisions that impact their profession, and allow them to interface with the decision makers who control three out of every five dollars in the community. For more information on the Congressional Visits Day program, or on the other AIAA public policy grassroots activities, please contact Duane Hyland at 703.264.7558 or at duaneh@aiaa.org.

AIAA members Matt Anguilo, A. Carey Sperling, and Tucker Pudwill with Arizona Congressman Joe Heck.

## AIAA WISCONSIN SECTION'S K–12 OUTREACH

*Todd Treichel*

The Wisconsin AIAA section has leveraged the talent of its members to provide a variety of outreach opportunities for precollege-aged students. Hands-on demonstrations, visual aids, and real-life space flight examples provide a foundation for bringing precollege-aged students face-to-face with space-related science, designed hardware, technology, and its potential benefits—increased interest in aerospace and space-related fields lead to study at the university level followed by career. Based on past success, NASA and the Wisconsin Space Grant Consortium (WSGC) awarded AIAA-Wisconsin a 2011 grant to support K–12 outreach.

AIAA-Wisconsin members Todd Treichel, Michael Fidler, and Dr. Martin Chiaverini developed a Rocket Science for Educators workshop specially designed to provide K–12 teachers with ideas, knowledge, and techniques for promoting science using both model and high powered rockets. The goal of the Rocket Science for Educators workshop was to assist schools in implementing rocket science into respective math or science curriculums. What better way to accomplish this goal than to educate the educator? Workshop topics provide educators with first-hand experience and training from real aerospace professionals intended to spark students' excitement about machines, space, aviation, how things work and fly, and why things happen. In short, the many facets of math and science.

Last month sixteen K–12 educators participated in a weekend workshop held in Green Bay, WI. Each educator who participated in this free workshop received a set of rocket science materials they could take back to their respective schools. A workshop taught by aerospace professionals provided a unique opportunity for teachers to learn about rocket science, provided meaningful activities for their classrooms, and aid in improving student performance in the fields of science, technology, engineering, and mathematics (STEM). Highlights of the workshop included a series of lectures accompanied by demonstration (static) firing of a demonstrator hybrid rocket engine and experimentation with altimeters. Design rocket simulation (RockSim) software was used to demonstrate rocket design techniques, 3D imaging, and flight simulation followed by construction and flight of a payload capable rocket.

A simple, compelling philosophy drives AIAA Wisconsin's commitment to math, science, and technology education. Make it exciting, make it empowering, and make it fun. The Rocket Science for Educators workshop is a far-reaching program that targets precollege students, and the educators who inspire them. Learning starts with a teacher, a curious student, and fun in the classroom.

AIAA-Wisconsin instructors Todd Treichel (far left) kneels next to his RockSim designed high powered rocket and Michael Fidler (far right) holds his scratch built two-stage high powered rocket in the Rocket Science for Educators group photo taken in Green Bay, Wisconsin.


Michael Fidler fires a table top demonstrator of a hybrid rocket.

Todd Treichel demonstrates differential pressure resulting from increased altitude.

K–12 educators build payload capable rockets.

Michael Fidler prepares payload capable rocket for launch.

**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.

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 are now 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 on the high quality or major influence of the piece rather than, for example, the importance of the underlying technological contribution. The award is an incentive for aerospace professionals to write eloquently and persuasively about their field and should encompass editorials as well as papers or books.

**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 carefully read award guidelines to view nominee eligibility, page limits, letters of endorsement, etc.

AIAA members may submit nominations online after logging into **www.aiaa.org** with their user name and password. You will be guided step-by-step through the nomination entry. If preferred, a nominator may submit a nomination by completing the AIAA nomination form, which can be downloaded from **www.aiaa.org**.

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

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

## OBITUARIES

### *AIAA Associate Fellow White Died in September 2011*

**Col. Stanley C. White, MC USAF (Ret.)**, died on 10 September 2011.

Dr. White had a distinguished career in the military and with NASA as one of the original space pioneers. His work involved the development of life support systems for manned space flight, the selection of the Mercury astronauts, and involvement with the Gemini, Apollo, and Skylab manned orbiting laboratory. He served as the president of the Aerospace Medical Association and the International Academy of Aviation and Space Medicine.

Upon retirement from the military, he continued in the medical sciences, finally retiring as the Senior Scientist, Group Manager Medical Operations and Human Research at The Bionetics Corporation at the Kennedy Space Center, FL.

### *AIAA Fellow Kullas Died in December 2011*

**Albert J. Kullas** died on 11 December 2011. He was 94 years old. Mr. Kullas had engineering degrees from Worcester Polytechnic Institute & New York University. He was a retired president of Martin-Marietta, now Lockheed Martin. Mr. Kullas had been a member of AIAA for almost 70 years, having joined in 1943.

### *AIAA Senior Member Harding Died in February*

**Wayne E. Harding, Jr.** died on 14 February 2012, at age 90.

Mr. Harding attended Phillips Exeter Academy in Exeter, NH; and Princeton University and graduated with an engineering degree. During World War II, he was a naval fighter pilot for Chance Vought Aircraft in Stanton, CT. Four of the nine company pilots were killed, so his father influenced him into a glass partnership by buying Acme Glass Co. in Topeka, KS, in 1947. That company became Harding Glass and by 1965 had grown into 53 operations in 8 states.

Mr. Harding co-founded Harding Steel in 1968, which makes mechanical parking devices. Mr. Harding was the author of 3 books: *The Extra 2% That Makes Sales Happen*; *His Edge*, and *Love's Edge*. He was a 70-year member of AIAA.

### *Associate Fellow Holloway Died in March*

**Richard B. "Dick" Holloway**, age 84, died on 5 March 2012.

Mr. Holloway earned a Masters in Library Science from the University of Illinois in 1951. As an officer during the Korean War, he was awarded the Silver Star for gallantry in combat. He earned a Masters in Aeronautical Engineering from Wichita State University (WSU) in 1958.

He worked for Boeing for 33 years as an engineer, manager, and in product development on the B-47, KC-135, B-52, and the SST, as well as airships, cruise missiles and numerous black programs. He held a patent on a drone called the Pave Tiger. At the time of his retirement in 1980, his title was Chief Engineer of Preliminary Design.

Mr. Holloway was instrumental in creation of the Dean's Circle for Engineering at WSU, and started the Wichita BEST (Boosting Engineering Science and Technology) program, a national competition for high school students who build radio-controlled robots and compete with each other. He began his association with AIAA as a member of its predecessor the Institute of The Aeronautical Sciences.

### *AIAA Member Lissaman Died in March*

**Peter Lissaman** died on 11 March 2012.

Dr. Lissaman graduated from Natal University in 1952 and then attended Trinity Hall, Cambridge University, UK, where he studied mathematics. He then studied at the California Institute of Technology, receiving a Ph.D. in aeronautics, and in 1990 was awarded an honorary Ph.D. in Design from Natal University.

After graduation, he returned to London, where he worked for Bristol Aeroplane Co. and Handley Page Aircraft as part of the team designing the wing of the RAF nuclear bomber. Dr. Lissaman returned to California in 1958, receiving a faculty appointment at the U.S. Naval Postgraduate School in Monterey, instructing naval aviators and astronaut candidates. He was proud of his classes and enjoyed stating that some of his students had "gone far—two went to the moon." Later he joined the aeronautics faculty at Caltech, specializing in wing design.

He worked as a director of research for Northrop, and in 1971, he was a founding VP at Aerovironment Inc., working on many innovative vehicles and concepts, including the Gossamer Condor, the first successful human powered airplane. He received the Kremer Prize from the Royal Aeronautical Society and the Longstreth Medal from the Franklin Society for his contributions to the Gossamer Condor and Albatross. At Aerovironment, he made many contributions to wind energy, and solar- and electric-powered automobiles and aircraft. He spent 30 years working on research related to environmental issues including air quality, wind and hydropower and solar energy. The last years of his career were at USC as an adjunct professor.

Dr. Lissaman published more than 150 scientific papers ranging from pollution, wind energy, and wing design to bird flight.

### *AIAA Fellow Domb Died in March*

**Uriel Domb** passed away in mid-March at the age of 69. His long and distinguished career in aerospace includes key roles in the ground team of the first lunar landing mission of Apollo in 1969, and in the launch of the world's first domestic communications satellite, Canada's Anik I, in 1972.

Mr. Domb earned a B.S. in Applied Mathematics and an M.S. in Astronautics from the Polytechnic University of New York, as well as an M.S. in operations research from Columbia University. He was a NASA Fellow at Cornell University, and an Adjunct Professor of Communications at York University (Canada).

In 1980, Mr. Domb founded Telespace Ltd., one of the world's leading satellite consulting companies, and has been its president and CEO since that time.

He was instrumental in supporting major international satellite organizations such as Inmarsat, Eutelsat, Intelsat, the European Space Agency, SES of Luxembourg, GE Americom, GTE/Spacenet and Comsat, as well as the national satellite communications systems of Canada, the United States, Brazil, Indonesia, Mexico, Thailand, Israel and Norway.

Mr. Domb was an AIAA Fellow, a registered professional engineer in Ontario, Canada, author of numerous technical papers on satellite technology, past chairman of several international aerospace conferences, and Canada's previous representative to the International Astronautical Federation. His name appears in the prominent American and Canadian *Who is Who* publications.

## Publications

# 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 Guidance, Navigation, and Control Conference
# AIAA Atmospheric Flight Mechanics Conference
# AIAA Modeling and Simulation Technologies Conference
# AIAA/AAS Astrodynamics Specialist Conference

13–16 August 2012
Hyatt Regency Minneapolis
Minneapolis, MN

## Event Overview

The AIAA Guidance, Navigation, and Control Conference, AIAA Atmospheric Flight Mechanics Conference, AIAA Modeling and Simulation Technologies Conference, and AIAA/AAS Astrodynamics Specialist Conference will combine in 2012 to provide the world's premier forum for presentation, discussion, and collaboration of science, research, and technology in these highly related fields as they relate to the aerospace industry. It will bring together experts from industry, government, and academia on an international level to cover a broad spectrum of issues concerning flight mechanics, modeling, simulation, and the guidance, navigation, and control of aerospace vehicles.

## Benefits of Attendance

***Why Attend?***
- Meet other professionals from government, academia, and industry, including U.S. and international constituencies
- Learn from experts about the latest advancements and research in the field
- Listen to high-quality technical papers and presentations
- Network, discuss challenges, and share ideas during sessions, coffee breaks, and receptions

***Who Should Attend?***
- All levels of engineers, researchers, and scientists from government, academia, and industry
- Engineering managers and executives
- Business development personnel
- Young aerospace professionals
- Educators and students
- Press/media

***What to Expect?***
- *Program*

— Access to more than 700 technical papers and presentations
— Keynote speeches by renowned experts and decision makers during the plenary sessions
— Continuing Education courses to refresh your knowledge and keep professionals at their technical best
— Student paper competitions to encourage and engage young minds as they enter the aerospace industry

- *Networking*

— NEW FOR 2012! Standalone networking coffee breaks to allow even more time for making new contacts and continuing the discussions from technical sessions
— Sunday welcome reception and Wednesday networking luncheon
— Awards luncheon to recognize outstanding members of the guidance, navigation, and control, atmospheric flight mechanics, modeling and simulation, and aerodynamics technical communities and celebrate their contributions to the industry
— Minneapolis activities, such as seeing a Minnesota Twins baseball game at the fabulous new Target Field, and exploring the remarkable Mall of America

# AIAA Programs

**Organizing Committees**

***AIAA Guidance, Navigation, and Control Conference***

**General Chair**
Julie Thienel
NASA Goddard Space Flight Center

**Technical Program Chairs**
Jack W. Langelaan
The Pennsylvania State University

Lesley A. Weitz
The MITRE Corporation

***AIAA Atmospheric Flight Mechanics Conference***

**General Chair**
Steven C. Komadina
Northrop Grumman Aerospace Systems

**Technical Program Chairs**
Clay Harden
Honda Aircraft Company

Mark H. Lowenberg
University of Bristol

***AIAA Modeling and Simulation Technologies Conference***

**General Chair**
Steven D. Beard
NASA Ames Research Center

**Technical Program Chairs**
Steven D. Beard
NASA Ames Research Center

Che-Hang C. Ih
The Boeing Company

***AIAA/AAS Astrodynamics Specialist Conference***

**AIAA General Chair**
David B. Spencer
The Pennsylvania State University

**AAS General Chair**
Anil Rao
University of Florida

**AIAA Technical Program Chair**
Mark E. Pittelkau
Aerospace Control Systems, LLC

**AAS Technical Program Chair**
Anastassios Petropoulos
NASA Jet Propulsion Laboratory, California Institute of Technology

## Special Events

***Plenary Sessions***

Each day of the conference will kick off with a keynote address. These presentations are given by renowned experts and decision makers in the industry.

*Monday, 13 August 2012*
0800–0900 hrs
AIAA Modeling and Simulation Technologies Conference Plenary
Speaker: Keith Colmer, Test Pilot, Virgin Galactic, Mojave, CA

*Tuesday, 14 August 2012*
0800–0900 hrs
AIAA Guidance, Navigation, and Control Conference Plenary
Speaker: Mason Peck, Chief Technologist, NASA Headquarters, Washington, DC

*Wednesday, 15 August 2012*
0800–0900 hrs
Duane McRuer Atmospheric Flight Mechanics Plenary
Speaker: Scott Winship, Vice President Advanced Concepts Air and Land, Northrop Grumman Corporation, San Diego, CA

***Welcome Reception***

A "happy hour" welcome reception will be held Sunday, 12 August 2012, 1700–1900 hrs. A ticket for the reception is included in the conference registration fee where indicated. Additional tickets for guests may be purchased upon registration or on site.

***Networking Coffee Breaks***

*New for 2012!* In response to attendee feedback, standalone networking coffee breaks have been added to the program to allow even more time for making new contacts, continuing the discussions from technical sessions, or checking emails and voicemails to keep in touch with the office while you are at the conference. Times are indicated in the program.

***Women in Engineering Luncheon***

The Women in Engineering Luncheon, hosted by the GNC TC, will be held Monday, 13 August 2012, 1200–1330 hrs. The speaker will be Lillian Zarrelli Ryals, Vice President and Deputy General Manager, Center for Advanced Aviation System Development (CAASD), The MITRE Corporation, McLean, VA. Women participating in any of the collocated conferences are invited to attend at no charge. Women are underrepresented in the engineering sciences and industry, and this luncheon provides an opportunity for women to meet informally, network, discuss experiences, and identify women who are leaders in their fields for recognition by AIAA.

***Minnesota Twins Major League Baseball Game***

AIAA has purchased a block of tickets at the new Target Field, home of Major League Baseball's Minnesota Twins!

| | Saturday | Sunday | | |
|---|---|---|---|---|
| 0700 hrs | | | | 0700 hrs |
| 0730 hrs | | | | 0730 hrs |
| 0800 hrs | | | | 0800 hrs |
| 0830 hrs | | | | 0830 hrs |
| 0900 hrs | | | | 0900 hrs |
| 0930 hrs | | | | 0930 hrs |
| 1000 hrs | Continuing Education Courses | Continuing Education Courses (End at 1700 hrs) | | 1000 hrs |
| 1030 hrs | | | | 1030 hrs |
| 1100 hrs | | | | 1100 hrs |
| 1130 hrs | | | | 1130 hrs |
| 1200 hrs | | | | 1200 hrs |
| 1230 hrs | | | | 1230 hrs |
| 1300 hrs | | | | 1300 hrs |
| 1330 hrs | | | | 1330 hrs |
| 1400 hrs | | | | 1400 hrs |
| 1430 hrs | | | | 1430 hrs |
| 1500 hrs | | | Registration (1500-1900 hrs) | 1500 hrs |
| 1530 hrs | | | | 1530 hrs |
| 1600 hrs | | | | 1600 hrs |
| 1630 hrs | | | | 1630 hrs |
| 1700 hrs | | Welcome Reception "Happy Hour" | | 1700 hrs |
| 1730 hrs | | | | 1730 hrs |
| 1800 hrs | | | | 1800 hrs |
| 1830 hrs | | | | 1830 hrs |
| 1900 hrs | | | | 1900 hrs |
| 1930 hrs | | | | 1930 hrs |
| 2000 hrs | | | | 2000 hrs |
| 2030 hrs | | | | 2030 hrs |
| 2100 hrs | | | | 2100 hrs |
| 2130 hrs | | | | 2130 hrs |
| 2200 hrs | | | | 2200 hrs |

Tickets are for the Monday evening, 13 August 2012, game against the Detroit Tigers. Target Field is rated the "#1 Fan Experience" in all of major league sports by ESPN Magazine. Tickets are $40 and include $15 worth of refreshments of your choice. The stadium is within walking distance of the hotel. A separate ticket is required and must be purchased by the early bird registration deadline of **16 July 2012** to reserve your ticket. Tickets are non-refundable (rain or shine).

***AIAA Awards Luncheon***

The AIAA Awards Luncheon will be held Tuesday, 14 August 2012, 1200–1400 hrs. The luncheon will start with the presentation of awards and end with a keynote presentation by Bo Bobko, SimLabs Program Manager, SAIC, and retired astronaut, NASA Ames Research Center, Moffett Field, CA. This year's luncheon is hosted by the AIAA Modeling and Simulation Conference. The cost of the luncheon is included in the conference registration fee where indicated. Additional tickets for guests may be purchased upon registration or on site.

The following awards will be presented at the conference:

- Aerospace Guidance, Navigation, and Control Award
- Mechanics and Control of Flight Award
- DeFlorez Award for Modeling and Simulation
- AIAA Foundation Guidance, Navigation, and Control Graduate Award
- Best Papers Certificate of Merit
- AFM Student Paper Competition Certificate of Merit: Overall Winner
- GNC Graduate Student Paper Competition Certificate of Merit: Overall Winner

***Shuttle Buses to Mall of America***

AIAA will be running shuttle buses between the Hyatt Regency Minneapolis and Mall of America on Tuesday evening, 14 August 2012, starting at 1830 hrs and ending at

# AIAA Programs

| Monday | Tuesday | Wednesday | Thursday |
|---|---|---|---|
| Speakers' Briefing | Speakers' Briefing | Speakers' Briefing | Speakers' Briefing |
| Plenary Session (MST) | Plenary Session (GNC) | Plenary Session (AFM) | Technical Sessions |
| Networking Break | Networking Break | Networking Break | |
| Technical Sessions | Technical Sessions | Technical Sessions | |
| | | | Networking Break |
| | | | Technical Sessions |
| Lunch Break/WIE Luncheon | Awards Luncheon | Networking Luncheon | |
| Technical Sessions | | Technical Sessions | |
| | Technical Sessions | | |
| Networking Break | | Networking Break | |
| Technical Sessions | Networking Break | Technical Sessions | |
| | Technical Sessions | | |
| | Shuttle Buses to Mall of America | | |
| Twins Baseball Game (Extra Ticket Required) | | | |

2130 hrs. All conference attendees and guests are welcome to use the shuttles. Since opening its doors in 1992, Mall of America has revolutionized the shopping experience and become a leader in retail, entertainment, and attractions. Mall of America is one of the top tourist destinations in the country, featuring 520+ stores, 20+ restaurants and food courts, and attractions such as Nickelodeon Universe, Sea Life Minnesota Aquarium, Lego and American Girl stores, movie theaters, and more. The mall is so large that 32 Boeing 747s could fit inside!

***Networking Luncheon***

A networking buffet luncheon will be held Wednesday, 15 August 2012, 1200–1330 hrs. Join your colleagues to catch up on the technical discussions of the week and solidify new contacts. The cost of the reception is included in the conference registration fee where indicated. Additional tickets for guests may be purchased upon registration or onsite.

## Student Paper Competitions

***Best Atmospheric Flight Mechanics Student Paper Competition***

The AIAA Atmospheric Flight Mechanics (AFM) Technical Committee, with the support of Calspan Corporation (**www.calspan.com**), is sponsoring a Best Student Paper Competition at the 2012 AIAA AFM Conference. Entrants will be judged by Technical Committee members and the winner will receive a certificate and $500 award at the conference awards luncheon. To be eligible for this award, the student must be the primary author of the paper and the work must have been performed while the author was a student. Students will present their paper in the relevant conference technical sessions on Monday and Tuesday morning. The scoring for the award will be equally based on written paper content and oral presentation. The written paper will be judged on: 1) relevance of the topic to atmospheric flight mechanics; 2) organization and clarity; 3) appreci-

**Before 16 July 2012**

| | Registration Type | Conference | Member Discount | Conference Sessions | Welcom Reception | Awards Luncheon | Networking Luncheon | Online Proceedings |
|---|---|---|---|---|---|---|---|---|
| Option 1 | **Full Conference** | **$765** | **$610** | ● | ● | ● | ● | ● |
| Option 2 | **AIAA Undergraduate Student** | **$50** | **$20** | ● | | | | |
| Option 3 | **AIAA Undergraduate Student** | **$188** | **$158** | ● | ● | ● | ● | |
| Option 4 | **AIAA Graduate or PH.D. Student** | **$90** | **$60** | ● | | | | |
| Option 5 | **AIAA Graduate or PH.D. Student** | **$228** | **$198** | ● | ● | ● | ● | |
| Option 6 | **AIAA Retired Member** | **n/a** | **$40** | ● | ● | ● | ● | |
| Option 7 | **Group Rate*** | **$549** | **n/a** | ● | ● | ● | ● | ● |
| Option 8 | **Professional Development Courses** | **$1,348** | **$1,243** | ● | ● | ● | ● | ● |
| | Extra Tickets | | | | $40 | $46 | $52 | $170 |
| | Baseball Game | $40 | | | | | | |

Pricing subject to change.

*10% discount off AIAA member rate for 10 or more persons from the same organization who register and pay at the same time

ation of the technical issues and sources of errors; and 4) meaningful conclusions of the research. The oral presentation will be judged for overall clarity, including: 1) background and problem definition statement; 2) explanation of technical approach; and 3) explanation of research results.

***GNC Graduate Student Paper Competition***

The AIAA Guidance, Navigation, and Control (GNC) Technical Committee is sponsoring a Graduate Student Paper Competition. Papers have been sought from graduate students on GN&C technical research topics, and six finalists will be selected by a panel of judges for inclusion in the AIAA GN&C Conference. To be eligible for the competition, graduate students must be enrolled at an institution of higher education and be in good academic standing at the time of submission of their manuscript. The student must be the first author on the paper with their graduate advisor as the second author. Selection will be based on a review of a full draft manuscript not exceeding a total length of 15 pages. Finalists will make two presentations at the conference: once in the Graduate Student Paper Competition session (held Sunday, 12 August 2012, 1800–2200 hrs) and again in an appropriate regular session. Finalists will receive a $1,200 award after attending and presenting their papers. An overall best paper and presentation will be selected from the Graduate Student Paper Competition session. The winner will receive a $2,500 prize and be recognized at the awards luncheon. Prizes are sponsored by the AIAA GNC TC.

## 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/events/gnc**, **www.aiaa.org/events/afm**, **www.aiaa.org/events/mst**, or **www.aiaa.org/events/asc**. Registering in advance saves conference attendees up to $200.

Early-bird registration forms must be received by **16 July 2012**, and standard registration forms will be accepted until **11 August 2012**. Preregistrants may pick up their materials at the advance registration desk at the conference. All those not registered by 11 August 2012 may do so at the on-site registration desk.

Cancellations must be received no later than **30 July 2012**. There is a $100 cancellation fee. Registrants who cancel beyond this date or fail to attend the conference will forfeit the entire fee.

*Attention AAS Members*: Current AAS members in good standing are eligible to register at the same rate as AIAA members. This fee does not include AIAA membership. To become an AIAA member or renew AIAA membership, AAS members should register at the nonmember registration rate.

For questions, please contact Sandra Turner, conference registrar, at +1 703.264.7508 or sandrat@aiaa.org.

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 **11 August 2012**.

***Extra Tickets***

| | |
|---|---|
| Welcome Reception | $40 |
| Minnesota Twins Baseball Game | $40 |
| (*separate ticket purchase required for game*) | |
| Awards Luncheon | $46 |
| Networking Luncheon | $52 |
| Extra Online Proceedings | $170 |

### On-Site Registration Hours

On-site registration will be held in the Nicollet Promenade at the Hyatt Regency Minneapolis as follows:

| | |
|---|---|
| Saturday, 11 August 2012 | 0715–0815 hrs (course only) |
| Sunday, 12 August 2012 | 1500–1900 hrs |
| Monday, 13 August 2012 | 0700–1700 hrs |
| Tuesday, 14 August 2012 | 0700–1700 hrs |
| Wednesday, 15 August 2012 | 0700–1700 hrs |
| Thursday, 16 August 2012 | 0700–1200 hrs |

### Meeting Site

Minneapolis–Saint Paul is a progressive destination with a dynamic vibe and a whirlwind of creative energy. Here, you'll find all the attractions, events, and excitement of a major metropolitan area, without the hassles. Looking for happy hour at the hot new spot, tickets to the Guthrie Theater or late-night plans to enjoy live music? No problem. Minneapolis is compact, easy to navigate, and affordable, so you'll squeeze a lot into your visit.

Nearly 40,000 people live in downtown Minneapolis, ensuring that it's alive 'round the clock. Take it all in: amazing theater, world-class museums, sports galore, picturesque strolls in a green, urban environment. The variety of what Minneapolis–Saint Paul has to offer is sure to delight. For more information, **visit www.minneapolis.org**.

### Hotel Reservations

AIAA has made arrangements for a block of rooms at the:

Hyatt Regency Minneapolis
1300 Nicollet Mall
Minneapolis, Minnesota, USA 55403
Tel: +1 612.370.1234

Experience the perfect hotel for business or pleasure travel when you visit the Hyatt Regency Minneapolis. Downtown Minneapolis is just outside the front door of our hotel, and our prime location on Nicollet Mall lets you easily explore an incredible array of Twin Cities attractions, from shopping to Minnesota sports and everything in between.

We have negotiated special event rates of $179 for single or double occupancy. Book your rooms early! Rooms will be held until **20 July 2012** or until the block is full. You must mention AIAA when you make your reservations to be included in this block. Visit the conference website for a direct link to make reservations. *Government Employees*: There are a small number of federal government per-diem rooms available. Visit the conference website for a direct link to make reservations.

### 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!

### Airport Info

The airport that serves Minneapolis is the Minneapolis-St. Paul International Airport (MSP), located approximately 14 miles from the Hyatt Regency Minneapolis. Transportation to the hotel:

- Taxi: $40–50 avgerage
- Shuttle (Blue Van): $18

### Cyber Café

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

| | |
|---|---|
| Sunday, 12 August 2012 | 1500–1900 hrs |
| Monday, 13 August 2012 | 0700–1800 hrs |
| Tuesday, 14 August 2012 | 0700–1730 hrs |
| Wednesday, 15 August 2012 | 0700–1730 hrs |
| Thursday, 16 August 2012 | 0700–1200 hrs |

### Conference Proceedings

Proceedings for these conferences will be available in online proceedings format. The cost is included in the registration fee where indicated. The online proceedings will be available on **6 August 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.

### 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.

### "No Paper, No Podium" and "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.

## 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 11–12 August 2012 at the Hyatt Regency Minneapolis, AIAA will offer Continuing Education courses in conjunction with the AIAA Guidance, Navigation, and Control and Collocated Conferences. Please check the conference website for up-to-date information regarding the courses. Register for any course and attend the GNC et al Conferences for FREE! Registration fee includes full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

***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 extensively addressing the flight dynamics and control of elastic vehicles. 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.

***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. The course reviews 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 provides 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.

***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)*

The instructor presents state estimation theory clearly and rigorously, providing the right balance of fundamentals, advanced material, and recent research results. After taking this course, the student will be able to confidently apply state estimation techniques in a variety of fields. The features of this course include: 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. This leads to an intuitive understanding of how theory works in practice. 3) MATLAB®-based state estimation source code for realistic engineering problems. This 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 presented with 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.

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

# AIAA Programs

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.

***Six Degrees of Freedom Modeling of Missile and Aircraft Simulations***
*(Instructor: Peter Zipfel, Adjunct Associated Professor, University of Florida, Shalimar, FL)*
As modeling and simulation (M&S) is penetrating the aerospace sciences at all levels, this two-day course will introduce you to the difficult subject of 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. For demonstrations, 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.

## Sessions-At-A-Glance

For the full conference program, including all paper titles and speakers, visit www.aiaa.org/events/gnc, www.aiaa.org/events/afm, www.aiaa.org/events/mst, or www.aiaa.org/events/asc.

***AIAA Atmospheric Flight Mechanics Conference Sessions***

Aeroservoelastic Control, Modeling, Simulation, and Optimization
Aircraft Dynamics
Aircraft Flying Qualities
Bio-Inspired Flight Mechanics
Linear and Nonlinear Equations of Motion
Loss of Control
Nonlinear Dynamics in Aerospace
Projectile, Missile, and Launch Vehicle Dynamics and Control
Reentry and Aeroassist Vehicle Technology
System Identification and Parameter Estimation
UAVs and Unmanned Systems
Unsteady and High Angle-of-Attack Aerodynamics
Vehicle Flight Test

***AIAA Guidance, Navigation, and Control Conference Sessions***

Advanced Control of Nonlinear Systems in Honor of the 70th Birthday of Prof. Mark Balas (Invited)
Airborne Separation
Aircraft Flight Control Applications
Control in Aerospace Robotics
Control Theory and Analysis
Decision Support
Environmental Impact of Aviation
Estimation
Fixed-Wing Micro Air Vehicles
Flapping Wing Micro Air Vehicles
Flight Control Applications in System Modeling, Identification, and Estimation
Flight Control Test Evaluations
Flight Experience of Cassini Spacecraft Attitude Control at Saturn
Human and Autonomous/Unmanned Systems
Intelligent Control in Aerospace Applications
Loss of Control
Missile Systems Control and Autopilots
Missile Systems Guidance and Trajectory Design
Missile Systems Navigation and Control
Motion Planning in Aerospace Robotics
Multi-Body Mission Planning and Guidance for Missile Systems
Multi-Vehicle Control
Navigation
Nonlinear Control in Flight Control Applications
Optimal Control Application in Flight Control System
Orion GNC Design and Analysis
Quadrotors and Aerospace Robotics
Recent Advances in Adaptive Control
Robotic Systems in Aerospace
Robust Aircraft Flight Control
Robust Launcher Flight Control System Design Verification and Validation (Invited)
Rotary-Wing Micro Air Vehicles
Sensing Systems in Aerospace Robotics
Sensor Systems for Guidance, Navigation, and Control
Space Robotics
Spacecraft Exploration and Transportation GNC
Spacecraft GNC: Attitude Control
Spacecraft GNC: Attitude Estimation
Spacecraft GNC: Guidance
Spacecraft GNC: Navigation
Spacecraft GNC: Orbit Control and HIL Simulator
Tracking and Planning
Trajectory Design and Guidance in Flight Control Applications
Trajectory Prediction
UAS Motion Video Tracking and Surveillance
Uncertainty Characterization
Vision-Based Micro Air Vehicle Control

***AIAA Modeling and Simulation Technologies Conference Sessions***

Aerodynamic Modeling and Simulation
Aeroelastics
Air Traffic Management
Aircraft Modeling
Aviation Safety
Hardware-in-the-Loop Simulation
Human Operators
Loss of Control
Model/Simulation-Based Design and Analysis
Modeling and Simulation for Flight Control Analysis
Modeling Tools and Techniques
Motion Systems
Simulation Environments and Framework
Simulation Validation and Verification
Simulator Design, Verification, and Validation
Space Systems
Systems and Environmental Modeling Techniques
Unmanned Aerial Vehicles
Upset Recovery
Vehicle Subsystems
Vision Systems

***AIAA/AAS Astrodynamics Specialist Conference Sessions***

Asteroid and Comet Missions
Attitude Control
Attitude Determination
Attitude Dynamics and Control
Constellations
Formation Flying
Large Space Structures, Tethers, and Solar Sails
Low-Thrust Missions
Lunar Missions
Near-Earth Objects
Orbit Determination
Orbital Debris and Conjunction Analysis
Orbital Dynamics, Perturbations, and Stability
Planetary Missions
Rendezvous, Relative Motion, and Proximity Missions
Space Situational Awareness and Surveillance
Spacecraft Guidance
Spacecraft Navigation
Trajectories about Libration Points
Trajectory and Maneuver Design and Optimization

## 22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar
## AIAA Balloon Systems Conference
## 20th AIAA Lighter-Than-Air Systems Technology Conference

***25–28 March 2013***
***Hilton Daytona Beach Oceanfront Resort***
***Daytona Beach, Florida***

***Abstract Deadline: 5 September 2012***

### Synopsis

AIAA is pleased to announce the collocated 22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, AIAA Balloon Systems Conference, and 20th AIAA Lighter-Than-Air Systems Technology Conference, to be held 25–28 March 2013 at Hilton Daytona Beach Oceanfront Resort in Daytona Beach, FL. This event provides an unrivaled opportunity to gather the world's leading parachute and flexible structure scientists, engineers, researchers, and managers from all over the globe for technical interchange and technology advancement.

Event participants will:

- Present recent advances before a knowledgeable international audience
- Educate industry customers and providers on their latest research and product developments
- Extract lessons learned from past system applications and programs to result in increased technical success, cost savings, and schedule savings for current or ensuing projects or programs
- Network to engage new contacts and refresh old ones
- Recognize significant achievements from within the community

The collocation of these related AIAA events provides attendees with a unique opportunity to expand their knowledge of technological advances of these interrelated disciplines and explore areas of common technical expertise.

### Collocated with the PIA Meeting and Symposium 2013!

The 2013 AIAA event will be held in conjunction with the Parachute Industry Association (PIA) Meeting and Symposium! PIA's primary areas of interest are the manufacture of parachute systems and materials, along with the more hands-on aspects of rigging, maintenance, and operation. The AIAA and PIA events will complement each other by providing a broader perspective of the field of aerodynamic decelerators. Joint activities will offer interaction between the groups and increase the value to all participants! For more information on PIA, please visit **www.pia.com**.

### Seminar

On Monday, 25 March, the ADS Technical Committee will host a one-day seminar on Entry, Descent, and Landing (EDL). Engineers presently involved in EDL research, development, and flight missions will present this seminar. The objective of this seminar is to introduce the attendees to the challenges associated with EDL, the technologies used to address these challenges, and the nomenclature typically used to discuss EDL. Topics will include trajectories, hypersonic aerodynamics and aerothermodynamics, rigid and deployable aerodynamic decelerators, supersonic retropropulsion, and landing systems. The seminar will conclude with a case study of a flight mission that utilized EDL.

*Collocated with the PIA Meeting and Symposium 2013*

***22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar***

**General Chair**
Ben Tutt
HDT Airborne Systems
ben.tutt@hdtglobal.com

**Technical Program Co-Chairs**
Oleg Yakimenko
Naval Postgraduate School
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Aaron Morris
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**Administrative Chair**
Ignatius Kapp
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**Seminar Chair**
Glen Brown
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***AIAA Balloon Systems Conference***

**General Chair**
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**Technical Program Chair**
Mike Fortenberry
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***20th AIAA Lighter-Than-Air Systems Technology Conference***

**General Chair**
Brandon T. Buerge
Wichita Analytical Group, LLC
bbuerge@WichitaAnalyticalGroup.com

**Technical Program Chair**
Mark E. Beyer
Wichita Analytical Group, LLC
mbeyer@WichitaAnalyticalGroup.com

### Abstract Submittal Guidelines and Procedures

Abstract submissions will be accepted electronically through the AIAA website at **www.aiaa.org/daytona2013**. Once you have entered the conference website, click "Submit A Paper" and follow the instructions listed. Abstracts must be a minimum of 350 words, with key figures and references as necessary. The deadline for receipt of abstracts via electronic submittal is **5 September 2012, 2359 hrs Eastern Time Zone, USA**.

The electronic submission process is as follows.

1) Access the AIAA website at **www.aiaa.org/daytona2013**.
2) On the right-hand side, click the "Submit Paper" button.
3) You will be prompted to login. If you do not have an AIAA account you will be asked to create one.

4) After completing your login, you will be in the ScholarOne Abstracts submission site.

5) Click the Submission tab at the top of the page to begin your submission. Select the appropriate conference to submit to on the following page.

6) Once you have selected the appropriate conference, you will be provided with general information on the conference's abstract submission requirements and policies. To begin the submission, click the "Create a New Submission" link on the left side. *Please Note*: If you have previously visited the site and begun a draft submission, click the "View Submissions" link on the left-hand side to resume your submission.

*Special Notes*

Submitted abstracts and submission metadata may be revised, but only before the abstract submission deadline. To do so, return to the submission site, click Submission > View Submissions and then select "Return to Draft." Once in draft status, click the edit button to open the submission and make the necessary changes. Authors then must resubmit at Step 6 for the submission to be eligible for consideration.

Authors having trouble submitting abstracts electronically should contact ScholarOne Technical Support at **ts.acsupport@thomson.com**, or at 434.964.4100 or (toll-free, U.S. only) 888.503.1050. Questions pertaining to the abstract or technical topics, or general inquiries concerning the program format or policies of the conference, should be directed to the Technical Program Co-Chairs.

Authors will be notified of paper acceptance or rejection on or about **8 November 2012**. Instructions for preparation of final manuscripts will be provided for accepted papers.

## "No Paper, No Podium" and "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. 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. If a paper is not presented at the conference, it will be withdrawn from the conference proceedings. These policies are intended to eliminate no-shows and to improve the quality of the conference for attendees.

## Publication Policy

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

*Please note*: AIAA policy precludes an abstract or paper from being submitted multiple times to the same conference. Also, once a paper has been published, by AIAA or another organization, AIAA will not republish the paper. Papers being submitted to the Student Paper Competition being held in conjunction with this conference may not be submitted to the general sessions. Author(s) must choose to submit to the Student Paper Competition *OR* to the conference. If your paper is selected for competition it will be published along with the conference proceedings.

## Final Manuscript Guidelines

Detailed instructions and guidelines for submitting papers will be made available to authors of accepted papers. Authors must submit their final manuscripts via the conference website no later than **5 March 2013**.

## Warning—Technology Transfer Considerations

Prospective authors are reminded that technology transfer guidelines have considerably extended the time required for review of abstracts and completed papers by U.S. government agencies. Internal (company) plus external (government) reviews can consume 16 weeks or more. Government review if required 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. The conference technical committee will assume that all abstracts papers and presentations are appropriately cleared.

## 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.

## Travel and Accommodations

### *Meeting Site*

Daytona Beach, Florida, is famous for its beaches and motorsports, but the area also offers an abundance of shopping, nightlife, cultural events, and sporting activities, making it the perfect family vacation spot. The beaches in the Daytona Beach area are always open and free to pedestrians! Cars are allowed on the beach in designated areas from sunrise to sunset depending on tidal conditions. Major Central Florida attractions located within driving distance from Daytona Beach include Walt Disney World (74 miles), Sea World (66 miles), and NASA Kennedy Space Center (51 miles). For more information, visit **www.daytonabeachcvb.org**.

### *Hotel Information*

This event will be held at the Hilton Daytona Beach Ocean Walk Village Resort, 100 N. Atlantic Blvd., Daytona Beach, FL 32118, Phone: +1.386.254.8200. Room rates are $129 per night. Cabana rooms are available for $229 per night. There is complimentary Internet access in all rooms. When making your reservation, please identify yourself as being with the PIA/AIAA conference. These rooms will be held for AIAA until **22 February 2013** or until the block is full. After **22 February 2013**, 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 upon check-in.

### *Airport Information*

Daytona Beach is within driving distance of three airports:

Daytona Beach International Airport (DAB)—5 miles/10 minutes from the hotel
Orlando International Airport (MCO)—70 miles/70 minutes from the hotel
Jacksonville International Airport (JAX)—95 miles/90 minutes from the hotel

### *Car Rental*

Hertz Car Rental Company saves members up to 15% on car rentals. The discounts are available at all participating Hertz locations in the United States, Canada, and where possible, internationally. For worldwide reservations, call your travel agent or Hertz directly at 800.654.2200 (U.S.) or 800.263.0600 (Canada). Mention the AIAA members savings CDP #066135 or visit www.hertz.com. Don't forget to include the CDP number.

### Technical Topics

Conference sessions and accepted abstracts will be organized according to the following technical areas. Topics include, but are not limited to, the following:

***Aerodynamic Decelerator Systems Technology***

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

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

- Other: Decelerator system and components aerodynamics; structural analysis; drag characteristics and stability; scaling; flow field and wake characteristics; pressure distributions; databases, storage and retrieval; technology transfer; education; and historical aspects.

***Best Student Paper Competition***

The AIAA Aerodynamic Decelerator System Technical Committee (ADS TC) is sponsoring a Best Student Paper Competition at this year's conference. Papers are sought from students on all research topics related to aerodynamic decelerators. Draft manuscripts are required, to include a brief assessment of prior work by others, an explanation of the paper's main contributions, and appropriate figures. It must include sufficient detail to allow an informed evaluation of the paper. Up to five finalists will be selected to make presentations at the conference.

Finalists will present their papers during technical sessions at the conference and all finalists will be recognized at the conference awards dinner. All finalists will receive a $1,250 award (to offset travel expenses and conference registration) and a complimentary ticket to the awards dinner after attending and presenting their paper. An overall best paper and presentation will be selected from the finalists, and the overall winner will be presented with an additional $1,250 prize. All prizes are provided by the ADS TC.

To be eligible for the competition, the student must be the primary author of the paper and the work must have been performed while the author was a student. The student author must also: 1) be an enrolled student in January 2013; 2) be a member of AIAA; 3) present the paper at the conference; and 4) along with the final paper, include a cover letter from his/her advisor stating that the student did the majority or a significant amount of the research in question.

Students should submit their abstract by **5 September 2012** according to the regular conference rules and indicate "Student Paper Competition" at the time of electronic submittal. All student authors will be notified of their status on or about **8 November 2012**. An electronic copy of the final paper must be submitted for scoring to the competition chair, Nathan Slegers, at slegers@mae.uah.edu, by **5 February 2013**. The final paper must be submitted electronically by **5 March 2013** according to the regular conference rules. Note that the deadline for submittal to the competition chair is earlier than the conference final manuscript deadline. Scoring for the award will be equally based on written paper content and oral presentation at the conference. Questions about the ADS Best Student Paper Competition should be referred to the chair, Nathan Slegers, University of Alabama in Huntsville, at slegers@mae.uah.edu.

***AIAA Balloon Systems Conference***

The AIAA Balloon Systems Conference provides a forum for the world's leading experts, scientists, and engineers in free flight balloon systems technologies to present recent advances in the field. Technical papers are being solicited in all areas consistent with the stated purpose of the conference and that touch on any aspect of ballooning. Papers on design, analysis, projects, programs, systems, software, operations, materials, and other related topics are encouraged. Topics may range from basic research and development to applied and advanced technologies. Topics include, but are not limited to, the following:

- Modeling and Simulation: Advances in thermal analysis for pressure, temperature, and factor of safety determination; atmosphere/environment generation and modeling; model testing of new systems to verify their integrity prior to flight; design qualification; and other theoretical efforts to predict the performance of inflatable structures.
- Materials and Manufacturing: Monolayer and co-extruded film capabilities for flight vehicles; composite materials as high-strength gas barriers; high-tenacity fibers; material testing methodologies; manufacturing quality; reliability and quality assurance processes; fusion and adhesive bonding; and other advances in the development of materials and manufacturing methods for inflatable structures.
- Flight Operations: Unique flight opportunities from Hawaii, Sweden, Antarctica, and other locations around the world; over-the-horizon communication; control of balloon functions and data recovery; flight systems; flight system qualification; dissemination of flight information/data; unique range capabilities; safety considerations pertaining to launch, flight, and recovery; recent advances in the ability to control multiple missions simultaneously around the world; and other advances in balloon deployment technology.
- Balloon System Applications: Inflatable system considerations for long-duration observations in flight; new designs; deployment and operation in hostile environments; unique terrestrial and planetary missions; and use of inflatable devices for orbit insertion and other planetary activities.
- Near Space/High Altitude Opportunities: Systems that take advantage of their position in the stratosphere as a platform for remote sensing, communication, Earth observation, and satellite control for both commercial and military applications; free flight balloon projects and science overviews; and technologies that may be used to achieve station-keeping in the rarefied atmosphere between commercial airspace and low Earth orbit.

***20th AIAA Lighter-Than-Air Systems Technology Conference***

Interest in the potential of lighter-than-air (LTA) systems to meet modern requirements continues to grow as fuel prices and the cost of conventional aircraft transportation infrastructures increase. An added incentive to airship and aerostat development comes from the worldwide concern over the negative environmental effects of jet aircraft on the global climate. LTA systems have become the subject of renewed interest due to their unique qualities of low energy (propulsion) needs and significant static lift that holds potential for commercial as well as intelligence, surveillance, and reconnaissance (ISR) missions. New hybrid LTA systems that incorporate a substantial degree of dynamic lift also offer great promise for providing additional air transportation services and access to remote regions. At the same time, major advances are being made in the development of key enabling technologies essential to the creation and operation of long endurance, unmanned LTA systems. These topics and more will be explored by industry experts at the 20th AIAA Lighter-Than-Air Systems Technology Conference. The conference is seeking papers that best reflect the latest advances in LTA designs, systems development, and operations. Topics of greatest interest include, but are not limited to, the following:

- Current and Planned LTA Projects, Systems, Initiatives, and Technologies: Airship and aerostat research and development, manned and unmanned systems, and high altitude and low altitude unmanned systems.
- Missions and Concept of Operations (CONOPS) Analysis: Military support, homeland defense, commercial operations management, and cargo operations in remote regions.
- Markets and Market Analysis: Commercial, military, scientific, economic, and business analysis; market demand; and price sensitivities.
- Flight Operations and Ground Handling: Infrastructure and logistics, safety considerations, and techniques to reduce ground crew size. "Lessons learned" from past successes or failures.
- Analytical Studies and Modeling and Simulation: Vehicle and payload design analysis, advanced power and propulsion systems, CFD, aerodynamics, structural analysis, operational support models, and cost models. There is particular interest

in flight-test or wind-tunnel validated CFD, aeroelastic analysis, and gust response.
- Systems Engineering and Optimization: System analysis that highlights either the integration/design of the air vehicle, its assembly and testing, or the function of the air vehicle as a "node" within a larger system that might include other airborne or ground assets. Multidisciplinary optimization including structural, aerodynamic, and operational tradeoffs.
- Regulations and Standards: FAA, EASA, and Asian aviation regulations for LTA systems. Certification criteria, fabric tear criteria, and updated gust criteria. Unique considerations for LTA UAVs.
- Manufacturing and Material Considerations and Methods: Reliability and quality assurance processes, test methodologies (static, ground, and flight), platform design and innovations, and structural analysis.

## 23rd AAS/AIAA Space Flight Mechanics Meeting

***10–14 February 2013***
***Kauai Marriott Resort, Lihue***
***Kauai, Hawaii***

***Abstract Deadline: 1 October 2012***

The 23rd Space Flight Mechanics Meeting will be held 10–14 February 2013 at the Kauai Marriott Resort in Lihue, Kauai, Hawaii. The conference is organized by the American Astronautical Society (AAS) Space Flight Mechanics Committee and cosponsored by AIAA Astrodynamics Technical Committee. Manuscripts are solicited on topics related to space-flight mechanics and astrodynamics, including but not necessarily limited to:

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

Manuscripts will be accepted based on the quality of the extended abstract, the originality of the work and/or ideas, and the anticipated interest in the proposed subject. Submissions that are based on experimental results or current data, or report on ongoing missions, are especially encouraged. Complete manuscripts are required before the conference. English is the working language for the conference.

### Special Sessions

Proposals are being considered for suitable special sessions, such as topical panel discussions, invited sessions, workshops, mini-symposia, and technology demonstrations. A proposal for a panel discussion should include the session title, a brief description of the discussion topic(s), and a list of the speakers and their qualifications. For an invited session, workshop, mini-symposium, or demonstration, a proposal should include the session title, a brief description, and a list of proposed activities and/or invited speakers and paper titles. Prospective special-session organizers should submit their proposals to the Technical Chairs.

### Breakwell Student Travel Award

The AAS Space Flight Mechanics Committee announces the John V. Breakwell Student Travel Award. This award provides travel expenses for up to three (3) U.S. and Canadian students presenting at this conference. Students wishing to apply for this award are strongly advised to submit their completed manuscript by the abstract submittal deadline. The maximum coverage per student is limited to $1000. Details and applications may be obtained via http://www.space-flight.org.

### Information for Authors

Because the submission deadline of **1 October 2012** has been fully extended for the convenience of contributors, there are no plans to defer this deadline due to the constraints of the conference planning schedule. Notification of acceptance will be sent via email by **12 November 2012**. Detailed author instructions will be sent by email following acceptance. By submitting an abstract, the author affirms that the manuscript's majority content has not been previously presented or published elsewhere. Authors may access the web-based abstract submittal system using the link available via the official website: **http://www.space-flight.org**. During the online submission process, authors are expected to provide:

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

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

### Technology Transfer Notice

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

### No-Paper/No-Podium Policy

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

# Calls for Papers

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

**AAS Technical Chair**
Dr. Sergei Tanygin
Analytical Graphics, Inc.
220 Valley Creek Boulevard
Exton PA, 19341
610.981.8030 (voice)
Email: stanygin@agi.com

**AIAA Technical Chair**
Dr. Ryan Park
Guidance, Navigation and Control Section
Jet Propulsion Laboratory
MS 301-121
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818.354.4401 (voice)
Email: ryan.s.park@jpl.nasa.gov

All other questions should be directed to the General Chairs:

**AAS General Chair**
Dr. Thomas Starchville
The Aerospace Corporation
15049 Conference Center Drive, Suite 600
Chantilly, VA 20151
571.307.4203 (voice)
Email: thomas.f.starchville@aero.org

**AIAA General Chair**
Ms. Lauri K. Newman
NASA Goddard Space Flight Center
Mail Code 595.1
8800 Greenbelt Road
Greenbelt, MD 20771
301.286.3155 (voice)
Email: lauri.k.newman@nasa.gov

# Upcoming AIAA Professional Development Courses

**2–3 June 2012**

**The following Continuing Education class is being held at the 18th AIAA/CEAS Aeroacoustics Conference in Colorado Springs, Colorado. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.**

To register for the Aeroacoustics course, go to **www.aiaa.org/Aeroacoustics2012.**

| | Early Bird by 7 May | Standard (8 May–1 Jun) | On-site (2–3 Jun) |
|---|---|---|---|
| AIAA Member | $1278 | $1378 | $1478 |
| Nonmember | $1355 | $1455 | $1555 |

**Phased Array Beamforming for Aeroacoustics** (Instructor: Robert P. Dougherty, Ph.D., President, OptiNav, Inc., Bellevue, WA)

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

**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.

**23–24 June 2012**

**The following Continuing Education classes are being held at the 28th Aerodynamics Measurement Technology, Ground Testing, and Flight Testing Conferences, 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; and 44th AIAA Thermophysics Conference in New Orleans, Louisiana. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.**

To register for a Fluids course, go to **www.aiaa.org/NewOrleans2012.**

| | Early Bird by 29 May | Standard (30 May–22 Jun) | On-site (23–24 Jun) |
|---|---|---|---|
| AIAA Member | $1248 | $1348 | $1448 |
| Nonmember | $1325 | $1425 | $1525 |

**Perturbation Methods in Science and Engineering** (Instructor: Joseph Majdalani, Professor, Mechanical & Aerospace Engineering, University of TN Space Institute, Tullahoma, TN)

This course is a must for all engineers and scientists aspiring to develop theoretical solutions to accompany their numerical and/or experimental work. The majority of problems confronting engineers, physicists, and applied mathematicians encompass nonlinear differential/integral equations, transcendental relations, equations with singularities/variable coefficients, and complex boundary conditions that cannot be solved exactly. For such problems, only approximate solutions may be obtained using either numerical and/or analytical techniques. Foremost among analytical approximation techniques are the systematic methods of asymptotic perturbation theory. The ability to derive closed-form analytical approximations to complex problems is becoming a lost art. Numerical solvers are relied on routinely to the extent that mastery of approximation methods is becoming a desirable tool and a must among engineers and scientists, especially those aspiring to establish new theories and/or achieve deeper physical insight than may be gained on the basis of numerical modeling alone.

**Space Environment and Its Effects on Space Systems** (Instructor: Vincent Pisacane, Heinlein Professor of Aerospace Engineering, USNA, Ellicott City, MD)

This course is intended to serve two audiences. First, those relatively new to the design, development, and operation of spacecraft systems. Second, those 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.

**Turbine Engine Ground Test and Evaluation** (Instructor: Andrew Jackson, Turbine Engine Project Engineer, Arnold Engineering Development Center, Arnold AF Base, TN; and Stephen Arnold, Turbine Engine Analysis Engineer, Arnold Air Force Base, TN)

This course will explain the role of altitude test facilities in the development and sustainment of turbine engine technology. Examples of altitude test programs will be reviewed to highlight the cost and risk reduction potential of the altitude test. A description of the Arnold Engineering Development Center's Engine Test Facility (EFT) will illustrate the complexity of the facilities required for a successful altitude test. The importance of pretest planning and program management to produce meaningful results will be discussed and will be a major subtext throughout the course. The critical measurements that are required in the altitude test will be described at an intermediate level. The role of engine models in support of test planning, data validation, and data analysis will be discussed. The importance of estimating data uncertainty and confidence level of test results through sound application of statistical techniques will be presented.

**Stability and Transition: Theory, Experiment and Modeling** **(Instructors: Hassan A. Hassan, Professor, Aerospace Engineering, NC State University, Raleigh, NC; Helen Reed, Department of Aerospace Engineering, Texas A&M; William Saric, Department of Aerospace Engineering, Texas A&M)**
The course is comprehensive covering fundamentals, experiments, modeling, and applications dealing with stability and transition.

**Computational Heat Transfer and Thermal Modeling** **(Instructor: Dean Schrange, Development of Commercial-grade Simulation Software, Research and Development in Thermal and Fluid Management, Strongsville, OH)**
This CHT (Computational Heat Transfer) course provides a singular focus on the thermal modeling and analysis process, providing a unique perspective by developing all concepts with practical examples. It is a computational course dedicated to heat transfer. In the treatment of the general purpose advection-diffusion (AD) equation, the course material provides a strong introductory basis in CFD. The course couples the computational theory and practice by introducing a multistep modeling paradigm from which to base thermal analysis. Six lectures form a close parallel with the modeling paradigm to further ingrain the concepts. The seventh lecture is dedicated to special topics and brings in practical elements ranging from hypersonic CHT to solidification modeling. The course is also designed around an array of practical examples and employs real-time InterLab sessions. The course has a strong value added feature with the delivery of a general purpose CHT-CFD analysis code (Hyperion-TFS) and a volume Hex Meshing tool (Hyperion-Mesh3D).

**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.**

**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.

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 |

**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.

# 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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