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March 2012

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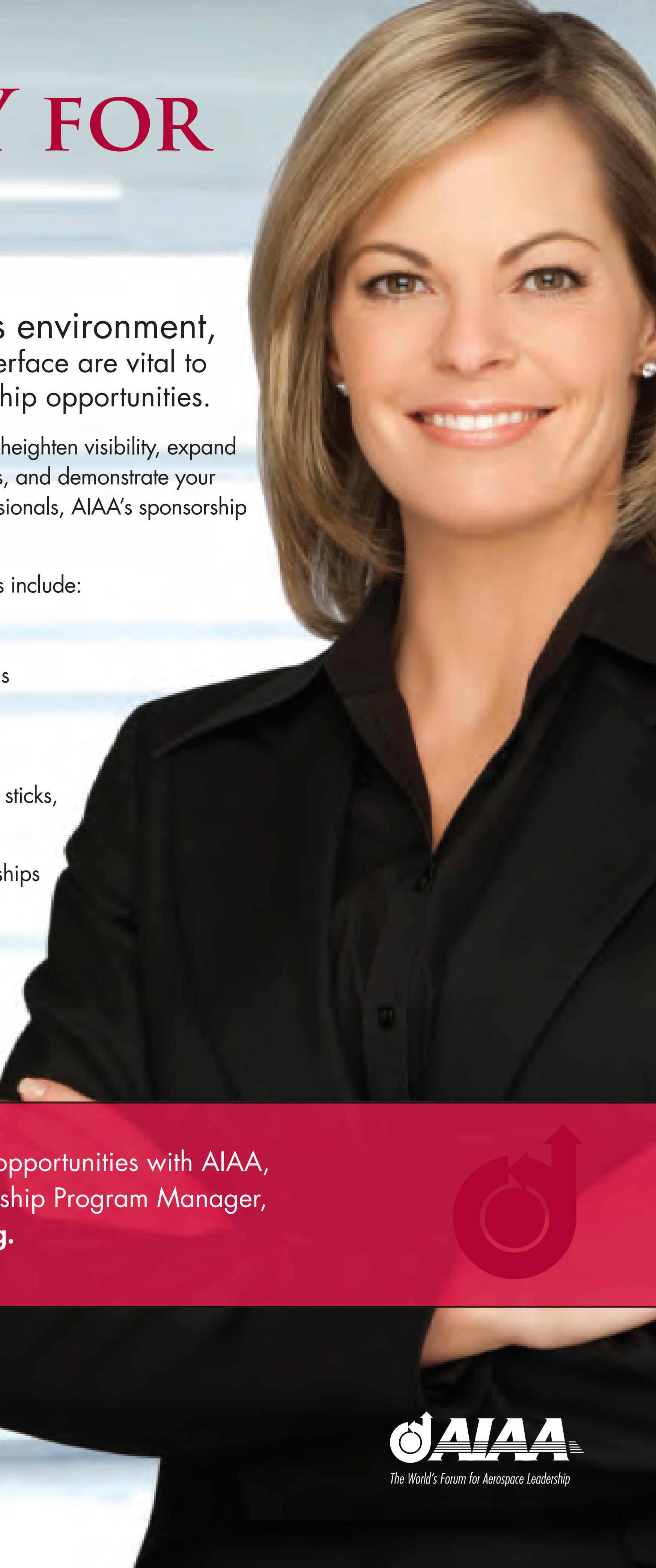

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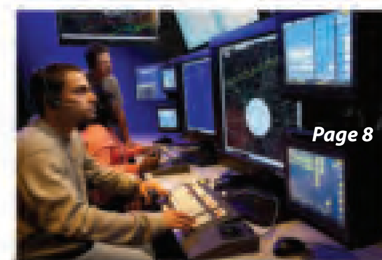
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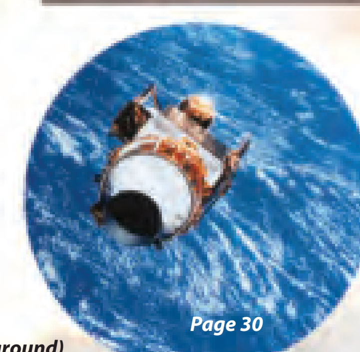
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EAs the development of satellite services grows at an astounding pace, the availability of frequency spectrum at the most commonly used bands is shrinking. Turn to page 30 to learn about the real estate being occupied at higher frequency bands.

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Editorial

The budget-go-round

In a deeply politically charged atmosphere, and with the countdown clock to the presidential election ticking so loudly very little else can be heard, President Barack Obama released his FY13 NASA budget request. Although more stalking horse than final outcome, it is, for the most part, less-than-stellar news.

In submitting his FY13 request, President Obama asked Congress for $17.7 billion for NASA, leaving the agency funded at its lowest level in four years. Just about everyone has something bad to say about it, but in these austere times, there is some good news: It's "not as bad as it could have been."

One of the few big winners in this budget cycle is commercial spaceflight. Funding for commercial crew vehicle development, at $830 million, is more than twice last year's allocation, underscoring the president's commitment to having private companies provide future transportation to the international space station. And despite slightly lower numbers, funding for the Space Launch System, to develop a rocket for travel beyond low Earth orbit, and the multipurpose crew vehicle remained sufficient for work to continue. Nothing, however, seemed to promise a chance to speed up the return of a U.S. capability to provide astronaut transportation before about 2017.

Funding for the James Webb Space Telescope program fared quite well. Despite being plagued with cost overruns, its funding rose over 20%, in the hopes, perhaps, of it finally reaching completion. Some Earth science programs also withstood the budgetary axe, and their overall budget saw a slight increase.

But losers outpaced winners. NASA's planetary science division, for example, saw its numbers take a steep fall. Under the proposal, the division's budget would drop from $1.5 billion to $1.2 billion, a reduction of 20%. With the agency's recent retreat from the joint ESA/NASA ExoMars program, messages from Curiosity, still on its way to Mars, may be the last we hear from our neighboring planet for years to come. Both lunar science and outer planets studies also suffered deep, if not mortal, wounds.

And NASA aeronautics, once again, came in on the losing end. While the budget numbers may be only a few percentage points lower than last year's allocation, the FY12 budget was already so low, any decreases are painful. Particularly hard hit was fundamental aeronautics, down from an already scant $186.3 million to $168.7 million. Once playing a leading role at NASA, it seems that aeronautics in recent years has become the agency stepchild.

All of these numbers are, of course, just a jumping off point. Each of the directorates has its champions, just as each center has members of Congress ready to proclaim its virtues and try to protect its particular strengths. But while there will be a push to rearrange the allocations, it will be primarily an effort to take money from one NASA pocket and place it in another. There is little expectation that, in the end, the total numbers will be any higher than they are now. And some fear they may fall even further.

This year the budget debate holds a particular irony. Fifty years ago, just one week shy of the date the budget was released, John Glenn became the first American to orbit the Earth, when he circled the globe three times aboard Friendship 7. What will we be able to look upon with wonderment and pride 50 years from now?

Elaine Camhi
Editor-in-Chief

U.K. and France fuse strategic missile capabilities

This year, the governments of France and the U.K. are due to announce a joint procurement contract for France's anti-navire leger (ANL), or light antishipping, missile and the U.K.'s future air-to-surface guided weapon (heavy), or FASGW(H). This will mean two requirements but a single product. Its genesis can be traced back to a March 2008 Franco-British meeting in London, where the two nations agreed to develop a common solution to their different requirements for long-range guided missiles.

MBDA, which is leading the missile's development, intends to have the weapon available for full-scale evaluation by 2013, with a projected initial in-service date of around 2016—depending upon when the production contract is announced. The end product will be a modular 100-kg-class weapon based on the reuse of proven technology. Intended to replace the U.K.'s venerable and combat-proven Sea Skua weapon, FASGW(H) builds on its progenitor's characteristics but has almost double the effective range.

The ANL is for a new requirement, intended for use from Panther and NH90 helicopters. The missile's primary target will be fast-attack craft up to corvette size, and it will have much better aim-point selection capabilities than the Sea Skua. A constantly updated target is transmitted via data link to the operator, who can then select the point of impact, resulting in more attacks of greater precision. Operators will also be able to decide whether to destroy or merely damage the target.

New industrial strategy

What may be even more remarkable about the FASGW(H)/ANL, however, is the new multinational industrial process being developed in Europe to deliver such a complex, strategically important technology.

MBDA was formed in 2001 by the major missile manufacturing companies of France, the U.K., and Italy. It is now jointly owned by BAE Systems (37.5%), EADS (37.5%), and Italy's Finmeccanica (25%). Following the Lancaster House agreements signed in London on November 2, 2010, France and the U.K. agreed to pool strategic military capabilities to an unprecedented degree, and the new missile will be one of the first major complex weapons to emerge from a new Anglo-French military industrial strategy.

The ANL is intended for use on NH90 helicopters.

"Until the Lancaster House agreement, we used to cooperate on a program-by-program basis," according to MBDA's Jean Dupont. "But since the agreement was signed we are now working to cooperate on a company scale. This means that MBDA will be restructured around a dozen centers of excellence, some in the U.K. and some in France, so we can make real savings around our multinational capabilities. This is only possible because the U.K. and France have decided to mutually rely on certain common aspects of their sovereign military capabilities."

Guided weapons technology is one of the ultimate strategic military assets a country can possess, and the decision to offload even part of this capability to a neighbor is not one that is taken lightly.

"The objective is to make a combined acquisitions and development policy by both countries so we can realize savings of up to 30% in the development, production, and support of these complex weapon systems," says Dupont. "These economies simply can't be obtained without setting up specialist centers throughout our multinational organization."

Team solution

The agreement between the French and U.K. governments with MBDA is a solution to the problem all governments face when confronted with the issue of retaining and funding a strategic technology capability without a number of long-term programs that

A Schiebel S-100 Camcopter is fitted with an LMM on display at Farnborough Airshow 2008.

commercially justify the investment. The need for the military to undertake operations with the minimum potential for collateral damage is an increasingly political concern; for industry, this means expensive and long-term research into increasing the precision, modularity, flexibility, and cost-effectiveness of these weapon systems.

The U.K.'s solution to this problem has been the team complex weapons (TCW) concept, part of the 2005 Defence Industrial Strategy set out by the U.K.'s Ministry of Defence. The TCW initiative nominated the core strategic technologies that the MOD wanted to keep within the U.K. and then teamed with industry partners down the supply chain to ensure that the technology and cost aspects of future complex weapon systems were kept on track. Within the TCW concept, six weapon systems have been identified for this approach.

According to a 2010 report from the RUSI (Royal United Services Institute), a U.K. military think tank, "MOD and MBDA signed a long-term partnering arrangement for the development and supply of new complex weapons (CW) to the U.K. Armed Forces to counter current and future threats. Under the interim Portfolio Management Agreement (PMA-I), MBDA will lead the transformation of the U.K.'s CW capability through the management of a portfolio of complex weapon projects potentially worth up to £4 billion over the next 10 years.

"To launch this arrangement, MBDA has signed a contract, worth some £330 million, for the first package of projects focused on deployment of new military capabilities into Afghanistan. Over the next 10 years, as further military capabilities are added, this portfolio approach will deliver efficiencies assessed at £1.2 billion for the U.K. MOD," says the report.

The benefits to the ministry have been complete financial and technical transparency down the supply chain. For the supplier, it has meant long-term funding and program commitments are also secured, allowing the companies to allocate their design, development, and production resources more efficiently. A similar process is now under way in France. This, coupled with the transformation of MBDA as a result of the 2010 Lancaster House agreements, should lead to further savings.

"Until now the transfer of strategic technologies between different MBDA countries has been subject to the same export license rules that cover technology transfers to other European countries. With the agreement to set up multinational centers of excellence, that will change," explains one MBDA official.

"There's been a fairly strong consensus that TCW has performed well," according to John Louth, senior research fellow and deputy head, defense, industries, and society at RUSI. "The proof of the pudding has been that TCW has been extremely responsive to the front-line needs in Libya, and the indications are the TCW companies have been prepared to work outside of contract to supply the front-line services there."


In the maritime role, the FASGW(L) version of LMM will be deployed on the Wildcat Lynx.

The challenge of politics

The biggest challenge to the future integration of the U.K./France partnership in the development of precision-guided missiles is that the political differences between the two countries might strain the industrial ties. Early this year the political leaders of both countries were locked into a series of disagreements on support to the Euro and the wider future of the EU.

The worry is that future strategic disagreements on defense policy by the two countries could lead to a fissure in the industry partnerships.

"Such high-level disagreements mask the much closer understanding that is taking place between France and the U.K. at an industrial level," says RUSI's Louth. "In terms of complex weapon systems they are working more closely together, and I expect to see this relationship go even further in the near future."

Rethinking requirements

Operational requirements that have evolved from low-intensity conflict and peace support operations in theaters such as Iraq and Afghanistan have driven the development of new tactics and new weapon systems characteristics. Modern air power requires modular weapons flexible enough to be used for multiple missions and accurate in the delivery of lethal effect to precisely located targets.

This has meant the designers and developers of air-to-surface weapons have had to rethink operational concepts, to reengineer guidance and lethality systems, to seek commonality in operational performance between different systems wherever possible and, finally, to repurpose existing systems and developmental items to minimize the need for added investment.

Another TCW project to incorporate the requirements is the FASGW(L) program, led by Thales UK, which has based its offering on its lightweight multirole missile (LMM) system. Unveiled in 2007, the LMM family of weapons addresses the requirement for a multirole, multiplatform missile in which low unit cost is the driving factor. Laser-guided, the LMM will initially rely on beam-riding technology; but a later version incorporating semiactive laser guidance will be offered, according to the TCW project. Last April Thales UK and the MOD agreed to 're-role' previously contracted budgets to facilitate the full-scale development, series production, and introduction of the LMM into service.

The contract included the design, development, and qualification of the laser beam rider version of LMM, production of an initial delivery of 1,000 LMM units, and the development of a precision guidance system that will deliver a highly accurate performance against static and mobile targets, and with low collateral damage.

A key aspect of the design is a multirole capability. In the maritime role, the FASGW(L) version of LMM will be deployed on the Wildcat Lynx helicopter platform. In a ground-to-ground role, LMM's dual-effect warhead (blast fragmentation and shaped charge) will make it suitable for a wide range of ground targets, including light/medium armor. And in an air-launched role, new alternative warheads will be developed, including seekers with a semiactive laser (SAL) version for precision strike surface attack roles. FASGW is designed to enable the Wildcat to defeat difficult targets in a complex littoral and maritime environment. Typical threats could be from fast inshore attack craft up to and including corvettes.

In December 2011, Thales UK was awarded an extension to the assessment phase contract to run from December 2011 to July of this year. The purpose of this extension was, in parallel with partners AgustaWestland and MBDA, to provide a full pack of information moving to a final decision on full-scale design and manufacture. In addition to the FASGW program, Thales UK plans to pursue other opportunities with Wildcat in both U.K. and overseas markets.

Storm Shadow and Brimstone

At the higher end of the effects ladder, MBDA's Storm Shadow/SCALP standoff weapon system is a good example of how developing requirements have driven system evolution. With a range in excess of 250 km, an overall length of around 5 m, and an all-up weight in the 1,300-kg class, Storm Shadow has been in development and production since the MOD awarded a £980-million contract to MBDA in 1997.

The RAF's requirement for Storm Shadow was to mount the weapon system onto the Tornado GR4 force as well as the Eurofighter Typhoon fleet. Integration onto the F-35 Lightning II to be acquired by the U.K. armed forces is also a requirement. At the same time, the French air force and navy called for the SCALP variant of Storm Shadow to be integrated onto Mirage 2000D and Rafale airframes. The French air force and navy conducted a joint long-range SCALP strike on an unnamed Libyan air base in March 2011. It was the first use of these missiles by French forces.

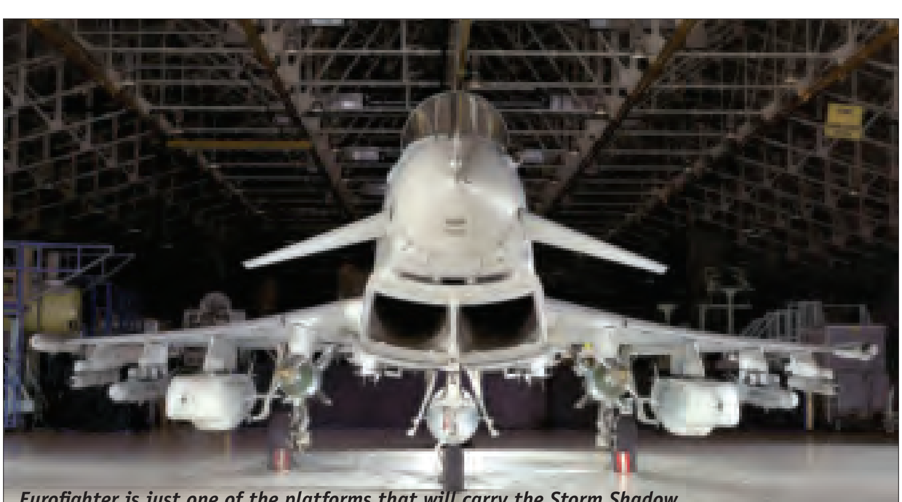
Italy, which joined the program in 1999, has sought to equip its Tornado and Typhoon aircraft with the same capability. Greece placed orders in 2000 and 2003 for Storm Shadow, with the intent of placing the system on its Mirage 2000-5 Mk. 2 aircraft.

Storm Shadow's design characteristics illustrate the complexity of modern air-launched weapon systems. The missile, released at medium altitude, flies to its target at very low altitude, thus reducing its potential vulnerability to radar detection. Initial guidance and midcourse corrections are provided by a mix of systems—principally forward-looking digital terrain profile matching, backed up with GPS and inertial measurement unit data from the launch platform. This use of multiple systems, though it adds to system complexity, contributes significantly to the twin objectives of high terminal accuracy and robust resistance to a wide variety of countermeasures.

In the terminal phase, high precision guidance is provided by imaging infrared sensors coupled to an automated target recognition system, in which images of the target on final approach are compared with images in a target library downloaded prior to launch. The result is a highly accurate weapon system, one whose perforation and explosive warhead enables commanders to bring powerful effect to bear on high-value targets at standoff distances, increasing launch platform survivability.

Storm Shadow saw its combat debut in 2003 with the RAF during Operation Iraqi Freedom and has been in service with the French armed forces since 2004. Between 20 and 30 Storm Shadows reportedly were fired by Italian Tornado IDS aircraft during the Libyan conflict.

The automated target recognition system on Storm Shadow, although a powerful asset, requires a degree of recognition and preparation that may not always be possible, given the types of conflicts many armed forces now face. An alternative answer, from



Eurofighter is just one of the platforms that will carry the Storm Shadow.

Brimstone is modular and sufficiently flexible to fulfill a number of different missions without ground-based intervention.

the development perspective, is to create a weapon system that is modular and sufficiently flexible to fulfill a number of different missions with no need for ground-based intervention.

In Libya the RAF used two forms of its radar-guided Brimstone air-to-surface missile. GEC Marconi (ultimately absorbed into MBDA) won the contract for the initial 'fire and forget' Brimstone system in 1996, and the missile went into service on RAF Tornado GR4s in 2005. It employed a millimetric wave (MW) radar seeker, originally designed to knock large tank formations. MBDA was given a contract by the MOD under an urgent operational requirement in 2007 to develop a more precise version of the system using a SAL guidance system, new energetics, and a new airframe with an insensitive munition-compliant warhead.

"This allows a flight crew to designate targets after the missile has been launched," says Brimstone market development executive Cliff Kimpton, "giving it the ability to target more agile, faster moving targets more precisely." MBDA is now converting many of the original MW units to a dual-use capability—MW and SAL.

The complexities of the weapon systems currently under development, the political pressures for more precision, and the economic pressures bearing down on French and U.K. governments are all pushing the weapons manufacturing and development capabilities of the countries closer together. Despite the newspaper headlines, it is a process that will likely intensify over the coming months and years.

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Correspondence

With my compliments to Richard Aboulafia's able analysis of the "national fighters" (**Indigenous fighters make an unexpected return**, January, page 20), but in reference to the five "reasons why and why not," I suggest that the fundamental notion underlying the 'indigenous fighters' may be simply that it is the thing to do for a nation, whether it ultimately equips its air power with its own combat aircraft or by procuring others'.

'National prestige,' indeed, of a militarily able but, more important, technically astute, air power underscores the nation's ability to survive in the modern world. And being engaged in fighter design and development gives the nation that 'prestige' and substantiating 'industrial strategy' edge, as does the possession of aircraft carriers to any world-class naval nation.

Dissolution of the bifurcated superpowers' control in the Cold War left all nations of the world, major and minor, in a precarious free-for-all coexistence. In the absence of clear and immediate oversight, rebuttal, reprisal, or even consent of the world as a whole, every nation has had to reinstitute its stand as to protecting its independence, sovereignty, and bound. That meant the military power, including air power, of a nation must serve to defend that independent entity, albeit within the respective particular geostrategic and geopolitical locale.

Japan's constitutionally established 'self-defense forces' typify this literally defensive posture of nations, where globalized economic competition has effectively replaced classic all-out world wars.

These widely varying and shifting localized defense needs defy staid specifications of 'world-class' aircraft or of high-low mix, let alone cookbook predictions of continuously advancing systems and technologies and correspondingly generated new mission modes and capabilities. Again, being engaged in the process of R&D and industrial strategy would give a nation the confident shortest route to an eventual build-or-procure decision.

Japan's obviously geopolitical decision for the F-35 would include industrial benefits of airframe assembly and parts building and exporting (*Aviation Week,* January 2, page 26). India's negotiation with Russia to factory-build the latter's Sukhoi T-50 'fifth-generation fighter' prototype would advance India's indigenous fighter industrial technology base.

An interesting contrast may be China's characteristically closed diplomacy and its equally characteristic reverse-engineering approach to technology advance. China's development of a 'national fighter,' be it the Russian Su-33-based carrier-operation fighter Jian J-15 or the just test-flown J-20 'fifth-generation' stealth fighter, may have a long way to go.

Aboulafia is right: Indigenous fighters "are going nowhere." But maybe they were meant to serve their 'indigenous' nations' need for a defense posture in the new world.

Thomas S. Momiyama
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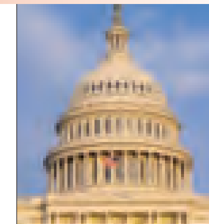
Reply by author: Thomas Momiyama makes a very good point. The post-Cold War world has redefined notions of national security. Many more countries now feel the need to demonstrate, to themselves and to others, a level of industrial and technological skill commensurate with combat aircraft design and manufacture. Of course, pursuing a fighter with this rationale still gets a government away from meeting the needs of its pilots.



An end to (some of) the waiting

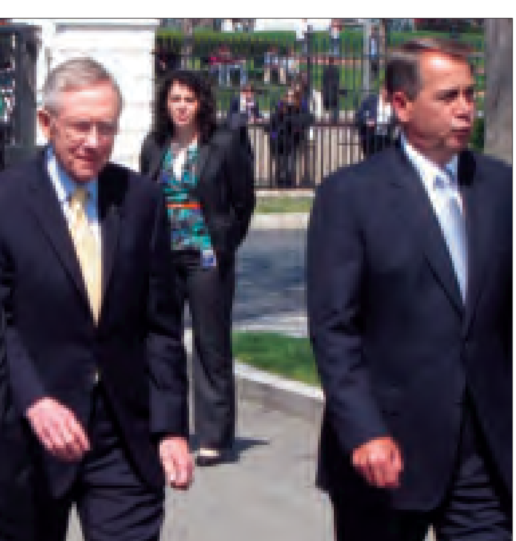
In Washington, lawmakers finally enacted the long-awaited long-term funding for the FAA. At the same time, the TSA is taking a good look at how it handles certain general aviation aircraft, and the F-35 may be out of the doghouse. And finally, the DOD offers a glimpse of President Obama's defense budget.

Test beds such as the NextGen Integration and Evaluation Capability lab at the FAA's William J. Hughes Technical Center help validate the effectiveness of NextGen advances.

FAA funding: Gridlock over?

On January 20, House Speaker John Boehner (R-Ohio) and Senate Majority Leader Harry Reid (D-Nev.) announced a deal to end a bitter labor dispute that has blocked a full-fledged FAA funding bill. The deal will end five years of short-term funding extensions that have created uncertainty at the agency, led to nearly 4,000 federal workers being temporarily furloughed last summer, and jeopardized the timeline for the much-delayed, very complex $40-billion NextGen air traffic system.

The agency that oversees civil and commercial aviation will still face challenges, and has been without a boss since the December 6 resignation of J. Randy Babbit.



Senate Majority Leader Harry Reid and House Speaker John Boehner.

The labor dispute involved a ruling that would make it easier for certain airline employees to unionize. House Republicans wanted to undo the ruling, issued by the National Mediation Board (NMB), which said that airline unionization efforts should be decided by a majority of those who vote. The ruling negated a long-standing rule that said eligible voters who opted not to vote would be counted as voting against unionization.

The compromise applies narrowly to the Railway Labor Act, which governs airline unionization, and will require a public hearing before the NMB makes future rulings. The NMB is an independent agency that coordinates labor-management relations within the airline and railroad industries; it is not a component of the FAA.

The compromise drops labor requirements that may have made it harder for workers to join a union. The deal, says Reid, "will change the way union elections are contested if the first ballot does not show a clear winner. Instead of a runoff between the top two unions vying to organize a firm, the top two options would be on the runoff ballot."

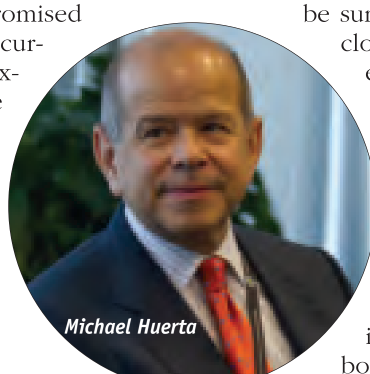
Jeff Foust at spacepolitics.com wrote on January 21 that a new FAA authorization bill "could resolve an issue for the commercial human spaceflight community: a provision in the Commercial Space Launch Amendments Act of 2004 that limits the ability of the FAA to pass safety regulations for such vehicles." The provision is set to expire this year unless new rules covering safety for spaceflight vehicles find their way into the bill.

As for NextGen, the air traffic and navigation system meant to take the nation's airways into the digital era, the FAA has begun a pilot program to introduce new airspace management techniques in Washington airports. The next step may be a source selection of an air-to-ground data communications network, a move expected from the FAA in June. But nationwide implementation of the NextGen air traffic system will require stable budgeting, plenty of money, and close cooperation between the FAA and the airport and airline industries.

There is also a need for enduring institutional knowledge: Toni Trombecky, the soon-to-retire FAA manager of strategic planning, told business leaders in Washington that FAA professionals are "making uninformed decisions" because they lack the institutional knowledge their predecessors once had. Trombecky suggested that large-scale retirements of experienced FAA workers might be undermining the overall efforts of the agency. Like everyone connected with civil aviation, she would like the FAA to return to a traditional budgeting process.

Congress has been forced to pass 22 short-term extensions allowing the FAA to operate since the last long-term legislation expired on September 30, 2007. While agency workers looked to Capitol Hill for the promised long-term solution, the current short-term funding extension was set to expire on January 31.

FAA Deputy Administrator Michael Huerta is the acting administrator; as yet, no nominee has been named for the top job.


Michael Huerta

LASP lament

The Transportation Security Administration plans to revive its Large Aircraft Security Program (LASP), which was put on hold several years ago after protests from advocates for general aviation (GA).

TSA says LASP is the key to providing needed additional security for GA aircraft—planes used for private and executive flying. The program will be rolled out in the spring even though the inspector general (IG) of DHS, which oversees TSA, published a report concluding that GA poses little threat to national security. The IG found that terrorists are more interested in large airliners, which can be used as cruise missiles, as they were on September 11, 2001.

When the TSA announced LASP in its original incarnation in October 2008, the agency threatened to ground every GA aircraft with a maximum takeoff weight exceeding 12,500 lb unless the operator adopted a security plan patterned on the screening performed at commercial airports. The new version of LASP is expected to be less stringent. TSA Administrator John Pistole now talks of 'risk management' rather than 'risk elimination.'

But details will not be known until the plan is released. Until then, business executives, medical personnel, athletes, and the wealthy, who have been flying on GA airplanes for decades, will be apprehensive about how LASP may affect them. Business leaders say executive flying saves valuable time, while others prize the privacy and convenience of their GA aircraft.

While no one in Washington will be sure until details are disclosed, officials reportedly intend to drop a requirement that they once proposed under which a GA flyer would have his name checked against a no-fly list, face restrictions carrying tools and sporting equipment on board—even if he owns the plane—and be required to reserve a seat for a federal air marshal.

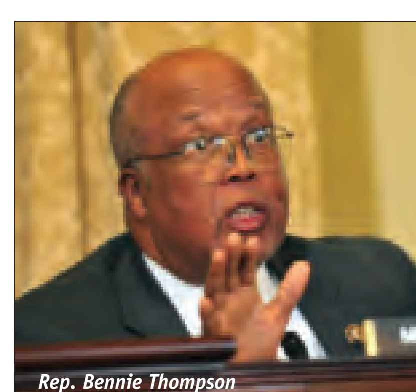
Even if these requirements do not survive the latest version of the program, LASP is viewed by many as an unfunded mandate for cash-strapped local governments to build new facilities at GA airports. But before LASP becomes reality, TSA runs up against a congressional body, the General Aviation Caucus, which includes 169 members of the House of Representatives and 36 senators.

Rep. Bennie Thompson (D-Miss.) says LASP is not suited to GA aircraft and should not go forward without industry input. Thompson urged Homeland Security Secretary Janet Napolitano to withdraw LASP and work collaboratively with the aviation industry to find "more efficient" means of achieving security goals. A common complaint by lawmakers on both sides of the aisle is that TSA takes decisions without seeking the input or expertise of citizens and interest groups.

"Congress created TSA 10 years ago to be a lean, risk-based, adaptive agency, responsible for analyzing intelligence, setting security standards, and overseeing the nation's transportation security structure," said Rep. John L. Mica (R-Fla.), chairman of the Transportation and Infrastructure Committee, in a statement. "Unfortunately, TSA has lost its way."

Mica added, "TSA has strayed from its security mission and mushroomed into a top-heavy bureaucracy that includes 3,986 headquarters staff making $103,852 per year on average, and 9,656 administrators in the field. Currently, TSA has 65,000 employees. Unfortunately, over the past 10 years, the agency has spent $57 billion on numerous operational and technology failures."

According to Craig Fuller, president of the Aircraft Owners and Pilots Association, there has never been a terrorist incident involving GA aircraft in the U.S. AOPA opposes LASP and fears it could cripple airports, close aviation businesses, cost jobs, and damage the overall health of the economy in communities nationwide.


Rep. Bennie Thompson

F-35B: Out of the penalty box

Defense Secretary Leon Panetta announced on January 20 that he was ending 'probation' of the short takeoff/vertical landing (STOVL) version of the JSF, the F-35B. To remove the restrictive status tacked to the aircraft by his predecessor, he traveled to the naval air test center at Patuxent River. He appeared with Marine Corps Commandant Gen. James F. Amos in front of an F-35B.

"We need to make sure we are on the cutting edge," said Panetta. He called JSF "absolutely vital to maintaining our air superiority," but insisted it is important "to get this right." The aircraft behind Panetta was one of two that had just completed sea trials aboard USS Wasp, one of 11 Navy assault ships that would be effectively left without a mission if the Marines did not have a STOVL fighter.

Critics of the aircraft, which has been plagued by cost increases and technical delays, wondered if a simple announcement might have sufficed in lieu of the somewhat flashy presentation. They were given more ammunition a few days later when the Pentagon issued a release reporting that the land-based F-35A model had made its first night flight. Bill Sweetman of the trade journal *Aviation Week & Space Technology* wrote that in 40 years of covering defense he had never before seen an aircraft's first night flight treated as news.

The end of probation marked the latest evidence of what many in Washington view as a fundamental change in the secretary. In earlier government posts, he was viewed as a fiscal hawk, rigorously scrutinizing ledgers and always ready and eager to cut costs. He may have been chosen for his current job for that reason. But since becoming Pentagon boss, Panetta has been unusually vocal in warning against any reduction in defense spending. Observers who expected him to cancel the aircraft now say that will not happen. On the day of his Patuxent River appearance, Panetta had a separate meeting with 40 U.S. aerospace industry executives and vowed to try to protect vital programs.

On January 20, Secretary of Defense Leon Panetta announced that the F-35B was off "probation."

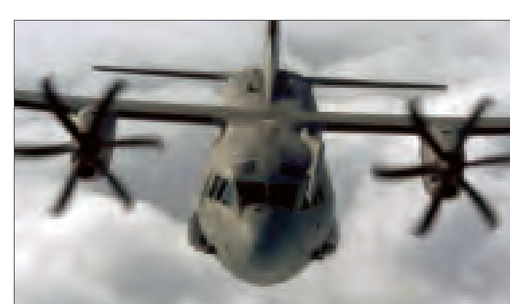
Panetta's announcement is a boost for advocates of the JSF, who say its stealth qualities and versatility are needed to wage modern war. But skeptics were quick to point out that the decision by former Defense Secretary Robert Gates to give the F-35B two years to improve, and Panetta's announcement that it had done so in just one year was mostly an inside-the-Beltway phenomenon. Writing in *DOD Buzz*, the online defense and acquisition journal, Philip Ewing said that Gates "wrote a big check he knew he'd never have to cash" by suggesting that the F-35B could face possible cancellation.

Panetta praised the Patuxent community for demonstrating "real progress" in testing the STOVL aircraft during 2011. And the decision was hailed by partner nations in the JSF program. Julian Fantino, Canada's associate minister of national defense, called the move "welcome news for Canada and our allies' participation in the multinational Joint Strike Fighter development program."

The defense budget rolls out

On January 26, Panetta revealed details of the president's proposed defense budget for FY13, which begins October 1. The proposal is an acknowledgement of the nation's fiscal crisis and a first step toward cutting $487 billion in defense costs over the next dozen years. The plan calls for a leaner, more specialized military force with fewer people in uniform and smaller buys of new equipment. It will face critics on Capitol Hill from two flanks—those who want to protect industry in their home districts and those who say the plan does not go far enough to address deficit and debt.

The plan makes no changes in one of the biggest chunks of the defense budget—military entitlements, including pay and benefits and especially the rapidly increasing cost of military pensions, known in military language



Among the announced cuts in the president's FY13 defense budget is the divestiture of 38 C-27J Spartan tactical airlifters.

as retired pay. Both the executive and legislative branches have been reluctant to tackle an arrangement that permits military members to retire after 20 years of service, even though all projections show the arrangement to be unaffordable.

The 2013 base budget, which totals $525 billion when overseas war costs are not included, is $6 billion less than what was approved by Congress for the current fiscal year.

The plan's proposed savings "will impact all 50 states and many…congressional districts across America," said the secretary. He added that so-called spending cuts are really only reductions in projected growth, not actual reductions in current spending. Nonetheless, the secretary acknowledged his budget plan "obviously will cause some pain."

Among the changes:

• The U.S. will have the capability to put fewer boots on the ground; the Army and Marine Corps will be downsized by a combined total of nearly 100,000 troops.

• F-35 purchases will be cut by 179 airplanes between now and 2017, although the long-term plan to acquire 2,443 will remain unchanged.

• The Air Force's RQ-4B Block 30 Global Hawk UAS, which had been slated to replace the U-2 Dragon Lady manned reconnaissance aircraft, will be canceled. The service life of the U-2, whose initial design dates to 1955, will be extended.

• The DOD will 'divest' itself of 38 C-27J Spartan twin-engined tactical airlifters. Although the inventory of these planes is modest, they equip half a dozen Air National Guard units, where hometown and state-capital support is strong. So far, it is unclear whether some other aircraft will be provided to equip Guard C-27J bases.

Panetta also wants to retire about 10% of the USAF fighter force, scale back procurement of the Navy's Littoral Combat Ship, and ease spending on regional ballistic missile defense.

The secretary and his advisors say the U.S. is not abandoning its long-time policy of being able to handle two wars at once. One Pentagon officer said the U.S. will still be able to blunt an attack by North Korea while also assuring the flow of oil tankers through the Straits of Hormuz.

Some observers say the nation has never really had a capability to handle two major conflicts simultaneously, and point to the near exhaustion of the armed forces and the need for a reboot after a decade of fighting in Iraq and Afghanistan.

Officials say U.S. military operations will be characterized by focus and precision, not brute force. Supporters of the budget proposal point out that the armed forces will still be at about their size on September 11, 2001, while detractors note that the nation will have fewer troops than at the time of Pearl Harbor.

A vigorous debate is likely in Congress this spring and summer.

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

Events Calendar

MARCH 3-10
2012 IEEE Aerospace Conference, Big Sky, Montana.
Contact: David Woerner, 626/497-8451

MARCH 20-21
Congressional Visits Day, Washington, D.C.
Contact: Duane Hyland, 703/264-7558; duaneh@aiaa.org

MARCH 21-23
Nuclear and Emerging Technologies for Space 2012, held in conjunction with the 2012 Lunar and Planetary Sciences Conference, The Woodlands, Texas.
Contact: Shannon Bragg-Sitton, 208/526-2367; shannon.bragg-sitton@inl.gov

MARCH 26-28
3AF 47th International Symposium of Applied Aerodynamics, Paris, France.
Contact: Anne Venables, 33 1 56 64 12 30; secr.exec@aaaf.asso.fr

MARCH 26-28
Tenth U.S. Missile Defense Conference and Exhibit (SECRET/U.S. ONLY), Washington, D.C.
Contact: 703/264-7500

APRIL 23-26
Fifty-third AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference; 20th AIAA/ASME/AHS Adaptive Structures Conference; 14th AIAA Nondeterministic Approaches Conference; 13th AIAA Gossamer Systems Forum; 8th AIAA Multidisciplinary Design Optimization Specialist Conference. Honolulu, Hawaii.
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

Mark T. Maybury

How do you see your job?

My job hasn't changed much since it was created after World War II. The chief scientist provides independent, objective advice to the secretary and the chief of staff of the Air Force and to other leaders on a broad range of S&T [science and technology] topics such as energy, cybersecurity, propulsion, remotely piloted aircraft [RPAs], resiliency of the force, space, and so on. My job is essentially to be the S&T spokesperson and also the trusted advisor to the Air Force leadership.

Your office has no budget to speak of. How does that work?

Having no 'skin in the game,' so to speak, actually frees me to do my job properly. I have no bias toward any particular Air Force program or activity other than science itself. My job is to look out for the Air Force from the S&T standpoint, to enable its leaders to anticipate developments and avoid surprises five, 10, or 15 years from now. That is an important aspect of my office.

What is your office involved in right now?

When I came into office, I spent time going through the Air Staff, looking all across the Air Force, identifying the S&T topics that I thought were most strategic. The chief of staff asked me to focus on relatively few, including energy, cyber, and RPAs. Those involve many hot topics in science and technology.

Let's begin with energy. Why all the latter-day emphasis on energy as a top S&T priority?

Because in order to fly and shoot and drop bombs and do everything else it has to do, the Air Force needs lots of energy. That's why we carefully chose our words 'assured energy advantage'—because we believe that energy is a center of gravity in battle that involves not only aircraft but naval ships, armored vehicles, you name it. Energy is of paramount importance to the warfighters. Unfortunately, our enemies and potential enemies know this, too. At least one has specifically said that our energy supply will come under attack.

"Energy is of paramount importance to the warfighters. Unfortunately, our enemies and potential enemies know this, too."

How would this happen?

Our enemies could attack our energy supply physically, with kinetic weapons, by cyber, or by human sabotage. To give you a sense of how urgent it is to protect our energy supplies, we have brought home in body bags more than 3,000 uniformed men and women and contractor personnel who were engaged in protecting our convoys, which are 80% water and fuel. The good news is we are now building water plants in theater—in CENTCOM—as an alternative to convoys. But the bad news is we still have to truck in the fuel that enables us to fly and fight. And it costs a lot more than the price of the fuel to truck it into theater and protect it on the ground.

What's happening in energy research and technology for the Air Force?

We have just completed, after a year of study, our report called *Air Force Energy Horizons*. It articulates our vision of how the Air Force should pursue and gain the assured energy advantage in air, space, cyberspace, and infrastructure. Our study was a collaborative effort involving the Dept. of Energy, other services, the National Science Foundation and other agencies, and all Air Force major commands, including Air Combat, Air Mobility, and Space. Air Force Research Lab's multiple directorates—propulsion, air vehicles, space vehicles, information, and so on—made a significant contribution. Each of the key areas of the study involved a representative from the Air Force operational and technical communities, and from the office of the chief scientist.

Tell us more about the Energy Horizons study.

I think that we broke some new ground, not only in articulating where the Air Force needs to focus in the near, mid, and far terms in energy S&T domains, but also in delineating the areas where the Air Force leads in space and in the air and the areas where the Air Force needs to become what we call a 'fast follower.'

What do you mean by that?

We need to be a fast follower—a partner and beneficiary—of energy research and technology in areas outside the Air Force. We need to help with and benefit from the work being done in other parts of government and in the civil sector where we can adopt, adapt, or augment others' investments. One example is the work the DOE is doing on power microgrids, and on providing greater measurement and control of energy output and making it more efficient.

Do you foresee a role for the Air Force in energy production?

The Air Force is not an energy company, nor a producer of energy. We do not produce biofuels, for example, but we will be certifying our fleet for biofuels, so we have to be ready to purchase them as soon as they are available from different sources. Some biofuels produced in the U.S. are foodstuff-based, such as corn. But the U.S. and other countries also produce biofuels that are not

Interview by James W. Canan

foodstuff-based, and we have to be prepared to use them before we begin operations in those theaters. In Latin America, for example, biofuels can be sugar-cane-based rather than corn-based like ours. We have to make sure our systems can operate with biofuels that come from a variety of sources.

Tell us more about all that.

Instead of using corn, which is widely used to feed humans and animals, we want to use alternative energy sources that are not foodstuffs and are much more ubiquitous. One is a woody reed called camelina that grows quickly and does not require much watering or fertilizer. We are working with the Dept. of Energy in testing camelina-based biofuels and others at DOE's National Renewable Energy Lab.

How does Air Force propulsion research tie into this?

If we can build an airplane engine that is 25 or 30 or 40% more fuel-efficient, and if it has a lower lift-to-drag ratio, it will be able to persist longer in flight by roughly the same percentages, and that could be the difference between success or failure in battle. So we want to make sure that we will have the assured energy advantage over our adversaries. Some day perhaps our aircraft will be completely powered by renewable energy. We've already flown some RPAs for weeks at a time. We have had hybrid-fuel vehicles in space for a long time.

Tell us more about propulsion research in general.

The Air Force is doing ground tests on two new ADVENT [adaptive versatile engine technology] engines, one built by General Electric, the other by Rolls-Royce North America, in a joint OSD [Office of the Secretary of Defense] program with the Navy. The engines burn fuel at higher pressure, higher temperatures, and give us better efficiencies than those of the conventional bypass engines. These ADVENT engines also have some new composite materials and blade designs that enable their turbofans to be more efficient. One of the most interesting things about them is what we call their 'third flow.'

What does that mean?

Each engine has three airflow passages through it instead of the usual two. By shutting off the third-flow valve, the pilot can maximize the engine's thrust and performance in combat. While flying out to the battle zone or doing some ISR [intelligence, surveillance, and reconnaissance] while waiting for an engagement, the pilot can open up that third valve and maximize the engine's airflow and efficiency, and make it, overall, about 25% more efficient than the standard bypass engine in terms of specific fuel consumption.

We will continue ground testing the engines in FY13, and then see how they perform at altitude. They are coming right along; they are making solid progress.

Mark T. Maybury is chief scientist of the Air Force. He serves as chief scientific advisor to the chief of staff and secretary of the Air Force, and provides assessments on a wide range of issues affecting the Air Force mission. He interacts with the Air Staff, Air Force operational and combatant commanders, Air Force acquisition, science and technology communities, the other services, and the Office of the Secretary of Defense.

Maybury serves on the Steering Committee and Senior Review Group of the Air Force Scientific Advisory Board. He also is the principal science and technology representative of the Air Force to the civilian scientific and engineering communities, and to the public at large.

A former Air Force officer, Maybury is on leave of absence as an executive director at MITRE. He has edited or coauthored 10 books, authored over 80 refereed publications, and been awarded several U.S. patents.

During his career, he has been research team chief at Rome Air Development Center, group leader, intelligence information systems, at MITRE and, also at MITRE, associate/department head, advanced information systems technology; deputy division manager, national intelligence; and executive director, Information Technology Div.

Maybury earned a BA degree in mathematics at College of the Holy Cross; a master of philosophy degree in computer speech and language processing and a doctor of philosophy degree, both at Cambridge University; and an MBA at RPI. His awards and honors include the Air Force Commendation Medal, Air Force Meritorious Civilian Service Award at RADC, Secretary of Defense Recognition Award for support to the Coalition Authority in Baghdad, Iraq, and a Presidential Recognition Award for planning for the Terrorism Information Sharing Environment.

What else is notable in propulsion technology development?

For one thing, we're adding significant efficiencies to the engines of our [propeller-driven] RPAs. Engines like those on Predator were never designed to be efficient. They were designed mainly to get the RPAs out onto the flight lines really fast, because they need to be ramped up very quickly. We discovered that just by putting fuel injectors into them, and also by converting some to less expensive fuel, we can make them significantly more fuel-efficient.

Talk about work on directed energy weapons. How's it coming?

Directed energy is one of our primary focus areas. We have a joint program with DARPA that is developing the next generation of solid-state high-energy lasers to provide greater power and better performance in smaller packages than chemical lasers can provide. We want to extend our options beyond chemical-based lasers, although those are very efficient and remain promising for utilization. We don't want to take any laser technology options off the table. There are several, including fiber-optics-based technology, that look promising. We still have challenges with thermal management and with beam control, and we continue to work on those.

What is the state of play in the development of high-powered microwave weapons?

High-powered microwave [HPM] technology is ready to go. In fact, HPM weapons may be used in the civilian sector before they are military-deployed. There are discussions right now about potential applications in, I believe, the Los Angeles prison system. Many military commanders have commented that they very much regret not having had nonlethal capabilities in combat. HPM weapons can give them that; they're very effective and very safe. They could actually save lives.

We're very careful in this office not to advocate particular systems, but I will say that HPMs provide a very important option for our military. In some circumstances, shooting to kill is a very difficult ethical decision. With HPM weapons, for example, you can stop, but you don't have to kill, an individual charging a checkpoint after you've repeatedly told him to stop. If he keeps coming after you've shot him with a high-powered microwave, then there's something wrong.

Have you had personal experience with high-powered microwaves?

I may have been the first chief scientist to be shot by one. I subjected myself to it. I had a very warm sensation for one or two seconds, followed by a very crisp, burning sensation, followed by an intense desire to get away. There was very minor penetration of skin and no after-effect. You could get hurt worse by falling asleep under the sun on a hot beach for an hour than you could from being shot by a high-powered microwave.

Let's turn to hypersonics research. Much has happened in recent years with the X-51 Waverider and other potential hypersonic systems. What is going on right now?

Hypersonics is a continuing area of interest. Hypersonic weapons, hypersonic platforms, are potentially important where speed is a need in penetrating denied environments. They are difficult to test, and one of the challenges lies in showing signs of progress. Hypersonics development requires a lot of experimentation to reduce the risks, so it is very expensive to run all of the required experiments.

"I had a very warm sensation for one or two seconds, followed by a very crisp, burning sensation, followed by an intense desire to get away."

Unlike in cyber research, where some research can be done at almost trivial expense, a hypersonic weapon requires development of a test range, wind tunnels tests, and special measurements of their extra-high speeds, all at considerable expense. Even so, hypersonics is a promising area, and still represents an important option. One of the jobs of S&T is to give the warfighters options, to advance discoveries, and to close gaps between science fiction and operational reality.

Your predecessor emphasized the importance of autonomous systems. How do you view them?

We have a range of autonomy, from what we call human-in-the-loop—where the human, together with the system, an RPA, makes changes in guiding the aircraft, telling it go here, go there—all the way to complete autonomy, where an RPA will be able to navigate on its own, fly to point X, see if anything interesting is happening, and decide what to do next. That's coming. On certain missions we will never have full autonomy. On nuclear missions, for example, we will probably always want humans in the loop.

To what extent are RPAs currently autonomous, would you say?

Right now we have hundreds of people in the loop with our RPAs and we have no problem with that. In fact, there are actually many more people in the loop, helping make navigation, surveillance, and battle decisions, than there are with pilots in the cockpits. If a pilot's mission in the old days was to take out a bridge, he didn't have anyone in the loop who could tell him that there was someone crossing the bridge, so hold off. Today we have many people, including the judge advocate, overlooking the scene to make sure that the rules of engagement are followed. So it's a much different environment, and I think that's healthy. Having more eyes on the target helps make better decisions overall.

But ever-greater autonomy remains the goal, doesn't it?

Sure. But we need our operators

“As people become more and more dependent on automated systems…they can lose situational awareness and vigilance, and their skills can diminish as a result.”

to have what we call ‘trust in automation.’ We want our systems to be much more aware of their environment and able to make decisions on their own. At the same time, we also want our people to be much more aware of situations where automation is in play. As people become more and more dependent on automated systems, or on automation in general, they can lose situational awareness and vigilance, and their skills can diminish as a result. So we need to guard against those risks.

So how would you describe the Air Force’s immediate goals for automated systems?

We want to make partly autonomous systems more fully autonomous, make them much more intelligent so they can do a lot of the low-level planning now done by humans. For example, we have to spend hours, sometimes days, planning the [surveillance] routes for the Global Hawk. It is very complicated. At every way-point, humans have to decide what the RPA should do next.

The RPA depends on GPS and communications links for navigation. A more knowledgeable, more autonomous aircraft with a vision-based navigation system and a terrain map of the world could navigate by itself, look down at the Earth, compare what it sees with what the terrain map shows, and decide on its own where to go next and what to do. We have research going on right now to accomplish that, in order to deal with denied GPS or lost communications.

The Air Force and all the services are cutting back in the current budget squeeze. This makes automation all the more important, doesn’t it?

Yes it does. For example, the Air Force has cut some 25,000 people and yet it has had an increase of about 21,000 in ISR. The number of full-motion video analysts has increased by 50%, from 4,000 to 6,000. The joint warfighting community depends on the Air Force for global reconnaissance, and the Air Force is responding to that need.

Are you advising the Air Force leadership on how to incorporate new technologies to compensate for the force cuts?

My job as chief scientist is to anticipate and understand the science and technology trends into the future, and to champion certain changes. We have emerging sensors that may require new kinds of analytic talents, new kinds of sensor-processing talents. So one of my jobs is to pay attention to the talents and the potential of the Air Force people who have STEM [science, technology, engineering, and mathematics] degrees. They make up 10% of the total force, but only 5%, roughly 25,000 people, are in STEM positions.

“The joint warfighting community depends on the Air Force for global reconnaissance, and the Air Force is responding to that need.”

On the basis of those numbers, you might say that we have twice as many STEM people as we need. But it turns out that we probably don’t have as many as we need, given our requirements. Half of our general officers have technical degrees. We have a very technically educated general officer corps in the Air Force, which is a blessing, as I would argue that there’s a correlation with the increased technological sophistication of modern threats and our weapon systems.

America works best when *everybody* works.

Learn more about the value and talent people with disabilities add to America’s employers and economy.

What can YOU do? The Campaign for Disability Employment
www.whatcanyoudocampaign.org

The Campaign for Disability Employment is funded under contract #DOLJ079426341 from the Office of Disability Employment Policy/U.S. Department of Labor.

Moving beyond Earth: NASA's steps through 2020

NASA's DECADE IN HUMAN SPACEFLIGHT is not off to a bracing start. The shuttle retired last year, and NASA is renting seats on Russian rockets through at least 2015. The agency faces static or declining budgets. Nothing suggests that the president or his prospective Republican opponents have new space initiatives in mind. NASA's commercial cargo providers are coping with delays, and their rockets remain locked to the launch pad.

Although NASA has direction to launch a human expedition to a near-Earth asteroid by 2025, the date is so distant that there is little public awareness of the goal, let alone excitement at the prospect. Those I meet frequently express sorrow that the space program has been canceled. The fact that U.S. astronauts Dan Burbank and Don Pettit are leading Expedition 30 at the ISS, 220 miles up, doesn't seem to counter that sentiment.

The perception of America adrift in space contrasts with China's release late last year of a national space exploration white paper. The document underlined the importance of space achievement to leaders of that rising power. Among the goals set for the next five years, the document noted that China will:

- Launch space labs, manned space-ship[s], and space freighters; make breakthroughs in and master space station key technologies, including astronauts' medium-term stays, regenerative life support, and propellant refueling; and make technological preparations for the construction of space stations.
- Conduct studies on the preliminary plan for a human lunar landing.
- Launch orbiters for lunar soft landing, roving, and surveying to implement the second stage of lunar exploration. In the third stage, China will start to conduct sampling [of] the Moon's surface matter and get those samples back to Earth.

These announced goals of orbital assembly and refueling and of robotic visits to the Moon are steps toward human lunar expeditions. It would surprise no one if China's next five-year plan made a clear commitment to a manned lunar landing, perhaps as early as 2020.

What activities could NASA reasonably undertake within the decade to preserve a U.S. technological edge in space? Recognizing budget and technical limits, can the agency make substantial progress toward leaving Earth's gravity well? Put another way, can the nation afford to remain bound in low Earth orbit for another decade?

After successfully docking with the Tiangong-1 target vehicle last fall, China's Shenzhou 8 unmanned spacecraft returned to Earth on November 7, 2011. The autonomous rendezvous and docking are steps toward China's development of a piloted space station. Credit: China News.

Why send humans to deep space?

What is our purpose in sending astronauts to the Moon or beyond? National pride is one relevant factor, especially in light of foreign ambitions, but it is by itself insufficient.

In my view, human flight beyond LEO comes at such great cost and risk that we should pursue it only because our specific objectives there demand skills and judgment that only astronauts can provide. Some skills are physical: humans bring to bear hands-on dexterity, coupled with acute visual perception. That brain-eye-hand combination can wield tools and controls in real time for exploration, or for dealing with failed systems and emergencies. Perhaps even more valuable are a human's experience and judgment, scientific and technical insight, well-honed problem-solving abilities, and the flexibility to respond to unexpected circumstances. NASA's objectives for deep space exploration should take maximum advantage of those on-the-spot skills, backed by 50 years of in-space experience.

Planetary scientist Steve Squyres, who supervised the missions of Mars rovers Spirit and Opportunity and now chairs the NASA Advisory Council, sees great rewards in having human explorers in deep space. In 2009 he told a Space.com interviewer:

"You know, I'm a robot guy, that's what I have spent most of my career doing, but I'm actually a very strong supporter of human spaceflight. I believe that the most successful exploration is going to be carried out by humans, not by robots.

"What Spirit and Opportunity have done in five and a half [now eight] years on Mars, you and I could have done in a good week. Humans have a way to deal with surprises, to improvise, to change their plans on the spot. All you've got to do is look at the latest Hubble mission to see that.

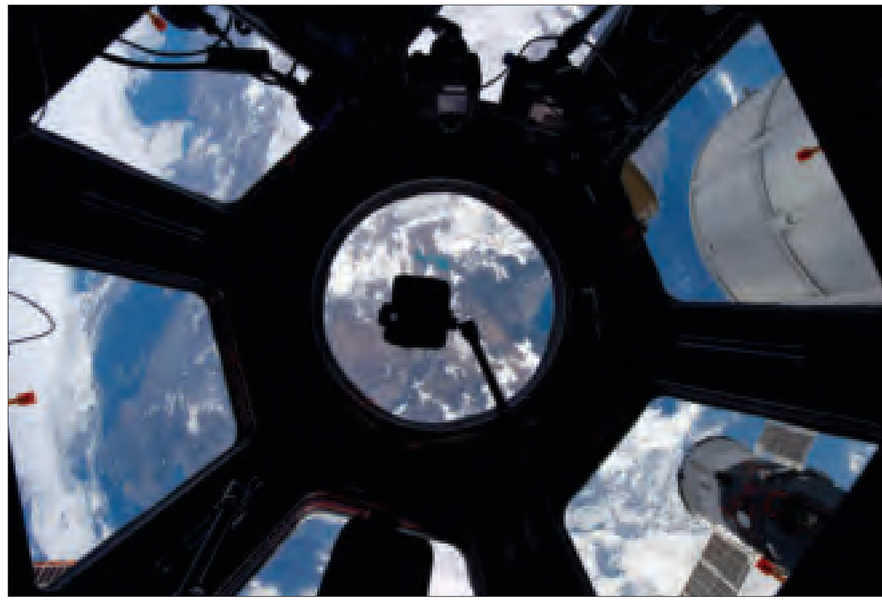
"And one of the most important points I think: Humans have a key ability to inspire, [which] robots do not."

Although putting humans on the Moon or an asteroid within a decade now seems almost impossible, fiscally and politically, NASA engineers, managers, and astronauts I've talked with think there are still ambitious things the agency can do by 2020. They hope to leverage our human, commercial, and international experience in space to push human presence beyond the Moon, and create the knowledge and momentum needed for interplanetary exploration in the decade following. Each outward step would expand operations experience and demonstrate technical capabilities, all setting the stage for asteroid expeditions and, ultimately, human expeditions to Mars.

Building on ISS

When I poll my audiences, only about one in four have actually seen the station passing overhead. Fewer still can say what scientific research is under way there. One sure way NASA can raise the station's profile is to use it as an exploration proving ground, where astronauts and engineers are testing the equipment needed to reach beyond LEO.

Let's announce what we'll need to build to reach the asteroids and Mars, and then test those systems at the ISS. Start with the new power and life support systems needed on deep-space habitats. Advanced, reliable water and atmospheric recycling systems are critical for multimonth trips to an asteroid; their operation would also help reduce demand for consumables at the outpost.



The Expedition 30 crewmembers took this image of Turkey through the cupola windows on the ISS on December 29, 2011. A Russian Soyuz spacecraft is docked to the station at lower right; part of the permanent multipurpose module can be seen just above it. Credit: NASA.

Within five years, NASA should fly an advanced spacesuit design to ISS, geared toward interplanetary exploration. Nothing will show we are serious about exploration better than a 21st-century spacesuit. Equip the ISS with an inflatable, deep-space habitation module, delivered by commercial or international partners. Outside, install a prototype solar electric propulsion system, using a next-generation photovoltaic array. The system could help with ISS orbit reboost as engineers test its reliability and efficiency. NASA

Lockheed Martin has proposed astronaut control of robotic lunar rovers on the Moon's far side, with Orion sent to Earth-Moon L2 on one-month missions. NASA is studying the feasibility of a small L2 outpost to enable lunar and interplanetary exploration. Credit: Lockheed Martin.

should also equip the exterior with an EVA climbing wall, a simulated asteroid surface enabling astronauts to test anchoring tools and grappling techniques in a free-fall environment.

Earth-Moon space

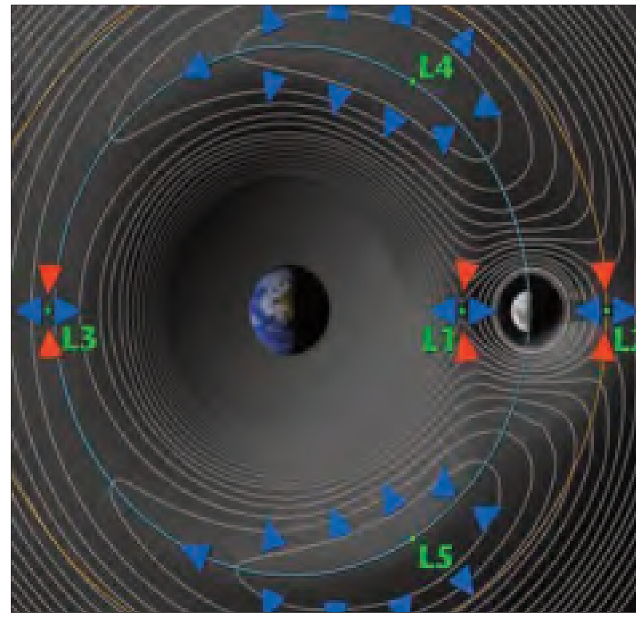
NASA announced plans last fall to begin flight tests of the Orion multipurpose crew vehicle in 2014, atop a Delta IV launcher. For its second mission, Lockheed Martin has proposed a piloted lunar swing-by, propelled by the Space Launch System (SLS) or a commercial substitute. With beyond-LEO performance, NASA could mount a series of increasingly complex missions centered on Orion, using additional components—a habitat, an airlock, a robotic manipulator arm—to create a versatile deep-space vehicle.

Assembled in LEO, the stack could then rendezvous with and service geosynchronous communication or imaging satellites, replacing ailing components or refilling empty fuel tanks. Crews would return to Earth in Orion, but the SEP system could reposition the habitat/airlock hardware for reuse. Such a demonstration by astronauts would be a pathfinder for follow-on commercial services that would use robot spacecraft.

After the lunar circumnavigation, Orion could move up another notch in capability, to an advantageous pair of gravitational equilibrium points, Earth-Moon L1 and L2. As at the other three Lagrange points, the effective forces at L1 and L2 are in equilibrium, and a small body placed there can theoretically remain stationary in that rotating reference frame.

Staying precisely at these two points, which are dynamically unstable, requires substantial maneuvering fuel. But looping around them in a lazy ellipse called a halo orbit requires only about 100 m/sec of delta-V annually—a figurative drop in the propellant bucket.

L1 point is on the Earth-Moon line, 325,000 km from Earth and 56,000 km from the Moon. L2 is on the extended Earth-Moon line, another 67,000 km beyond the Moon; it takes about eight days and 3,450 m/sec to get there from LEO. From an L2 halo orbit, astronauts would have a direct view and radio link to Earth, because that orbit would be far larger in angular extent than the Moon's disk. A craft in such an orbit could also serve as a relay between Earth and the lunar far side.

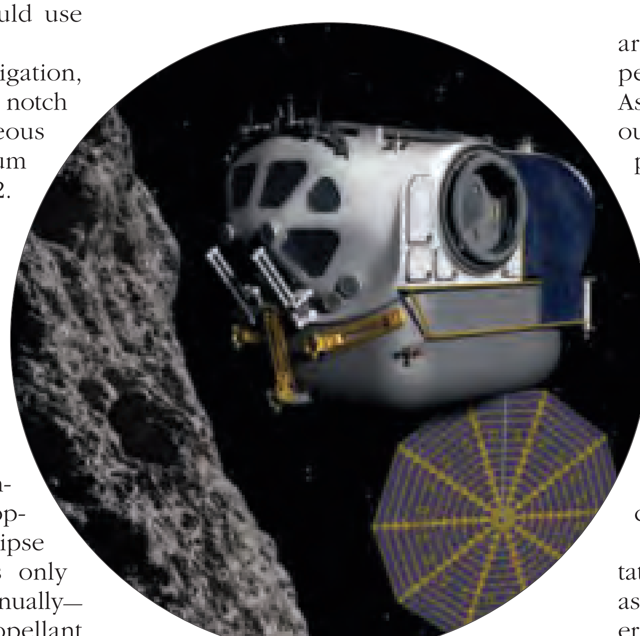


Contours of the effective gravitional potential in the Earth-Moon two-body system show the five Lagrange points. Arrows show the potential gradient: red is 'downhill' toward the L-point; blue is downhill away from it. Credt: NASA.

Using early SLS test launches (which have to go somewhere, after all), NASA could autonomously assemble in an L2 halo orbit a sort of 'line shack,' a human-tended facility useful for a variety of exploration tasks. Components would be copies of ISS designs or actual station spares to minimize the cost of development. For example: a build-to-print ISS solar array, a small SEP unit for orbit maintenance, a modest MPLM-derived habitat, supply vehicles from ISS partners, or even an old orbiter airlock.

The L2 line shack would host an array of science-oriented activities performed by visiting Orion crews. Astronauts could assemble and check out a series of lunar or NEO probes, piggybacked on SLS, commercial, or international partner supply runs. Farside rovers could be commanded by astronauts or, more routinely, by relay from Earth. Lunar samples rocketed from the surface to L2 could be collected, stored, and returned to Earth, again by visiting Orion crews. Lunar, Earth, and astrophysical observations would continue under remote command between crew visits.

Because of its advantageous gravitational perch, L2 could also be used as a gateway for assembling and delivering robot probes or space telescopes to lunar orbit, the lunar surface, the Earth-Sun L-points, near-Earth objects, or even Mars. These assembly activities could be enhanced by delivery of


NASA's two-person space exploration vehicle concept, here free-flying at a near-Earth asteroid, is one of the deep-space systems that could be deployed and tested at ISS. Credit: NASA.

an inflatable, pressurized hangar where astronauts could put together large telescope elements or spacecraft, free of bulky pressure suits and gloves (inside the low-pressure envelope, crews would have to breathe supplemental oxygen through a mask).

Opportunity at the Moon

L1 and L2 are very close to the Moon. The latter, 67,000 km from the far side, is a superb vantage point for remote sensing, and an ideal relay station for commanding far-side rovers from Earth. Enabling visiting astronauts to operate those same rovers from L2 would demonstrate how future crews could explore Mars by teleoperating rovers from a Phobos outpost.

At the Moon, NASA could deploy a series of landers and rovers to pursue high-value lunar science. These probes could sample ancient rocks from the South Pole-Aitken Basin, prospect for ice deposits in shadowed craters, and scout sites for future human exploration.

I am intrigued by recent Lunar Reconnaissance Orbiter images of skylights, cave-in openings into ancient lava tubes. One skylight in Mare Ingenii (appropriately, the Sea of Cleverness), is 130 m across; a rover could trundle up to its rim and take a detailed peek inside. Such lava tubes might be excellent sites for outpost habitats, shielded from radiation yet in the middle of a fascinating geological setting.

Science aside, a detailed assessment of lunar resources such as water, oxygen, and metals is a necessary step in opening up cislunar space to commercial development. The LCROSS impact experiment in 2009 revealed that its target crater, Cabeus, holds an estimated billion gallons of water, enough to fill over 1,500 Olympic-size pools. Similar ice deposits could feed many decades of LOX/LH_2 propellant production for lunar and in-space use.

By the year 2020, NASA could be leading a multinational lunar science campaign, using robots to explore the most promising regions of the Moon. The discoveries they make could put the U.S. at the forefront of lunar exploration, while American astronauts at L2 prepare for true deep-space expeditions.

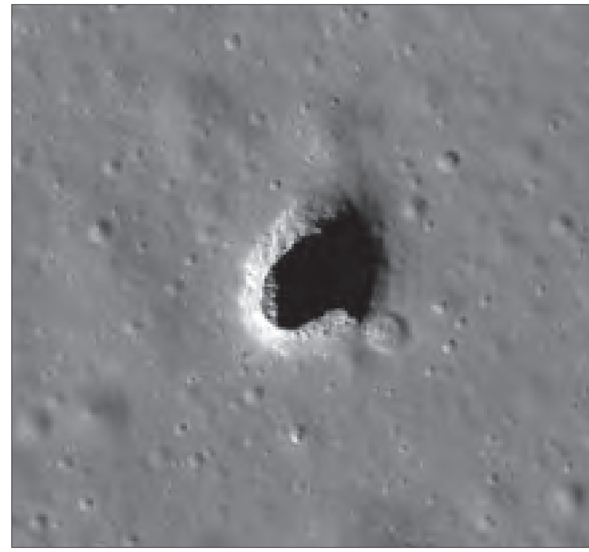
Gateway to the NEOs

From a perch at L2, the mesmerizing view takes in the rugged lunar far side, backdropped by a delicate blue Earth hanging in a velvet-black sky. Building on ISS expeditions and a series of month-long visits to this L2 gateway, we would be ready by the early 2020s to reach even farther into deep space.

By that point we should have enough evidence from a space-based search telescope, and a series of near-Earth object (NEO) precursors, to select several likely targets for human exploration. Ancient, unprocessed, water-rich NEOs should be of prime interest: meteorite evidence indicates that those with hydrated silicate surfaces contain up to 20% water by weight. If confirmed by probes like JAXA's Hayabusa II and NASA's OSIRIS-REx, then a 100-m asteroid, weighing about a million metric tons, could harbor 200,000 tons of water.

A resource of that magnitude would be almost impossible to ignore, and would invite a NASA-industry effort to figure out how to extract it and get it back to useful locations in cislunar space. Human expeditions could demonstrate ore handling and extraction processes, then give way to robotic exploitation of a handful of promising NEOs. The same robot and human explorers would return extensive remote sensing data and physical samples, revealing much about the origin, composition, and history of these ancient remnants of planetary formation.

A decade of study would also yield the collective knowledge and operations experience needed to divert a NEO from a collision course with Earth.



This skylight into a probable lava tube is in Mare Ingenii, the 'Sea of Cleverness,' on the lunar far side. The opening is about 130 m in diameter, and the image is 550 m across. Illumination is from the upper right. Credit: NASA Goddard/Arizona State University.

Taking flight

NASA's outlook in the face of static budgets and national deficit struggles is challenging, but there are some bright spots: The ISS is complete, commercial launch partners are making progress, and the agency has Orion and SLS in the pipeline. By using the space station as a testbed, capitalizing on commercial innovation to lower launch costs, bringing in contributions of hardware and expertise from its international partners, and harnessing bright ideas from its own engineers, managers, and flyers, NASA can execute a series of small but concrete steps to put the U.S. at the threshold of deep space.

It's a modest but appealing program that can take us to the Moon and beyond by 2020. We'll need stable funding, smart thinking, and politicians who won't turn the space effort upside down every four years. But if NASA's leaders can convince the White House and Congress to turn its explorers loose, this decade should see us move beyond Earth for the first time since 1972, when we last knew how to carry out truly epic journeys of exploration. It's time to get started.

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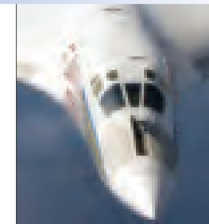


Strategic bombers—relevant again

The last new U.S. strategic bomber, a Northrop Grumman B-2, was delivered in 1997. It joined a legacy fleet of aging aircraft destined for frequent use, uncertain upgrades, and with no replacement in sight. Efforts to create a new bomber have repeatedly failed due to budget constraints.

Yet money remains in place for a new program start. And a new U.S. defense posture reflects a growing emphasis on range and power projection. This strategic shift makes it much less likely that the new bomber development effort will become a budgetary casualty.

The strategic context

The 2010 Quadrennial Defense Review, or QDR, finally got rid of the impossible notion of a next-generation long-range strike platform entering service in 2018. In the FY12 budget proposal, R&D funding for a next-generation bomber implied a significant new program start, with funding ramping up quickly. In December, Congress approved $297 million in R&D funding for FY12, about $100 million more than the Air Force request.

There were two problems with this impressive-looking funding plan. First, it was just a drop in the proverbial bucket. A total of about $4 billion over the five-year plan would pay for less than 10% of the development bill for a new bomber. Even before production, development of the Northrop Grumman B-2 had cost $40 billion in today's money.

The second, related problem is that in a budget crunch, new starts like this tend to wind up as bill payers for other projects. New programs are easy targets. They promise nothing of military value for at least a decade, they ramp upward when the budget ramps downward, and they have almost no labor or political constituencies to defend them. Many observers believed that the new bomber would be an obvious target in the FY13 budget.

However, this outlook changed with President Obama's new national military strategy, announced in January 2012. This new strategy shifts the U.S. military focus away from Iraq and Afghanistan and large-scale counterinsurgency and toward a more global outlook. Defense Secretary Leon Panetta spoke of an "enhanced presence, power projection, and deterrence in Asia-Pacific." The new emphasis is also placed on countering anti-access/area-denial (A2/AD) threats.

The accompanying report on military power said that the new strategy involved "sustaining our undersea capabilities, developing a new stealth bomber, improving missile defenses, and continuing efforts to enhance the resiliency and effectiveness of critical space-based capabilities."

In short, with a new strategic approach like this, it is difficult to imagine an FY13 budget that does not accelerate next-generation bomber funding. Developing a new bomber would provide the administration with evidence that it was bolstering the nation's global military reach, rather than merely exiting two difficult wars.

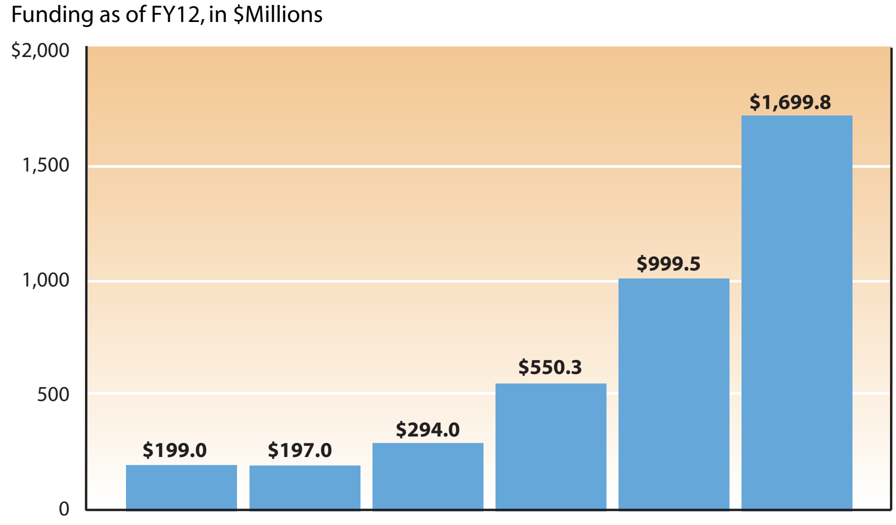
The shape of something new

At this stage in the program, there are no concrete details about the next-generation bomber design. The most promising aspect of designing an all-new bomber is the possibility of being able to reconcile stealth and high speeds for the first time in a large aircraft. However, the limited guidance provided indicates a preference for high subsonic speeds.

The next issue relates to technology benchmarking. The new bomber will face the usual tension between using tested, low-risk components and looking for new technologies and capabilities. The cost of these new capabilities, of course, is higher risk and greater concurrency in testing and manufacture. Right now, the emphasis is on off-the-shelf components, particularly with propulsion and radar.

Along with the long-range bomb-

USAF NEXT- GENERATION BOMBER FUNDING PLAN
Funding as of FY12, in $Millions



X-45A

ing role, the new plane will also serve as an intelligence, surveillance, and reconnaissance (ISR) and command and control asset. This would leverage a long-endurance and stealthy platform, with plenty of room onboard for multirole sensors.

One certainty relates to the new bomber's crewed status. For years, visions of a next-generation long-range strike tool have referenced UAVs as a likely option. In particular, there were thoughts of scaling up Boeing's X-45 unmanned combat air vehicle, a stealth aircraft resembling a B-2, into a strategic asset. While UAVs play a growing role, especially in tactical situations, their prospects of providing a next-generation bomber are quite unlikely.

Much of the reason for this has to do with costs. Creating a small tactical strike fighter or reconnaissance asset involves a high ratio of planning for the pilot (relative to the rest of the airframe and systems), and the need for a protected cockpit and the associated human-machine interface. But with a large, long-range strategic vehicle, airframe, engines, onboard sensors, and munitions are in relative terms much greater considerations. In terms of aircraft cost, size, weight, and overall technical considerations, crew accommodations for any modern strategic bomber are considered practically an afterthought.

In addition, the December 2011 loss of an RQ-170 stealth UAV over Iran highlighted the risks associated with high-value UAV assets. Whether it was brought down by Iranian interference or technical error remains debatable, as does the issue of whether Iran can learn from the onboard sensors, or sell any aircraft secrets to third-party countries. All that matters is that the incident was a wake-up call for anyone who regarded UAVs as truly expendable. After all, a next-generation bomber would be a much greater loss, particularly given the expense, cutting-edge airframe technology, and likely onboard sensors and munitions.

With negligible cost savings and high risk associated with large, long-range UAVs, the Air Force is now set to make the next bomber 'optionally manned.' This, of course, means that it will be like almost all other manned aircraft. After all, even 1960s vintage F-4 fighters are routinely converted to QF-4 drones. A new bomber would be used as a manned vehicle for overland strike, nuclear, and most ISR missions that require high value sensors; the unmanned capability will be reserved for a much smaller set of missions, such as maritime strike. But again, given the likely $600 million-$1 billion recurring unit cost associated with a next-generation bomber, it is quite likely that it will never be used without a pilot onboard to help guarantee its safe return.

Regarding contractors, the three surviving major airframe primes will all aim for some kind of role. With its B-2 experience, Northrop Grumman has an advantage, although it is not clear how much of the related talent and knowledge still resides within the company. Recognizing this advantage, in 2008 Boeing and Lockheed Martin formed a joint effort to pursue the bomber program. But in June 2009 all related work on the 2018 bomber was halted, and the current status of the Boeing/Lockheed teaming arrangement is unclear.

In terms of procurement objectives, the most recent guidance has been for 120 deployed aircraft plus another 55 planes for training and in reserve. But bombers have not been built in those quantities for many decades. For comparison, the original procurement objective was 132 B-2s. Just 21 were actually built.

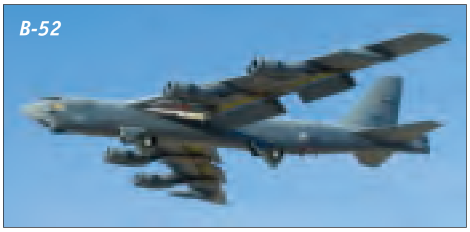
The loss of an RQ-170 over Iran last year highlighted the risks associated with high-value UAV assets.

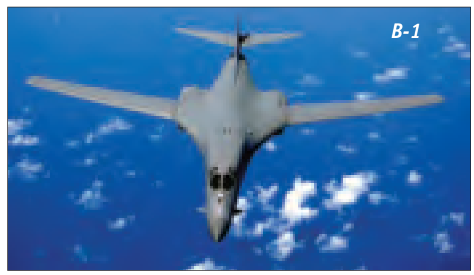
The U.S. legacy fleet

If built, the next bomber would follow a remarkable legacy. Total jet bomber production in the U.S. came to 744 B-52s, 116 B-58s, 76 FB-111s, 100 B-1s, and 21 B-2s. As recently as FY89, there were over 400 strategic bombers in the USAF's active force inventory. Today, there are just 150; but the force is very well looked after.

The current USAF plan calls for 130 combat-capable bombers to be fielded through 2030, with about another 30 available for reserves, testing, training, and attrition. This includes 20 B-2s, 60 B-1s, and 76 B-52s.

The B-52s are not slated for retirement until 2040. By then, the youngest planes will be about 80 years old. The airframes receive necessary overhauls, and there have been minor electronics and weapons updates, but there have





The U.S. bomber fleet offers a wide mix of aircraft.

been no major upgrades implemented and none are planned. The airframe is too robust to require a major rebuild. While new engines have been proposed several times over the past few decades, short-sighted budgeting decisions mean the aircraft are still powered by their original turbojets, even though new turbofans would have paid for themselves years ago with lower fuel consumption and maintenance costs.

The newer B-1 fleet is scheduled to retire sooner, in 2030. Its main limitation is its flawed electronic warfare (EW) suite, the ALQ-161. This system may prove unsustainable and/or useless after the next few years. The B-1 may eventually get some kind of EW system replacement, but there is a very good chance that the B-1 may never again serve as a penetration bomber. Instead, it will continue to be relegated to standoff munitions carriage, just as the B-52 is. If the new bomber proceeds, the B-1 will likely be the first aircraft retired early.

The B-2 force is not scheduled for retirement until after 2050, which only seems remarkable until you compare it with the age of today's B-52 fleet. In 2002 the Air Force announced that the B-2's APQ-181 radar would receive an active electronically scanned array and other new components under the Radar Modernization Program (RMP). Northrop Grumman is prime on this $1.3 billion effort, but Raytheon is doing much of the work. Flight tests began in April 2006, with initial operational capability scheduled for 2013. In addition to improving the B-2's strike performance, the RMP upgrade was necessary to prevent conflicts with a civil communications frequency.

The B-2 also benefits from more modest updating programs. In 2004 the B-2 fleet began receiving new low-observable coatings under the advanced high-frequency material program. A new 'smart bomb rack' allows carriage of up to 80 joint direct attack munitions.

Bombers elsewhere

Russia, like the U.S., is reliant on an aging legacy bomber force, albeit a far less formidable one. Russia's most capable bomber is the Tupolev Tu-160 Blackjack, but it was basically a Soviet era response to the B-1, which it closely resembles. While most production took place before the end of the Soviet Union, in May 2000 another copy was procured from Kazan Aviation Production Organization (KAPO), possibly from existing parts. In all, Russia has 15 Tu-160s currently flying. KAPO is also in charge of an upgrade program, begun in early 2002. The first of the Tu-160s to be upgraded was redelivered in April 2009.

Russia also still has around 100 Tu-22s and 60 Tu-95MSs in service. These are smaller, slower, and less capable than the Tu-160. Russia never built the equivalent of the U.S.'s B-2, even in prototype form.

The biggest weakness of Russia's strategic bomber force, however, is a feeble air-to-air refueling capability. While the USAF air tanker fleet includes 417 KC-135s and 59 KC-10s, Russia has 20 Il-78M Midas B tankers, and their readiness rate is notably low due to serviceability concerns. With an air refueling force this thin, Russia's air power projection capabilities can be termed minimal, at best.

Also, like the U.S., Russia has not been able to fund a new bomber program, despite hopes of starting one. Sukhoi's T-60, which had been considered for this role, is a dormant effort, and will probably stay that way. Still, work on a notional stealth bomber continues, under the PAK-DA program. This effort is managed by Tupolev, with development scheduled to conclude mid-decade. Production is scheduled to begin around 2020-2025, with a service entrance around 2025-2030. But there is very little evidence of progress on this effort.

Outside Russia, France and the U.K. are the only powers that have operated strategic bombers in the recent past. The French airborne nuclear

mission was transferred from the Dassault Mirage IV, a dedicated bomber retired in 1996, to multirole tactical aircraft (Mirage 2000N, then Rafale). The Royal Air Force abandoned the strategic bombing mission after its last Avro Vulcans were retired in the early 1980s (after one final high-profile role in the Falklands conflict). But neither country plans to restore this capability. Instead, they will continue to rely on aircraft carriers for power projection, and on land-based and submarine-based missiles for a nuclear deterrent force.

China's military air arms have no experience of strategic bombers, and no firm plans to develop or acquire them. The People's Liberation Army Air Force and Navy do have several hundred Harbin H-5s, a copy of Russia's Il-28 light/medium bomber, and a smaller number of Harbin H-6s, after Russia's Tu-16 medium bomber. Both


Rafale

types are obsolescent. There are currently no signs of new bomber development efforts, and China's new fighter development programs have met with uncertain levels of success.

China's growing defense efforts in recent years have mostly stressed asymmetric capabilities, such as cyberwarfare or antiship missiles. However, over the past two years China has also begun stressing more symmetric forms of weapon development such as stealth fighters and naval power projection, including aircraft carriers. This raises the question of whether China will begin investigating a long-range air power capability, for bomber, ISR, or maritime combat/reconnaissance missions.

If China does not choose to develop a strategic bomber force, and the U.S. continues to develop a next-generation bomber while upgrading its existing fleet, this will represent a key discriminator between the two powers. If the U.S. next-generation bomber program is cancelled, the U.S. bomber force will remain a legacy asset through around 2050, a reminder of a time when the U.S. had the greatest power projection capability of any country in history.

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The ephemeral ‘advanced propulsion’

New technologies with the promise of more affordable, more efficient, and safer propulsion for space launch currently seem to be out of reach. That, however, does not mean that we should stop searching.

by **Jerry Grey**
Editor-at-Large

Frequent letters to the editor and commentaries in space journals have decried current and past deep-space mission concepts as being doomed by inefficient propulsion systems. They call upon NASA or DARPA to develop ‘advanced propulsion’ technologies that will make those difficult missions more efficient, more affordable, more capable, more whatever.

The term ‘advanced propulsion,’ properly, has been applied primarily to in-space technologies, not those suitable for Earth-based launches. These have included various electric propulsion methods (electrostatic, electromagnetic, electrothermal, magnetoplasmadynamic), nuclear thermal rockets, various forms of catapults (railguns, tether ‘slingshots’), laser-heated propellants, photon sails (solar or laser), charged-particle sails, or ‘way out’ concepts using nuclear fusion or antimatter-based energy sources.

Unfortunately, advanced propulsion with sufficient thrust for Earth-based launchers requires concepts involving esoteric materials (often denoted as ‘unobtainium’) or other new (or as yet unknown) principles of physics such as antigravity, modifying the structure of space-time, employing electromagnetic zero-point energy, faster-than-light drive, or ‘wormholes.’ None of these is likely to be operational in the foreseeable future. So, for Earth launch, we are stuck with the few high-thrust technologies available within our current understanding of physics: liquid-propellant and solid-propel-

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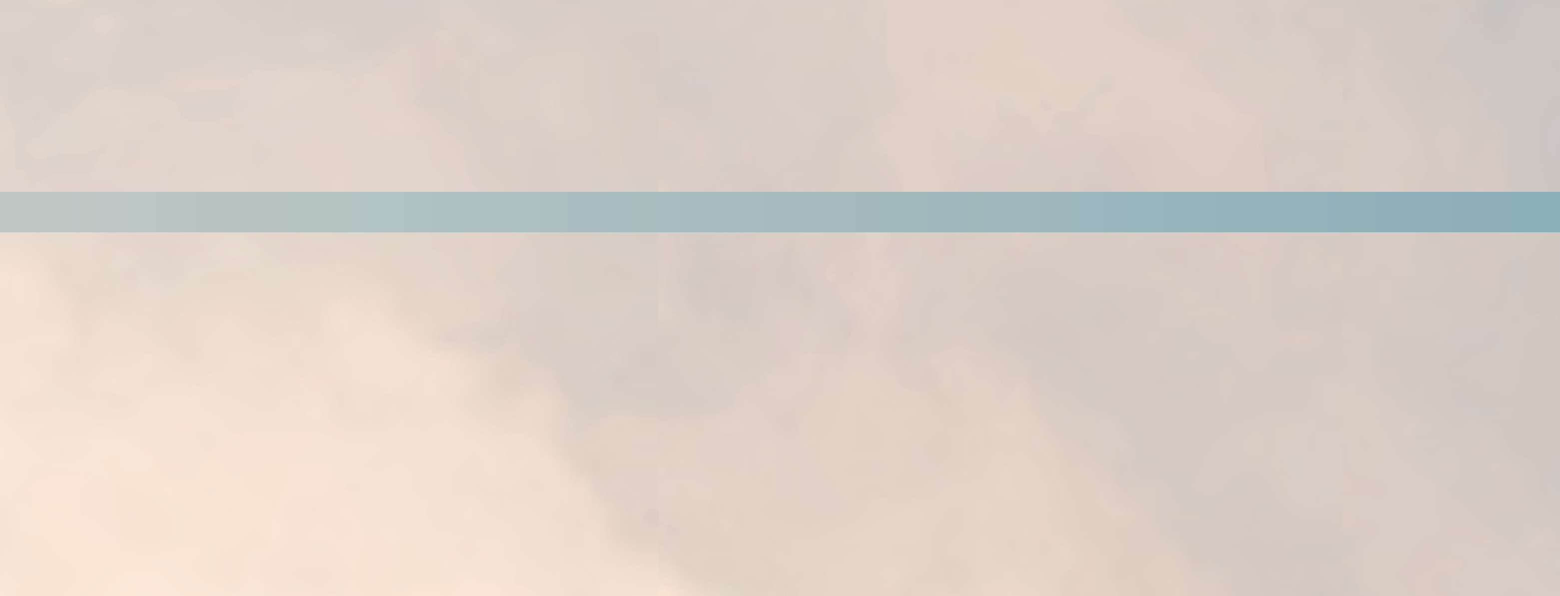


lant rockets, combined-cycle systems involving air-breathing engines and rockets, guns, and nuclear-thermal rockets.

Neither guns nor nuclear-thermal rockets are suitable for space launch from Earth; guns because of their need to achieve orbital or escape velocity—over 7 km/sec—while still in the high-density atmosphere (even high-altitude launch sites or airborne gun-launch platforms have been studied and found to be eminently impractical and economically disastrous), and nuclear-thermal booster rockets because of valid environmental concerns.

Indeed, the most advanced but still practicable Earth-launch propulsion available to us today or in the foreseeable future remains the one first conceived by rocket pioneer Konstantin Tsiolkovsky in the 19th century—the oxygen-hydrogen rocket. True, we can get slightly better performance from fluorine-hydrogen or ozone-hydrogen, but only with unacceptable cost, hazard, and complexity issues (both have been tried in the past). Other improvements in liquid- and solid-propellant rockets are, of course, possible, and are indeed likely to be pursued, but they are equally likely not to provide game-changing breakthroughs.

Nevertheless, in December 2011 the Air Force announced funding of the first major research phases of a reusable booster system intended to replace its costly expendable launch vehicles, with initial contracts issued to Boeing, Lockheed Martin, and Andrews Space.

THE PROMISE OF THE COMBINED CYCLE

Most past efforts to improve launch performance via air-breathing engines combined with rockets (the so-called combined-cycle systems) have never been able to demonstrate practical, operationally suitable results, although there are still several such concepts currently being pursued—at funding levels too low to possibly produce much in the way of operationally useful systems for years to come. However, there are a few recent developments in this category that appear to be worth following up actively, if sufficient funding can be made available.

Of the many research efforts seeking to demonstrate a practical high-speed air-breathing engine that might be adaptable to space launch, only two have achieved significant flight demonstrations: the third flight of NASA's X-43A in November 2004, whose supersonic combustion ramjet (scramjet) engine operated for 10 sec and boosted the craft to a new world speed record of Mach 9.8, and the first powered flight of Boeing's X-51A Waverider, which reached a Mach number of 4.87 in May 2010 and boasts the longest operating time to date of a scramjet engine: 143 sec. The engine was developed and built by Pratt & Whitney Rocketdyne.

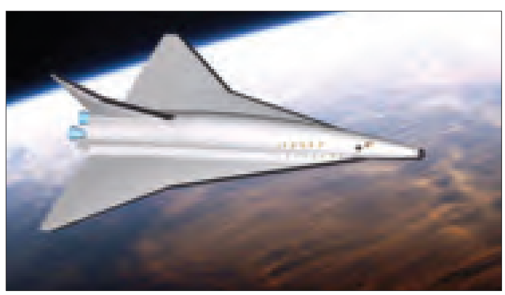
Several other potential combined-cycle approaches are also worthy of note. For example, Aerojet has proposed a three-engine concept, the TriJet, which combines the two classical combined-cycle designs—turbine-based and rocket-based—to achieve a smooth transition from start to over Mach 7. Lockheed Martin's axisymmetric scramjet, based upon a design conceived during DARPA's canceled Blackswift project, has been proposed as the turbine-based combined-cycle powerplant for a new Air Force Research Laboratory prototype of a long-range strike missile, planned for flight testing in 2016. Boeing's successor to the X-51 is another candidate for that mission.

Whereas current U.S. high-speed com-

Dr. Jerry Grey, an honorary fellow of the AIAA and a fellow of Britain's Royal Aeronautical Society, was professor of aerospace engineering at Princeton University, director of science and technology policy for the AIAA, and the founder and first publisher of Aerospace America. *He was instrumental in completing successful research on preventing rocket combustion instability, founder and director of Princeton's Nuclear Propulsion Laboratory, and organizing chairman of the University Space Research Association's Center for Space Nuclear Research. He was president of the International Astronautical Federation and deputy secretary-general of the United Nations' Unispace-82. He now consults on space policy and space propulsion.*

The black X-43A rides on the front of a modified Pegasus booster rocket hung from the special pylon under the wing of NASA's B-52B mother ship.

Lapcat has flight test targets of Mach 5 and Mach 8 using a hydrogen-fueled dual-mode ramjet-scramjet.



SpaceLiner is a two-stage all-rocket-propelled vehicle launched vertically from the ground for ultra-fast long-range flights.

bined-cycle engine concepts are aimed at military applications, Europe has been especially active in research on combined-cycle engines for high-speed transport that could be adaptable to space launch. ESA's Lapcat-II concept, a study conducted under the 4-year Long-Term Advanced Propulsion Concepts and Technologies program, has flight test targets of Mach 5 and Mach 8 using a hydrogen-fueled dual-mode ramjet-scramjet named Scimitar. This engine,designed by the U.K.'s Reaction Engines, employs air cooling and a shaftless air-compression system. One Lapcat-II vehicle design is derived from Reaction Engines' single-stage-to-orbit Skylon concept; another is based on a waverider under study by ESA's Estec and the U.K.'s Gas Dynamics; a third is being explored by France's ONERA and the Universities of Brussels and Rome.

A separate project under Lapcat is the Future High-Altitude High-Speed Transport 20XX (FAST20XX), a two-stage vertical-takeoff SpaceLiner concept by ESA and Germany's DLR. Both of its recoverable stages land horizontally; its upper stage uses a new staged-combustion hydrogen-oxygen rocket. Germany's Sharp Edged Flight Experiment (Shefex-2), whose design speed is Mach 11, is a pathfinder for suborbital reentry tests in 2020, building on the prior Shefex-1 flight at Mach 6 in 2005.

But despite all this activity, it is still far from clear that any of these efforts eventually can produce a practical, low-cost, operational space-launch capability.

Some will ask, "What about the Holy Grail of space transportation: fully reusable single-stage to orbit (SSTO)?" Unfortunately the physics of orbital launch (or at least, our present knowledge of physics) simply does not allow us to attain this ultimate goal. With our highest performance Earth-to-orbit launcher, the hydrogen-oxygen rocket, the rocket equation tells us that we need a mass ratio (propellant mass divided by takeoff mass) of about 0.9; that is, the total mass of engine, tanks, structure, controls, return and landing vehicle, and payload can total only about one-tenth of the launch vehicle's initial mass. For comparison, 0.9 is about the mass ratio of a hen's egg, if we consider the contents to simulate the propellant and the shell to contain everything else.

Past efforts to beat those odds, even with the benefit of an air-breathing boost engine, haven't even come close; for example, the X-30, the X-33, and Lockheed Martin's VentureStar. Britain's Skylon project, another single-stage-to-orbit wannabe, is still in its very early stages and will not be able to prove its worth (if any) for a long, long time.

And if we were to forgo advanced-technology Earth-launch concepts and devote our attention to reducing space transportation costs by using advanced higher thrust in-space propulsion for upper stages and space 'cruise' operations, we would face a nearly insurmountable cost and mass barrier: the need by all such systems (other than nuclear thermal rockets) for high electric power. This requirement, which calls for multikilowatt or even megawatt nuclear (or less practical solar) powerplants, imposes such severe mass penalties on the craft as to make any mission that requires both high performance and high thrust both impractical and much too costly. Several studies have explored the prospect of using beamed power from another satellite serving as a 'power depot,' but this option, although its basic technology is reasonably well advanced, would require considerable, expensive development.


Stratolaunch Systems, a new company based in Hunstville, Alabama, will develop and operate a new carrier aircraft bigger than a 747.

INNOVATION AND RISK

So with what options does this somewhat discouraging picture leave us? For Earth launch in the foreseeable future, there is really only one: Find ways to reduce the cost of space transportation by seeking major improvements in development practices, manufacturing and testing, and perhaps most important, flight operations. Such improvements—in all three areas—require both innovative thinking and, even more important, greater willingness to accept risk.

Innovative development practices have already begun to be pioneered in the U.S. by the new commercial entrepreneurs, most notably SpaceX and Scaled Composites. These companies, in contrast to the other 'new space' wannabes, have demonstrated initial operational success in flight, with development funding that is significantly lower than that of NASA or of the legacy launch-service providers. As cited in *Aviation Week* last August, "…SpaceX is ramping up plans to become the world's largest producer of rocket engines in less than five years, manufacturing more units per year than any other single country."

One of the newly revived operational concepts is airborne launch, which could be significant mainly for the abovementioned combined-cycle propulsion systems. Prior limited use for small payloads carried by rocket-powered orbital launchers, such as the highly successful DARPA/NASA Pegasus launch system developed by Orbital Sciences and ATK, has not demonstrated significant cost reduction. Indeed, two more recent programs for such launches, DARPA's 2003 Responsive Access Small Cargo Affordable Launch and the 2008 DARPA/USAF Quick Reach booster, were both canceled shortly after inception.

Nevertheless, in November 2011 DARPA reinstated the prospective use of airborne launch for small (45-kg) payloads in a new program named Airborne Launch Assist Space Access (ALASA).

Also, operational practices being pioneered by The Spaceship Company, a joint venture of Burt Rutan's Scaled Composites and Richard Branson's Virgin Galactic, along with their innovations in development and testing, could lead to significant cost reductions using airborne launch. Indeed, in December 2011 Paul Allen, cofounder of Microsoft, announced a new Huntsville, Alabama-based launch company named Stratolaunch Systems that will develop and operate a new carrier aircraft bigger than the Boeing 747. The aircraft will be designed and built by Scaled Composites; the rocket launcher it carries, able to orbit payloads up to 6,100 kg, will be designed and built by SpaceX. Although the current plan is to fly only unmanned payloads, the company's future prospects envision a human-rated launcher.

Allen's impressive design team includes Burt Rutan, his collaborator on X-Prize winner SpaceShipOne; Elon Musk, the CEO of SpaceX; former NASA Administrator Mike Griffin; David King, a former director of NASA Marshall; and Stratolaunch Systems' current president and CEO, Gary Wentz, a former NASA chief engineer.

Another interesting operational innovation is orbital refueling, currently being pursued as low-level research by both NASA and DARPA, with a relevant but low-budget

NASA demonstration project ($2.4 million in several study contracts) being considered by the Office of the Chief Technologist for 2016. Several commercial efforts to refuel and refurbish satellites have been abandoned, however, and NASA has recently downplayed orbital refueling as a low-percentage option. For human space missions, human-rating-proven legacy launchers such as Atlas V and Delta IV are another prospect, but one that does not offer much in the way of major cost reduction.

Outside the U.S., improvements in launch effectiveness (although not specifically in propulsion) are being pursued by all the spacefaring countries—Russia, China, Japan, and India—as well as the European Space Agency. ESA is considering the development of an Ariane 6; Russia is developing the Angara and Phoenix families to launch, among other payloads, a new human-carrying space vehicle (to replace the tried-and-true Soyuz launcher and capsule), and a brand-new Siberian launch site, Vostochny. China is designing several new high-payload versions of the venerable Long March family. India is upgrading its Geostationary Satellite Launch Vehicle, and Japan has the new H-2B. Although none of these developments can be categorized as employing 'advanced propulsion,' their improvements in development, test, and operations will contribute to some launch cost reduction and/or capability enhancement.

THE NUCLEAR AND SOLAR-ELECTRIC OPTIONS

Aside from these potential improvements, which are certainly worth pursuing but do not lead to the game-changing dreams of advanced-propulsion proponents, there appear to be only two prospects with any realistic near- to midterm hope of offering significant gains in cost and/or capability: the nuclear thermal rocket and one or more of the solar-electric options. Neither is applicable to Earth launch, the most costly component of space transportation; they are suitable only for upper-stage or in-space operations.

The nuclear thermal rocket, in which a relatively small nuclear fission reactor is used to heat hydrogen propellant to very

December 1, 1967, the first ground experimental nuclear rocket engine is seen in 'cold flow' configuration as it arrives at the Nuclear Rocket Development Station in Jackass Flats, Nevada.

high temperatures, offers reasonably high thrust (on the order of 75,000 lb) and about double the specific impulse of the best chemical rockets. It saw extensive development in the 1950s and 1960s, undergoing a series of quite successful ground tests. Its primary application was seen as a prospective propulsion system for a Mars mission, but when that mission faded from NASA's view in the early 1970s so did the nuclear thermal rocket. However, with renewed recent interest in human flights to Mars, the prospect of using the nuclear thermal rocket in an upper stage has seen some revival. NASA Marshall is currently conducting research on simulated nuclear-thermal rocket configurations, using electric heating to simulate the nuclear reactor's energy. A November 2009 *Aerospace America* commentary ("Nuclear propulsion—the affordable alternative") identified two key points:

• "Planning for human solar system exploration has stubbed its toe, badly, on a simple bit of reality: The performance of chemical rocket propulsion is inadequate. The mass ratio required to deliver something to Mars is over 20 times greater than with nuclear propulsion. The added costs of necessary ferry flights and on-orbit integration are fatal."

• "To resuscitate this option, major decisions must be made, beginning with recovery of the engineering data and equipment still available from remnants of the extensive Rover/NERVA nuclear rocket testing and development programs in the 1950s and 1960s. A fast-track program ranging over six or seven years to flight appears feasible."

Electric propulsion has seen not only extensive development in the past half-century or so, but also a large number of actual mission applications, ranging from comet and asteroid explorers to operational use for station-keeping in commercial communication satellites to orbit-raising of military satellites. Offering proven reliability and specific-impulse performance orders of magnitude higher than chemical or nuclear-thermal propulsion, it nevertheless has the principal drawback of all electric propulsion systems, as noted earlier: very low thrust in the absence of onboard megawatt-level electric powerplants.

However, if flight time is not of the essence, solar-electric propulsion can deliver reasonably high payloads much more efficiently than other propulsion options. For example, as an enabling technology for future human flights to near-Earth objects and Mars after 2020, NASA is now considering the prospects for multi-hundred-kilowatt solar-electric propulsion systems, with projected savings of required mass in low Earth orbit of up to 60% for such missions.

Skylon is a grandchild of the early British single-stage-to-orbit HOTOL concept. Currently being planned by Alan Bond of the U.K.'s Reaction Engines, it uses the Sabre engine,which combines turbomachinery using pre-cooled air with a hydrogen-oxygen rocket to enable flight from standstill to orbital speed.

But the engineering obstacles for even the smallest of these prospects (300 kW) are daunting: building an 800-m^2, high-voltage (~300 volt), radiation-protected (glass-covered) solar-cell array that is deployable in space and can withstand the Earth-departure acceleration. Moreover, getting budget approval of the development cost for such systems may be difficult: Even a small 15-30-kW demonstration project, begun by NASA in 2010, had a $1-billion-plus price tag before being cut back to a less ambitious undertaking.

All in all, the near- to-midterm prospects for applying 'advanced propulsion' to create a new era of space exploration are not very good. Nevertheless, there is every reason to continue seeking breakthrough technologies as an investment in the future, for example, via recently initiated programs such as DARPA's 100-year Starship project and NASA's Innovative Advanced Concepts, an outgrowth of the former highly successful NASA Institute for Advanced Concepts that was terminated in 2007 after 10 years.

But don't expect anything approaching *Star Trek*'s faster-than-light 'warp drive' for many years to come.

Real estate in frequency

The air around us is criss-crossed with invisible radio waves from TV transmitters, cell-phone masts, and satellites. Invisible because our eyes have evolved to detect wavelengths of what is called, for obvious reasons, the visible spectrum—'light.'

Those radio waves, the light from a TV screen and a host of other phenomena such as microwaves, heat, and UV rays, have more in common than most people realize. They are all part of the electromagnetic spectrum, a continuum of wavelengths from the ultralong waves of the radio spectrum to the ultrashort waves of the X-ray and gamma-ray spectrum, with the tiny window to which our eyes are sensitive somewhere in between.

Today, in the established field of satellite communications, the production of radio waves is as important as ever, but the challenge now is to utilize shorter wavelengths, or their inverse higher frequencies.

Frequency bands

In October 1957, when the first satellite, Sputnik, was launched, it announced its existence by means of an iconic 'beep-beep' in the earphones of radio amateurs and professionals around the world. The radio frequencies that produced these sounds were approximately 20 MHz and 40 MHz, toward the lower limit of what we know as the VHF, or very high frequency, band.

Since then, largely to avoid interfering with terrestrial transmissions, satellites and other spacecraft have gradually been developed to use higher and higher frequencies—not in the megahertz range but in the higher, gigahertz range.

This part of the spectrum has been divided into subbands, such as the familiar C-band and Ku-band. To an extent, the history of these divisions also provides a timeline for the development of satellite communications frequencies.

The first band widely developed for commercial fixed-receiver satellite communications services, such as trunk telephony and TV distribution to cable head-ends, was C-band (defined by the IEEE as spanning 4-8 GHz). The

by Mark Williamson
Contributing Writer

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As satellite services have grown more popular, the frequency spectrum available at currently used bands has been steadily filling up. This has created a need to develop new 'real estate' at higher-frequency bands, and to advance the technologies required for operating there. Technical challenges remain, but more and more satellite companies are beginning to invest in Ka-band systems.

driver for this was the relative ease with which the satellite and ground station hardware could be manufactured: The physical dimensions of antennas, feeds, and waveguides are intimately related to the wavelength of the radio waves, and because the relatively low frequencies of C-band equate to longer wavelengths, the waveguide dimensions are larger.

Put simply, in the 1960s and 1970s, equipment manufacturers would have been hard pressed to meet the smaller sizes and manufacturing tolerances required for the higher frequency bands. And if they had tooled up to deliver those finer tolerances, the equipment would have been unaffordable in the commercial market.

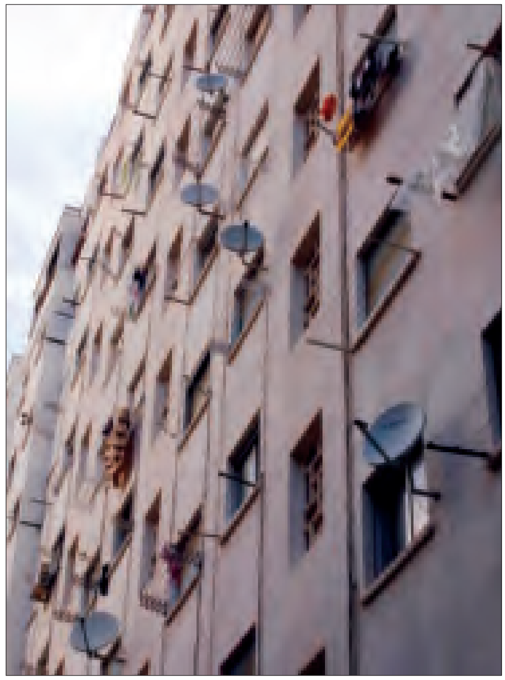
As it was, once C-band satellites became established, 5-m-diam. satellite dishes sprouted on apartment buildings and in motel parking lots across the U.S. like mushrooms, because wherever you were, all you needed was a satellite dish and a power supply. There was no need to dig up the roads to lay miles of cable.

Virtual real estate

C-band was sufficient for everyone's need for satellite channels in the early days, but as satellite services increased in popularity the frequency spectrum available at C-band began to fill up. Once frequency spectrum is fully utilized, all you can do is make 'tweaks,' such as developing ways to use the same bit of spectrum more than once—so-called frequency reuse, which is done by transmitting on opposite polarizations.

The same frequency band can also be reused by transmitting from satellites spaced widely apart on the geostationary arc, so that ground station antennas are pointing at completely different parts of the sky, and thus do not suffer interference. But this works well only when your nation is spread across a wide range of longitude, as is the U.S. In Europe, angular separation is extremely limited, so engineers began to develop the alternative real estate of Ku-band (which offered an extra 6 GHz of frequency space between 12 and 18 GHz).

Global Xpress, comprised of Inmarsat-5 satellites, will mark the first use of Ka-band by a commercial operator of a global satellite system.



Small TV antennas were the legacy of Ku-band. Credit: Mark Williamson.

The move to Ku-band, pioneered by ESA in the late 1970s, resulted in development of the first-generation Eutelsat and Inmarsat satellites, known respectively as ECS and Marecs (for Maritime ECS).

The technical advantages included the ability to provide the narrower coverage areas, or footprints, required by the smaller nations. This follows from the physics of antenna design that prescribes a narrower beamwidth at higher frequencies for the same physical antenna size. Moreover, narrower footprints meant that frequencies could be reused many times across a region without interference. This led ultimately to the development of multiple spot beams for frequency reuse within individual nations, akin to the now-familiar cell-phone network pattern.

But it was satellite-delivered direct-to-home (DTH) television that proved to be the 'killer app' for Ku-band. According to Roger Dewell, managing director of U.K.-based High Q Systems, it was Ku-band developments that engendered the small, wall-mounted receive dishes and made the DTH market viable in the first place, "because you need a smaller physical area at higher frequency bands to achieve the same amount of gain." Imagine, by contrast, having to mount a 5-m C-band antenna on your apartment wall!

Indeed, before long, Ku-band had become the de facto frequency space for broadcast TV and other advanced telecommunications applications in the developed world, leaving C-band for legacy cable distribution in the U.S. and for entry-level satellites in emerging nations. Meanwhile, lower frequency bands had been adopted for other applications: broadly speaking, L-band for mobiles, S-band for satellite telemetry, tracking and command, and X-band for military applications.

THE MAIN SATELLITE FREQUENCY BANDS *(as defined by ITU)*

Frequency band	Frequency range, GHz
L-band	1-2
S-band	2-4
C-band	4-8
X-band	8-12 (in U.S., 8-12.5)
Ku-band	12-18 (in U.S., 12.5-18)
K-band	18-27 (in U.S., 18-26.5)
Ka-band	27-40 (in U.S., 26.5-40)
O-band (not yet developed)	40-50 (Q-band in U.S.)
V-band (not yet developed)	50-75

Push to Ka-band

But even Ku-band was not enough. As early as the 1980s, there was a general realization that the technical advantages would be accentuated by an ordered progression from Ku- to K- and Ka-band (the designations Ku and Ka reflect their positions 'under' and 'above' K-band). Indeed, the 22-GHz of frequency space encompassed by K- and Ka-band speaks for itself.

In a push to provide the technologies required for the higher frequencies, ESA began developing Ka-band systems in the late 1970s. This culminated in 1989 with the launch of its Olympus technology demonstration satellite. Olympus carried a 20/30-GHz communications payload and a Ka-band beacon payload to quantify atmospheric attenuation at those frequencies. Its successful operation proved the potential of Ka-band and led to the development, by Italy, of the Italsat 1A and 1B satellites, designed to demonstrate the operational capabilities of an advanced Ka-band payload and provide a preoperational service within the Italian telecommunications network.

The Italsat spacecraft were launched in 1991 and 1996, respectively. Research into Ka-band was further advanced by NASA's ACTS (Advanced Communications Technology Satellite), launched in 1993, and Japan's COMETS (Communications Engineering Test Satellite), launched in 1997.

A major reason for the investment by space agencies in Ka-band research was the trend toward greater attenuation at higher frequencies. Typically, a signal transmitted through the atmosphere at Ka-band will suffer between five and 10 times the attenuation of a C-band signal. Thus, if nothing is done to increase the transmission power, the receiver will have to be that much more sensitive (and expensive), or the antenna will have to be larger.

In addition, the absorption of radiated energy by rain drops (so-called rain attenuation) can easily be more than 10 times as bad at Ka-band as at C-band. As Joseph Pelton, director emeritus of the Space and Advanced Communications Research Institute at George Washington University, notes: "This makes Ka-band much harder to implement in places with particularly heavy and seasonally intense rainfall, such as Southeast Asia and tropical Africa, where it can persist for months."

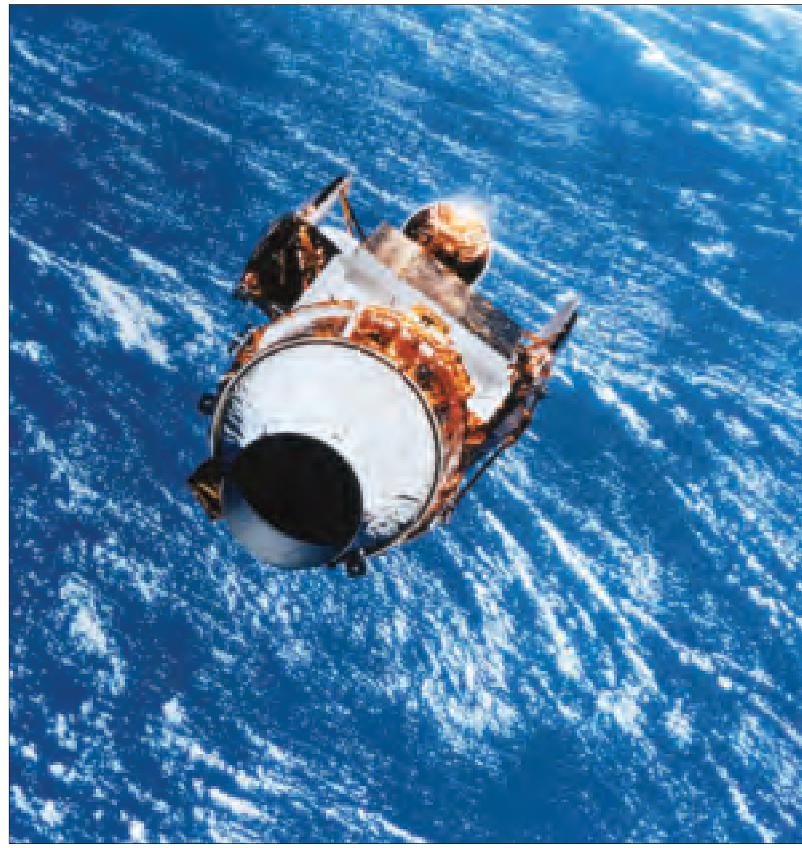
Luckily, Pelton explains, there are several solutions, including "highly concentrated antenna beams (0.5 degrees or smaller)" to provide higher radiated power to offset the attenuation, and adaptive systems that can target areas experiencing high rain rates "on demand." Although onboard processing can "correct the signal and restore its integrity on board the satellite," he continues, more R&D is needed "to develop cost-effective and reliable onboard processing capabilities."

Reasons for reluctance

But all this development costs money, which goes some way to explain why Ka-band systems are far from prevalent more than two decades after the pioneering technology demonstrations of ESA's Olympus.

Why have commercial operators shown such reluctance to jump on the Ka band wagon? For a start, explains Dewell, "moving to new frequency ranges means that new hardware must be designed and qualified for use in space. This is very costly for the supplier, and then for the purchaser, at a time when manufacturing volumes are low." Moreover, he adds, because "satellite communications is not built on first-mover advantage, hardware tends to be non-leading edge, as heritage and reliability win out over the latest designs." And because the dimensions of Ka-band hardware are smaller, any manufacturing defects will have more of an effect than at lower frequencies.

However, Dewell maintains that technical issues such as rain attenuation are "more of a system constraint than a commercial disincentive." It is more a question of "need vs. ability," he says. "There have to be overriding reasons why operators can no longer live with the older frequency bands, such as congestion of the spectrum." So we are back to real estate.



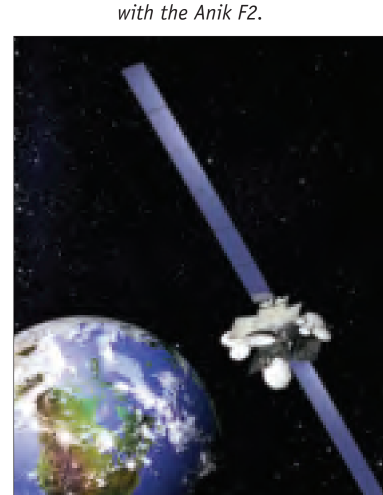
The 1993 launch of ACTS helped further Ka-band research.

Developments

Despite the challenges, in recent years, several satellite companies have invested in Ka-band systems. According to a July 2011 Euroconsult study of fixed satellite service operators, "17 operators have invested in Ka-band over the last 18 months, with six companies actually having launched Ka-band capacity."

Canada's Telesat was among the first to specify Ka-band on an operational, as opposed to experimental, basis with its Anik F2 satellite, which carried 38 Ka-band transponders to orbit in 2004.

Telesat was among the first to specify Ka-band operationally, with the Anik F2.



In the U.S., long-time operator Hughes, bought by EchoStar in 2011, has been migrating subscribers to its Spaceway 3 satellite, which has a Ka-band payload. However, the big push will come with Jupiter, its all-Ka-band satellite slated for launch by midyear: According to Hughes, it will have 10 times the throughput of Spaceway and will be able to handle 1.5 million-2 million subscribers. Like-

In Europe, Eutelsat has been leading the Ka-band rollout, most notably with its aptly named KA-SAT.

wise, Hughes' competitor ViaSat plans to capitalize on its ViaSat-1 satellite, launched in October, for its WildBlue broadband service.

In Europe, Eutelsat has been leading the Ka-band rollout, most notably with its aptly named KA-SAT: Its payload is based on 82 narrow spotbeams, which allow frequencies to be reused 20 times, and a total throughput of some 70 Gbps. Although Eutelsat's key competitor, SES, has been slower to adopt Ka-band, its Astra2Connect consumer broadband service will migrate from Ku- to Ka-band on future spacecraft. SES has three such satellites on order—Astra 2E, 2F, and 2G—and expects to launch them between this year and 2014.

More unusual is SES's participation as the largest shareholder of O3b networks, a Channel Islands-based company aimed at emerging markets. O3b (an abbreviation for other three billion, referring to people in regions lacking modern satellite services) plans to launch its first eight satellites in the first half of 2013 and has recently ordered four more from Thales Alenia.

Arguably the most surprising investor in Ka-band real estate is Inmarsat, which until now has used mainly the L-band spectrum. Its next-generation Inmarsat-5s will, according to the company, "form the backbone of our new Inmarsat Global Xpress network, offering broadband [download] speeds of 50 Mbps around the world" to mobile user terminals as small as 60 cm, and upload speeds of 5 Mbps.

Planned for launch in 2013-2014, the three Boeing 702 satellites are part of a new $1.2-billion worldwide wireless broadband network designed to make Inmarsat "future proof" in the face of increasing competition. As the company puts it, "Each Inmarsat-5 will carry a payload of 89 Ka-band beams, capable of flexing capacity across the globe and enabling Inmarsat to adapt to shifting subscriber usage patterns over their projected lifetime of 15 years."

Perhaps most significant—although Boeing is also prime contractor for the USAF's Wideband Global Satcom system, which uses Ka- as well as X-band—Global Xpress will mark the first use of Ka-band by a commercial operator of a global satellite system.

Supply issues?

A potentially show-stopping issue brought to light by the news media is an alleged 'supply bottleneck' of key satellite payload components that threatens to delay satellite manufacturing programs and launches in the coming years. The most critical item appears to be the Ka-band traveling wave tubes (TWTs) that form the heart of the satellites' high-power amplifiers.

The problem is one familiar to all markets of high-technology components, especially in the early development phase. R&D is expensive and often fraught with technical problems that can delay deliveries. Initial demand for products is low, because the market is wary of moving to new technology, but can ramp up quickly once early adopters have broken the ice (which is

Radio spectrum: Managing the resource

Every spacecraft needs a radio link with Earth. These communications links are made using specially designated parts of the radio frequency (RF) spectrum, a portion of the electromagnetic spectrum in the range 3 kHz-300 GHz. For convenience, the spectrum has been divided into bands by the ITU (International Telecommunication Union), the Geneva-based body responsible for planning and regulating international telecommunications services:

• VLF	3-30 kHz	• UHF	300-3,000 MHz
• LF	30-300 kHz	• SHF	3-30 GHz
• MF	300-3,000 kHz	• EHF (lower)	30-300 GHz
• HF	3-30 MHz	• EHF (upper)	300-3,000 GHz
• VHF	30-300 MHz		

Satellite communications frequencies are mainly in the SHF band, but UHF and EHF are also used.

The ITU allocates and coordinates radio frequencies for communications satellites, imaging satellites, science spacecraft, and any other space-based or terrestrial system that communicates using radio frequencies. It also allocates and coordinates geostationary orbital positions and nongeostationary orbital elements for a variety of spacecraft.

For frequency allocation, the ITU has divided the world into three regions: Region 1 is Europe, Africa, the CIS, and Mongolia; Region 2 is the Americas and Greenland; and Region 3 is Asia, Australasia, and the Pacific.

Satellite operators apply for the frequencies and orbits they intend to use to the ITU, which publishes the details for comment. In the U.S., the FCC performs a similar function. If no conflicts with existing or planned systems are identified, the resources are allocated to the operator (usually for exclusive use, but in some cases on a shared basis).

The process of frequency coordination ensures that satellite and terrestrial communications systems can operate without mutual interference. It entails the submission of details of channel frequencies, satellite orbital position, geographical location of the intended Earth station, a polar diagram of the antenna radiation pattern, and other parameters such as transmitter power and data format. An interference analysis is performed to determine whether the proposed service will interfere with existing communications links

The ITU defines a number of different satellite services, depending on how the satellite will be used. The most important are the FSS (fixed-satellite service), BSS (broadcasting-satellite service) and MSS (mobile-satellite service).

Of growing interest is the issue of resource management and control, the problem being that the ITU has no powers to police the applications or punish spectrum-hoarders, interferers, or other rule-breakers; it is simply a service organization tasked with the administration of frequency allocation and coordination. The process has operated smoothly in the past only because of the mutual understanding among users that breaking the 'rules' will eventually result in chaos for all.

The eventual solution—though there is little sign of it—may be to extend the ITU's remit by international negotiation, to let it police the spectrum for the good of all users. If the world is to maintain the communication links it now takes for granted, a solution must be found—sooner rather than later.

Clean room standards are extremely high for fabrication of devices such as traveling wave tubes, or TWTs, built at this Thales manufacturing facility. Credit: Thales Electron Devices.

now happening with Ka-band satellites).

But the overall market, by its nature, is relatively small and can support only a few key component suppliers (especially considering the high costs of entry), meaning buyers have a limited choice of supplier. For these and other reasons, there are arguably only three Ka-band TWT suppliers in the world considered 'up to the job': Thales Electron Devices of France, Tesat-Spacecom of Germany (formerly AEG-Telefunken), and L3 Communications of the U.S. (formerly Hughes Electron Dynamics).

Despite the news reports, Paul Maisonnier, vice president for microwave and imaging subsystems activities at Thales, says "To date, we have no production issues. We are in line with our contractual commitments." However, he finds it difficult to estimate his company's market share and cannot comment on any production issues at L3. "We have two factories producing space TWTs," he says. "Our competitor has one, so we estimate that global needs are spread similarly over these three factories." Although Maisonnier appears not to recognize Tesat as a significant competitor (despite its being the supplier of Ka-band tubes for the Inmarsat-5 system), he knows that "other companies are developing products, mainly in Asia," a market western suppliers ignore at their peril.

Building reliable space-qualified amplifiers is not like making iPods—when demand increases, you can't just turn up the speed dial on the production line. TWTs and other RF components usually are hand crafted by experienced technicians, while any technical problems are addressed by teams of expert engineers with resumés as long as their arms. Moreover, manufacturers, mindful of the telecommunications downturn of the early 2000s, are wary of expanding production too fast.

Despite this being a quality business, quantity too is an issue. Twenty years ago, a satellite equipped with 20 or 30 travelling wave tube amplifiers (TWTAs) would be fairly standard; today, it is not unusual to find 90 or 100 TWTAs on board. If it were simply a matter of multiplication, tube manufacturers might be able to cope; but quality control is so strict that many of these components have to be rejected before they get anywhere near a satellite. As Maisonnier puts it, "the constraints lead to lower manufacturing yield and longer manufacturing cycles." Some industry commentators suggest that rejection rates are over 50%. This simply adds to the pressure on tube manufacturers.

Given the problems with TWTAs, is there an alternative? Yes…and no. For decades, solid-state power amplifiers (SSPAs) have been replacing tubes as the high-

There are two main types of traveling wave tube, one cooled by conduction through a baseplate, the other by direct radiation to space (the bell-shaped cover has been removed to show the radiator fins). Credit: Thales Electron Devices.

power amplifier of choice in the lower frequency bands, but, as with tubes, it is more difficult to build them for higher frequencies. Perhaps more important is the SSPA's limitation on output power, mainly because of the difficulty of removing excess heat.

As satellite systems have evolved, the requirement for higher powers (coupled with narrower spot beams and smaller ground antennas) has driven the development of communications payloads, securing a role for the TWTA. Indeed, the recent move to Ka-band appears to have guaranteed the market for TWTAs for the foreseeable future.

Looking forward

The drive to develop the new real estate of Ka-band is rooted in the challenges of technology development, but is not a new phenomenon; nor is the leisurely pace of adoption. We are simply seeing a repeat of the 1970s' transition from C-band to Ku-band, which meant change for both satellite buyers and satellite users.

A satellite communications payload shows traveling wave tubes and electronic power conditioners. Credit: Mark Williamson.

Pelton is sanguine about the need for users to upgrade their ground segment hardware to handle the higher frequencies: "Today the costs of Ka-band ground systems are still much higher than C-band and Ku-band, but in 10 years Ka-band technology development and mass production volumes will bring the costs down," he says. In a forecast he conducted for NASA, Pelton concluded that, for comparable throughputs, the cost of Ka-band VSATs (very small aperture terminals) will be "about the same as Ku-band VSATs in 2015."

However, Dewell adds a warning that applies to any field of technology experiencing an upgrade: "There is a vast quantity of legacy home-receive equipment at C- and Ku-band that is effectively left behind by going to Ka-band," he says. How much of this equipment ends up in the recycling bins remains to be seen.

Pelton sets the prospects for Ka-band satellite services in the broader landscape of telecommunications: "The future in my view will be shaped as much as anything by the economics of not only fiber optic networking technology, but also the cost-efficiency of broadband terrestrial Wi-Fi and Wi-Max systems," he says. "One of the key things to watch is the O3b satellite system, which is optimized to support Internet protocol-based services and to interface with Wi-Fi and Wi-Max systems."

Pelton envisages a future in which "terrestrial fiber, coax, satellite, high-altitude platforms, and terrestrial wireless have largely seamless air interface standards that allow the consumer to get broadband services anywhere and at any time." This would make the Ka-band satellite just one of many options and, he says, would even "obviate the need for a large migration to Ka-band and certainly forestall a further migration to Q/V-band frequencies."

Despite the uncertainties, Dewell's overall view is positive. "I think there is a great deal of interest in Ka-band for commercial satellite services," he says, "and the pace of implementation will grow now that space-qualified hardware has become available."

However, while recognizing the benefits of smaller receive terminals and "the ability to operate for a while in a reduced-interference environment," he believes the rush toward Ka-band will "plateau once there is a reasonable community of users around the world and potentially very different systems have to coexist." Much of the initial effort will amount to "land-grabbing…claiming an early stake in a new operating region of the spectrum."

Developing the real estate of space, even the virtual resources of frequency space, has never been easy. But those hard-to-predict applications—DTH television, in-car satellite radio, real-time telemedicine, UAV operations, satellite navigation—are testament to the return on investment and effort. If Ka-band opens the door to more of the same, then bring it on! A

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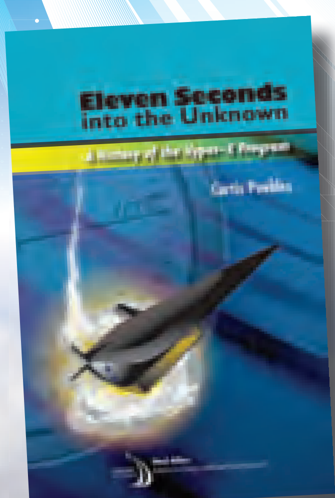

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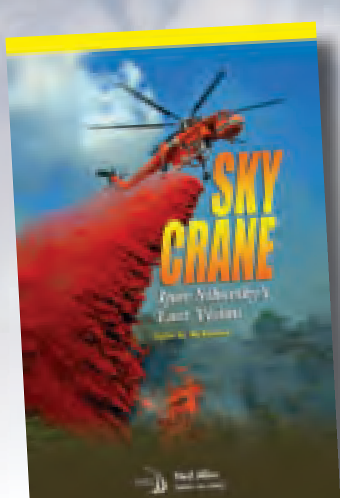

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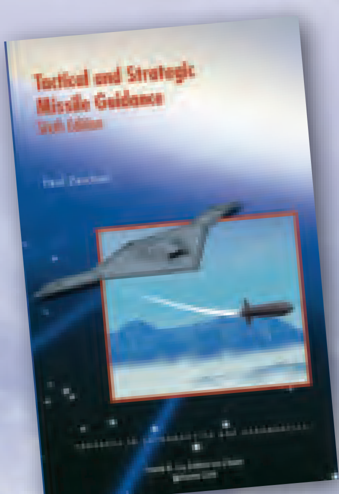

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President Obama announced in 2010 that NASA's next major destination would be an asteroid, an interim step in long-range plans for travel to Mars. Missing from the administration's roadmap is the Moon, which is getting a second look from planners who now see it as an ideal site for proving hardware and training crews for the coming asteroid missions.

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SLS Development begins

The towering Space Launch System (SLS) rocket, under design by NASA to propel U.S. astronauts beyond Earth orbit again, may find the road to President Obama's 2025 asteroid goal paved with Moon dust.

There are two versions of the SLS: the initial Block 1, which will lift 70 metric tons of payload to Earth orbit, and the much larger Block 2, with 130-metric-ton capability. Major contracts for initial development will be awarded to several major contractors this year.

LEAN APPROACH

For the Block 1 version, NASA plans to use lean manufacturing techniques that can equally benefit development of the larger Block 2 rocket. The purpose is to achieve a matrix of cost-effective launch capabilities needed to accomplish the deep-space human exploration goals of this century.

Scientists believe NASA must also plan visits to more than one asteroid to make such a national undertaking worthwhile, although the president called for only one.

Engineers led by John Shannon, former space shuttle program manager, are now working on an SLS Exploration Roadmap. Details emerging from that work indicate that a first mission, to take place as early as 2017, will be an unmanned lunar orbit flight, although the vehicle will be carrying the Orion multipurpose crew vehicle. Reentry from a high apolune will test the Orion heat shield's performance with at least 20,000-mph reentry heating.

Then, in 2018 or 2019, the second SLS mission could be launched carrying astronauts into lunar orbit. The proposed mission would be a unique exploration focusing on the far side of the Moon and the Aitken Basin, an 8-mi.-deep crater exposing eons of lunar geology.

The SLS program has worked out in ways that are having some profound effects. The Obama administration opted for an asteroid mission as a stepping-stone to Mars, shunning the Moon because "we've already been there," as the president said.

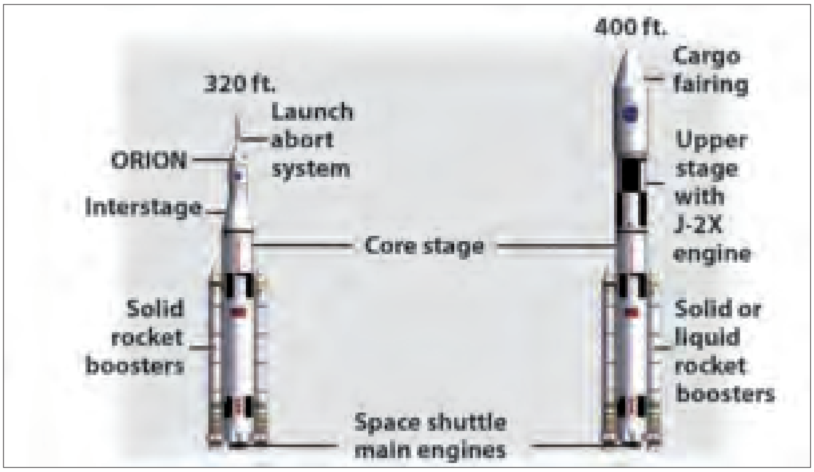
That drew unusually sharp public criticism, led by former astronauts Neil Armstrong and Gene Cernan, former NASA Administrator Mike Griffin, and the agency's first manned flight director, Chris Kraft, who was an architect of the Apollo program and also director of NASA Johnson.

With all that will be required for reaching and studying an asteroid, it has become clear to NASA and its contractors that much remains to be learned—about all the hardware and human interactions with it, including life-support systems. The Moon, they believe, is a good place for learning all this. Training on or near the Moon would mean crews could return to Earth in only three or four days. That would be instead of taking on, at first shot, the six-to-eight-month round trips required for minimum asteroid missions.

It will be several more months before the Exploration Roadmap is complete, and NASA is not commenting on it yet, all of which has left a vacuum for more criticism by Kraft: "The present concept, to initiate [the SLS] large-scale rocket with the plan to land on an asteroid in 2025 and travel to Mars in 2035, is not a realistic goal," Kraft wrote in a December 2011 opinion piece in *Space News*. "The national budget will not

The initial 320-ft-tall Block 1 version of the SLS could fly as early as 2017. It would be 43 ft shorter than the 363-ft Saturn V, and its 70-metric-ton payload capability would be somewhat less than the two-stage version of Saturn V that launched Skylab. Depending on mission needs, the Block 1 could have an interim cryogenic propulsion system as a small upper stage. NASA image.

by Craig Covault
Contributing writer



A comparison between the Block 1 (left) and Block 2 versions shows the scale of the two rockets. The smaller vehicle would fly by 2017; the larger would wait until about 2024. NASA Image.

support the cost and the technology required to accomplish these objectives. The money is simply not available, nor will it be anytime soon."

LUNAR ALTERNATIVES

Given the emerging emphasis on lunar precursor missions, Kraft may get his wish in a serendipitous way. Instead of the SLS, he is calling for "an aggressive multinational effort to pool launcher and spacecraft capabilities" for a push to return to the Moon, this time for exploitation of its resources. This would include use of the lunar far side for optical and radio telescopes that will "search the universe to uncover secrets not viewable by other means," he sayst.

If SLS-2 is launched in 2018 it will mark the 50th anniversary of Apollo 8, when astronauts Frank Borman, Jim Lovell, and Bill Anders were the first humans to fly 240,000 mi. to visit the Moon from lunar orbit and see the entire Earth from afar. In other words, it will have taken the U.S. 50 years to return to what it had already achieved as a human exploration starting point half a century ago.

This time, however, the proposed SLS-2/L2 mission would fly a far different trajectory, splitting the time between the L2 Lagrange point and a course above the lunar far side, where the crew would have more dwell time.

The strawman manifest is important under the Obama administration plan, because of costs and because the missions on the coming roadmap are the only reasons for the SLS to exist. A return to limited lunar landings, theoretically, would also demonstrate on the Moon a range of asteroid-related shelters and space exploration vehicle candidates—a must, some planners believe.

One option proposes that five manned lunar missions log a total of 28 days on the Moon to prove out such hardware before sending a crew to an asteroid. But that plan would have a near impossible ride in the budget process.

PERFORMANCE TRADEOFFS

NASA public affairs personnel often tout how the SLS will be the most powerful rocket ever built. And that will be true for Block 2, but not for the 70-metric-ton payload version to be developed and flown between now and 2021. The Block 1 SLS will have 4 tons less payload capability than the two-stage Saturn V that launched the Skylab space station.

The 70-metric-ton version is based on no second stage or upper stage. But for manned missions it might well use an interim cryogenic propulsion system—essentially a Delta IV Heavy upper stage.

The Saturn V of Apollo and Skylab fame could place 260,000 lb, or 117 metric tons, in orbit in its Apollo three-stage configuration. It could launch about 74 metric tons in its two-stage form. Ironically, during its only launch carrying Skylab, that 'small' Saturn V's first stage developed nearly 9 million lb of thrust during its climbout, more than any other Saturn V flown, NASA documents show. All Saturn Vs had five first-stage Rocketdyne F-1 engines powered by LOX/RP-1 propellants; the 12 flown as three-stage lunar versions, nine of them to the Moon, had LOX/ hydrogen second and third stages.

The 70-metric-ton SLS version will be powered by three space shuttle main engines (SSMEs) in the first-stage core and two five-segment ATK solid rocket boosters. Dominating development until about 2021, it will trailblaze new manufacturing processes and lead testing of most structures, propulsion, and avionics.

The more powerful SLS Block 2 will have five first-stage SSMEs to launch 130-metric-ton payloads. Again, the issue is cost savings.

Comparisons with the 363-ft, 7.5-million-lb-thrust Saturn V are unavoidable: Both versions of the SLS will improve on the Saturn's liftoff thrust, the smaller one by 10% and the larger one by 20%.

For the larger, five-SSME-engine version, NASA plans to use the same tooling and lean manufacturing technology to realize cost savings. The development would be staggered so that they would not be built until closer to the time they will be flown, starting about 2025.

Twin strap-on solid rocket boosters like the new five-segment ATK motors will be used initially. But as 2021 looms, NASA will compete large solid motors against large liquid-propellant strap-ons, likely using LOX/RP-1 propellants. Potential contender strap-on Block 2 engines are the SpaceX Falcon 9, the Energomash/Pratt Atlas V RD-180, and the Orbital Sciences Aerojet Taurus II AJ26 program modification of Russian NK-33s, used in the first stage of the Soviet N-1 Moon rocket.

Powering the vehicle's upper stage will be the Rocketdyne J-2X, an uprated version of the engine that powered the second and third stages of the Saturn V. Conceivably, it could also see service atop the Block 1 SLS with the program's matrix philosophy.

Between 2017 and 2024, Block 1 could launch payloads to the ISS and astronauts to Lagrange points and geosynchronous orbit. One concept yet to be raised significantly is a capability for SLS/ Orion astronauts to service the Webb Space Telescope, set for launch in 2018 to a Lagrange point a million miles from Earth. Many planners believe that after the troubled and expensive Webb development it makes sense to have a servicing capability via the SLS/Orion. A simple grapple fixture is on the Webb for this purpose, and Lockheed Martin has already designed an Orion version equipped with a manipulator arm for such servicing.

BUDGET CONCERNS

Kraft and other experienced space managers remain concerned about whether the coming administrations, and especially Congress, will fund the SLS program adequately. The Obama administration, on being presented with the booster program, had sticker shock for months.

After extensive review with the administration, NASA has settled on an $18-billion budget spread over six years to develop the Block 1 through its first unmanned test flight in 2017. That figure also includes continuing development of the Lockheed Martin/Ball Aerospace Orion, proposed by the company for a 2014 initial Earth orbit test to be launched on a Delta IV Heavy. This will provide the project with $3 billion a year in level funding until the first ascent.

But there is a catch. Only about $1.2 billion out of the $3 billion will be solely for the SLS. The rest will go to Orion, to the continuing search for asteroids that would be suitable mission destinations, and to development of everything else needed to support such missions.

"We think this is a very good funding number for the initial capability and shows we have the core system and ground operations for a 70-metric-ton capability that can be human rated with the Orion multipurpose crew vehicle on the first SLS unmanned flight," explains Bill Gerstenmaier, NASA's associate administrator for space operations.

"The way we have been looking at this is that roughly $3 billion per year [is] for six years of core system design, development, and initial flight with an Orion multipurpose crew vehicle and the ground operations involved.

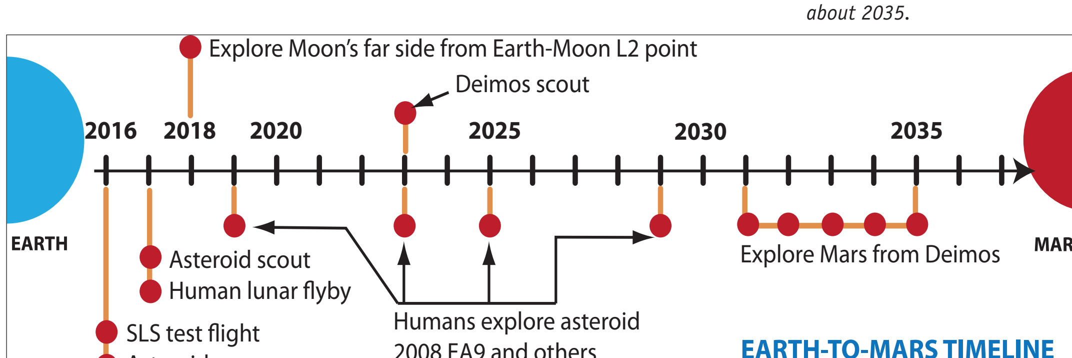
"We think that is a very good number for the initial capability. It shows that we have a 70-metric-ton capability that flies initially in an uncrewed configuration but is designed to be human rated; and part of the human rating is this first uncrewed flight," Gerstenmaier says.

The cost through the mid-2030s for gaining experience beyond the Moon is estimated at about $35 billion.

"So we have that basic capability in place, and then we have to buy production units and other elements to fly, to add additional capability to the rocket," he says.

Dan Dumbacher, NASA deputy associate administrator for exploration systems development, told potential SLS contractors in Huntsville in December that "SLS development is on track, and we are meeting the dates" NASA set for the program.

Mission planning is also a key element in building excitement and support for continued human exploration and for develop-



The straw man manifest proposed by Lockheed Martin, the company that is building the Orion multipurpose crew vehicle, shows a range of SLS missions, including four asteroid landings, before the big push to manned Mars flights about 2035.

The six space shuttle main engines (SSMEs) that powered Endeavour and Atlantis on the final two shuttle missions are readied at KSC for shipment to Pratt & Whitney Rocketdyne. There they will be prepared for use as expendable engines on early SLS flights. NASA image.

ment of the SLS booster, especially if budgetary or political turbulence in Congress becomes a serious threat to the program.

That mission planning includes at the front end a wholesale restructuring of management leadership lines, directorates, and their roles and internal offices at NASA Marshall, Johnson, and Kennedy.

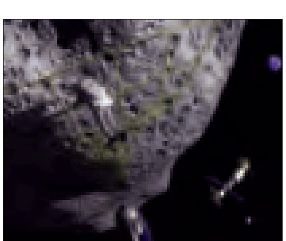
"For example, in Houston, the famed Mission Operations Directorate has outlined a draft memorandum of understanding with the SLS program, ranging from their involvement from a flight operations standpoint, through to ascent operations and participation with the systems requirements review process," says Chris Bergin, writing for the authoritative NASAspaceflight.com website.

In documentation prepared for introducing specifications to an initial group of 60 major contractors, NASA opted for a much broader view, saying "SLS is a national asset for 'multiple stakeholders' and partners." The lunar science, asteroid, and Mars science communities are all examples of 'multiple stakeholders,' as are the Defense Dept., National Reconnaissance Office, and CIA.

EXPLORING THE FAR SIDE

One idea drawing considerable interest is a possible 2018 mission to explore the lunar far side by using an SLS to launch an Orion crew to the L2 Lagrange point. The minimal planetary gravity there would enable a highly instrumented Orion to cycle easily between the lunar far side and L2. This would give crews unprecedented time over the target area, enabling them to conduct studies and control rovers that explore the Moon's south pole Aitkin Basin. Difficult to reach with a cost-effective manned mission, the basin is "among the highest priority activities for solar system science." The mission could retire risk by:

- Demonstrating Orion in deep space with a high-speed Earth reentry.
- Enabling a 30-35-day mission into translunar space as early as 2018.
- Providing a crew with deep space flight distances 15% greater and three times longer in duration than those of Apollo.
- Enabling crews on Orion to practice controlling robotic rovers on the lunar far side before asteroid or Mars missions.
- Demonstrating the use of small orbital habitats like those to be used during longer stays at asteroids or Mars.



This graphic illustrates how a future astronaut could lay a grid structure on an asteroid as both a handhold and workspace guide. Orion, with circular solar arrays attached to a habitat, is far below, while an astronaut vehicle is tethered to the asteroid. NASA image.

A Human Space Exploration Science Community Workshop held in San Diego in November 2011 ended by proposing the L2 lunar far side mission for 2018, to be followed by asteroid missions in 2019, 2024, 2025, and 2029.

The Martian moon Deimos could be explored on a 2031-2035 flight, leading to the initial manned Mars landing in that timeframe.

HARDWARE NEW AND ALSO OLD

To make these future visions a reality, a great deal of SLS hardware development will be needed over the next four years. Both the 70- and 130-metric-ton SLS vehicles will have 27.56-ft-diameter first-stage cores with both liquid hydrogen and liquid oxygen tanks. Saturn had a 33-ft-diameter first stage, but the SLS will still have a larger propellant load because it uses hydrogen rather than RP-1 and has a much taller first stage—176.7 ft for SLS compared to 'only' 138 ft for the Saturn V.

The SLS first-stage diameter was selected to save development money up front at the Kennedy Space Center, says Gerstenmaier. Because the diameter is the same as that of the shuttle's external tank, the same huge processing equipment used for the shuttle during stacking in the Vehicle Assembly Building and transport on a mobile launch platform can also be used with the SLS during stacking and transport to Launch Complex 39B.

"We will initially use three Pratt & Whitney Rocketdyne RS-25D 500,000-lb-thrust space shuttle main engines underneath the core and at some point grow to five first-stage SSME engines," he says. "That will give us a variable thrust capability, which will help for different versions of SLS."

The Michoud Assembly Facility in New Orleans will manufacture the core, as it did the shuttle external tank and the Saturn V first stages before that. Contract selections are pending, however, for SLS tank work.

Pratt & Whitney's continued management and hardware support for the RS-25Ds, or SSMEs, is being retained for the SLS program. Fifteen of these reusable engines are now being readied for SLS flights beyond Earth orbit. There will be a transition to the less expensive expendable version of the SSME, known as the RS-25E, either after the four sets of RS-25Ds have been used or after two additional RS-25D sets have been manufactured. Eventually, the engine driving the core stage will be the expendable, and cheaper, RS-25E.

The MPS (main propulsion system) engine plumbing that snaked through the shuttle's aft compartment has been pulled from each orbiter for use in the SLS program. Discovery's MPS will likely be used on test stands. Atlantis and Endeavour's MPS plumbing will probably be reflown to provide the liquid oxygen and liquid hydrogen propellant to the engines powering SLS-1 and SLS-2 on their initial ascents.

The propellant tanks that will make up the SLS upper stage are being designed simultaneously and with the same 27.6-ft diameter as the first stage so it too can be built with the same tooling to save costs.

Manufacturing of upper stages will be paced more with flights that need them in the 2020 time frame. The upper and core stages will be designed simultaneously to use the same core as well as common electronics and tooling, again to save costs.

"We think the RS-25D and newer E engines will give us a nice flexibility...a rocket that can fly in a variety of thrust ranges, a variable rocket that meets our heavy-lift needs for exploration activity beyond LEO, and that also can satisfy some other potential needs," Gerstenmaier says.

The Pratt & Whitney Rocketdyne J-2X upper-stage engine that was in development for the Constellation program is being retained as the upper-stage engine for the 130-metric-ton SLS.

The initial LOX/hydrogen J-2 was used on the Saturn V. There were six on each Saturn—five on the second stage and one in the third. But the J-2X for SLS is a substantially uprated engine. The J-2 had 232,000 lb of thrust and a specific impulse of 421 sec. The J-2X for the SLS rocket will have 294,000 lb of thrust and a 448-sec I_{sp}.

Some J-2X testing continues at a low level at NASA Stennis. A November 9, 2011, J-2X test lasted 499.97 sec and will likely be the last big test until later in the program, to help smooth out the cost picture.

But a major effort is under way to develop as many common components and suppliers as possible for parts and electronics used on both the J-2X and SSMEs, again to lower costs.

NASA intends to use ATK five-segment solid rocket motors in the first few flights of the SLS, then shift to more advanced solids or liquid propellant strap-on boosters for added safety and performance for the 130-metric-ton SLS.

The planned shift away from the ATK five-segment motor is going to spark one of the most significant rocket propulsion competitions in decades, and both solid and liquid entrants will be accepted. The competition will also advance the work already under way at various contractors and federal labs on new LOX/kerosene engines that could provide tremendous power as strap-on boosters to the SLS hydrogen-fueled core.

The 355-ft-tall mobile launcher built at Kennedy for the Constellation program will fit both SLS versions very well. In late 2011 the launcher was rolled to Launch Complex 39B, where its dominating presence on the coast in front of the VAB was a sign that the U.S. manned space program, despite cancellation of the shuttle, is alive.

However, Chris Kraft remains undeterred. "Come on NASA, wake up!," he writes in *Space News*. "Take the lid off and turn loose the human resources you already have in place. Most of these bright people came to NASA excited about the future, about going back to the Moon to stay and becoming a part of what could be another renaissance in space.

"Building a great big rocket is not a necessary expenditure at this time. In fact, the budget that will be consumed by this big rocket will prevent NASA from any meaningful human exploration for at least the next decade and probably beyond. We don't have to march in place while we wait for the powers that be to cancel it. Let's be innovative; let's wake up the sleeping giant and have at returning to the Moon right now," urges Kraft.

But such a concept has its own major challenges, and given the space program's state following the termination of the shuttle and layoffs in the thousands, the program is ready to move on with development of an SLS. And the rocket may possibly be Moon-bound after all, at least as a stepping stone toward new human discovery and enterprise in deep space.

A highly uprated and modernized version of the Pratt & Whitney Rocketdyne J-2X used originally in the Apollo second and third stages will be the upper-stage engine Block 1 SLS. It will have 294,000 lb thrust, 69,000 lb more than the Apollo J-2. NASA Image.

The ATK five-segment SRB produced 3.6 million lb thrust during more than 2 min of burn time during this test near Promontory, Utah. Two five-segment motors can provide an SLS with 30% more boost than the four-segment versions used on the shuttle. ATK image.

25 Years Ago, March 1987

March 9 To escape a takeover threat by TWA, USAir moves quickly to announce its $1.59-billion purchase of Piedmont Aviation. The agreement is one of the last possible marriages remaining among big independent airlines in the rapidly consolidating business. R. Gladstone, AP, *Houston Chronicle*, March 10, 1987.

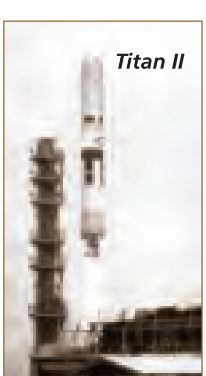
50 Years Ago, March 1962

March 4 The Discoverer 38 satellite is successfully air-snatched by a C-130 recovery aircraft near Hawaii after being launched four days earlier from Vandenberg AFB, Calif. *The Aeroplane*, March 8, 1962, p. 242.

March 5 United Technology announces the successful first firing of four experimental 10,000-lb-thrust hybrid rocket motors using solid fuel and a liquid oxidizer. The company is now considering scaling up these engines and using high-energy propellants for possible upper-stage propulsion. *Flight*, March 15, 1962, p. 412.

March 6 A Convair B-58A Hustler supersonic bomber flown by Capt. Robert G. Sowers and crew between Los Angeles and New York breaks three world records on the round-trip flight. One is for flying coast to coast in 2 hr 58 min 71 sec at 1,216.47 mph; one for a round-trip made in 6 hr 41 min 11 sec at 1,044.5 mph; and one for a double crossing of the U.S. For these feats the crew is awarded both the MacKay and Bendix Trophies. F. Mason and M. Windrow, *Know Aviation*, p. 62; D. Daso, *U.S. Air Force: A Complete History*, p. 428.

March 7 The first 450-lb Orbiting Solar Observatory, OSO-1, is sent aloft from the Atlantic Missile Range by a Thor-Delta launch vehicle. The satellite and its data are designed to provide the first clear understanding of the Earth-Sun relationship and enable more accurate predictions of solar storms. OSO-1 will measure solar electromagnetic radiation in the ultraviolet, X-ray, and gamma-ray regions, and is said to have potential for returning more scientific data than any previous satellite. *Aviation Week*, March 19, 1962, p. 29.



Titan II

March 13 NASA Administrator James E. Webb recommends to President John F. Kennedy that the Apollo manned Moon landing program be assigned a DX priority, the highest priority in the U.S. government's procurement of critical materials. I. Ertel and M. Morse, *The Apollo Spacecraft, Vol. I*, p. 143.

March 16 A Titan II ICBM makes its first successful launch from Cape Canaveral, Fla., and lands in a designated target area 5,000 mi. down range. This is also the first flight in which a U.S. missile uses storable propellants of nitrogen-tetroxide and hydrazine. *Aviation Week*, March 26, 1962, p. 24.

March 16 The USSR launches Cosmos 1, also designated Sputnik 13, to investigate the ionosphere and space and to "test the design elements of a spacecraft." It is the first of the famous Cosmos series, which will comprise thousands of satellites over time. Many are secret Soviet spacecraft about which the USSR releases a minimum of information, but some are identified by Western authorities as reconnaissance or other military craft. *Flight*, April 12, 1962, p. 539; *Aviation Week*, March 26, 1962, p. 24.

March 17 President Kennedy's proposals to Soviet Premier Khrushchev for U.S.-USSR cooperation in space are made public. Suggested projects include two weather satellites to provide global coverage, the exchange of information on space medicine, and cooperation on experimental communications satellites. *Flight*, March 22, 1962, p. 447.

March 21 A bear named Big John is given tranquilizers and flown from Edwards AFB, Calif., aboard an Air Force Convair B-58 Hustler bomber at 870 mph. The bear is then ejected at 35,000 ft in a fully enclosed test ejection capsule built by Stanley Aviation, landing safely by parachute after a descent lasting more than 7 min. Big John was chosen as a test subject because his internal organs and spinal column are similar to those of a man. *Aviation Week*, April 2, 1962, p. 25; *Flight*, April 19, 1962, p. 599.

P-21A

March 29 The four-stage all-solid-fuel Scout vehicle is launched at NASA's Wallops Island site. It carries a 90-lb ionospheric probe called P-21A to a peak altitude of 3,910 mi. to measure electron and ion densities

Past

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

under nighttime conditions, concluding experiments important for radio tracking and guidance and for understanding the Earth's ionosphere. *Flight*, April 19, 1962, p. 600.

And During March 1962

—The first Boeing C-135B, which will extend the operational range capability of the Air Force's Military Air Transport Service in the Pacific, is delivered to Travis AFB, Calif. The craft has about 40% more thrust from each engine than the C-135A, and has the same basic airframe as the KC-135 and C-135A. *Aviation Week*, April 9, 1962, pp. 98-99.

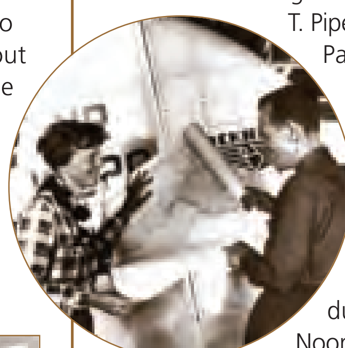
75 Years Ago, March 1937

March 1 The first operational Boeing B-17 is delivered to the General Headquarters of the Army Air Corps, 2nd Bombardment Group, at Langley Field, Va., becoming the first four-engined bomber to enter the Air Corps and the first plane to fulfill William 'Billy' Mitchell's concept of an effective all-weather long-range bomber. E. Emme, ed., *Aeronautics and Astronautics 1915-60*, p. 35.

March 9 The British secretary of state announces that Imperial Airways' experimental passenger, mail, and freight service between Penang and Hong Kong, which began March 23, 1936, will continue on a permanent basis. *The Aeroplane*, March 17, 1937, p. 333.

March 13 The first presentation of the Rear Adm. William A. Moffett Memorial Trophy is made to Lt. Robert F. Hickey, commanding officer of the USS California Aviation Unit of Observation Squadron 4. The award, established by naval aviation pioneer Glenn H. Curtiss, goes annually to the battleship- or cruiser-based aviation unit that conducts its operations throughout the year with the maximum safety. *Aero Digest*, April 1937, p. 84.

March 16 A fire almost totally destroys the factory of Taylor Brothers Aircraft in Bradford, Pa., halting production of the popular light personal planes called Taylor Cubs. Later in the year, the new owner and former general manager, William T. Piper, renames the firm Piper Aircraft and moves it to Lock Haven, Pa. The planes, thereafter known as Piper Cubs, attain phenomenal success. *Aero Digest*, April 1937, p. 86.



March 17 Amelia Earhart and Fred Noonan fly from Oakland, Calif., to Honolulu, Hi., on the first leg of a proposed round-the-world flight. However, the trip is temporarily abandoned because of damage to their Lockheed Electra from a tire blown out on takeoff. It is during the attempt in the summer of 1937 that Earhart and Noonan are lost over the Pacific. *Aviation Year Book 1938*, p. 408.

March 22 Five Soviet airplanes leave Moscow for the North Pole to explore the possibility of establishing a midway station for a polar air route from Moscow to San Francisco. Ten scientists and a number of assistants and sleigh dogs are included in the expedition. *The Aeroplane*, April 14, 1937, p. 424.

March 30 Pan Am Capt. Edwin C. Musick, piloting a Sikorsky S-42B flying boat, completes a 7,000-mi. survey flight from Pago Pago, American Samoa, to Auckland, New Zealand. *Aero Digest*, May 1937, p. 86.

100 Years Ago, March 1912

March 1 Capt. Albert Berry makes the first successful parachute drop from a plane, at St. Louis, Mo. C. Gibbs-Smith, *Aviation*, p. 166.

March 28 Claude Graham-White makes Europe's first, albeit brief, night flight. Other pilots, including James Travers and Bentfield Hucks, soon make their own flights and also start to use the first field lighting in Europe. This consists of CAV electric lighting, familiar to motorists, as well as searchlights. C. Gibbs-Smith, *Aviation*, p. 154; *Flight*, Aug. 14, 1912, p. 776.

MECHANICAL ENGINEERING – WRIGHT STATE UNIVERSITY

Wright State University (WSU) invites applications for one tenure-track faculty positions in the Department of Mechanical and Materials Engineering. The position is affiliated with the Micro Air Vehicle Center at WSU, which has state of the art MAV fabrication equipment, and there is also opportunity to work in a state-of-the-art bench- and flight-science facility to fabricate and validate the designed vehicles.

The position is at the assistant professor level, however, exceptional candidates can be considered for a higher rank. The successful candidate will be expected to develop a funded research program and teach courses in Mechanical Engineering at both the undergraduate and graduate levels.

Applicants must have an earned PhD in Mechanical Engineering or related discipline before the anticipated start date of August 16, 2012. Applicants for assistant professor are expected to show propensity for scholarship, generating a research program, and teaching. Consideration for higher ranks requires significant additional experience and a demonstrated proficiency in scholarship, sponsored research, and teaching commensurate with the level sought.

Applicants for the MAV position must apply through Wright State University website https://jobs.wright.edu/ . Review of applications will begin April 2, 2012.

WSU is a public institution of over 19,000 students located in a technologically rich region of southwestern Ohio adjacent to Wright-Patterson Air Force Base. The Department has recently received funding for a Center of Advanced Power and Energy Conversion and features centers for Micro Air Vehicles and Computational Design and Optimization.

WRIGHT STATE UNIVERSITY is an Affirmative Action/Equal Opportunity employer.

University at Buffalo *The State University of New York*

Faculty Position in Aerospace Engineering

The Department of Mechanical and Aerospace Engineering at the University at Buffalo, State University of New York seeks an outstanding individual for a tenure-track position at the Assistant Professor level in the area of guidance, navigation and control of aerospace vehicles. Appointment at higher rank is possible in exceptional cases. Research topics include, but may not be limited to, air-traffic management, orbital/attitude dynamics, autonomous aerospace vehicles, distributed estimation and control of multi-vehicle systems, methods for model-data fusion and optimal information collection to enhance situation awareness, space-weather modeling, conjunction assessment, and collision avoidance methods.

Applicants with original and creative visions of research will be given high priority. The successful candidate will be expected to develop an independent, externally-funded, internationally-recognized research program, teach graduate- and undergraduate-level courses, develop new specialized courses, supervise graduate research and contribute to departmental affairs.

The School of Engineering and Applied Sciences at Buffalo is the largest and most comprehensive of the SUNY engineering schools. The Department of Mechanical and Aerospace Engineering currently has 29 fulltime faculty. The Department is expected to grow significantly over the next five years with particular emphasis on Aerospace Engineering and related applications.

Applicants must have an earned doctorate in Aerospace or Mechanical Engineering or in a relevant science or engineering discipline with a dissertation on the representative department research areas. Applicants should submit a curriculum vitae, an integrated teaching and research plan (not to exceed three pages), and names of at least three references via the UBJobs system, at http://www.ubjobs.buffalo.edu, referencing posting number 1200073. Reviews will begin as soon as applications are received and the position will remain open until filled. Women and other under-represented minorities are especially encouraged to apply. The University at Buffalo is an Equal Opportunity and Affirmative Action Employer.

THE AIAA SUGGESTION PROGRAM

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

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

AIAA

AIAA Bulletin

On 7 February, a United States Marine Corps helicopter is seen flying past the full moon and the U.S. Capitol; photo taken at Arlington National Cemetery. (Image Credit: NASA/Bill Ingalls)

MARCH 2012

AIAA Directory

AIAA HEADQUARTERS
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Reston, VA 20191-4344
www.aiaa.org

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Customer Service: 800/639-AIAA†

Other Important Numbers: ***Aerospace America*** / Greg Wilson, ext. **7596*** • ***AIAA Bulletin*** / Christine Williams, ext. **7500*** • **AIAA Foundation** / Suzanne Musgrave, ext. **7518*** • **Book Sales** / **800.682.AIAA** or **703.661.1595**, Dept. 415 • **Corporate Members** / Merrie Scott, ext. **7530*** • **International Affairs** / Megan Scheidt, ext. **3842***; Emily Springer, ext. **7533*** • **Editorial, Books and Journals** / Heather Brennan, ext. **7568*** • **Education** / Lisa Bacon, ext. **7527*** • **Exhibits** / Fernanda Swan, ext. **7622*** • **Honors and Awards** / Carol Stewart, ext. **7623*** • **Journal Subscriptions, Member** / **800.639.AIAA** • **Journal Subscriptions, Institutional/** Chris Grady, ext. **7509*** • **Online Archive Subscriptions** / Chris Grady, ext. **7509*** • **Professional Development** / Patricia Carr, ext. **7523*** • **Public Policy** / Steve Howell, ext. **7625*** • **Section Activities** / Chris Jessee, ext. **3848*** • **Standards, Domestic** / Amy Barrett, ext. **7546*** • **Standards, International** / Nick Tongson, ext. **7515*** • **Student Programs** / Stephen Brock, ext. **7536*** • **Technical Committees** / Betty Guillie, ext. **7573***

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

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

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

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				
3–10 Mar†	**2012 IEEE Aerospace Conference**,	Big Sky, Montana (Contact: David Woerner, 626.497.8451; dwoerner@ieee.org; www.aeroconf.org)		
13–15 Mar†	**Space Technology & Applications International Forum (STAIF II)**	Albuquerque, NM (Contact: Shelley Thomson, 830.625.5230, Thomson@staif2.org, www.staif2.org)		
21–23 Mar†	**Nuclear and Emerging Technologies for Space 2012 (NETS-2012) held in conjunction with the 2012 Lunar & Planetary Sciences Conference**	The Woodlands, TX Contact: Shannon Bragg-Sitton, 208.526.2367, shannon.bragg-sitton@inl.gov, http://anstd.ans.org/NETS2012.html		
22–23 Mar†	**Space Weather Community Operations Workshop**	Park City, UT (Contact: W. Kent Tobiska, 310.573.4185, ktobiska@spaceenvironment.net, http://spaceweather.usu.edu)		
26–28 Mar†	**3AF 47th International Symposium of Applied Aerodynamics**	Paris, France (Contact: Anne Venables, 33 1 56 64 12 30, secr.exec@aaaf.asso.fr, www.aaaf.asso.fr)		
23–26 Apr	**53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** (Jan) **20th AIAA/ASME/AHS Adaptive Structures Conference** **14th AIAA Non-Deterministic Approaches Conference** **13th AIAA Gossamer Systems Forum** **8th AIAA Multidisciplinary Design Optimization Specialist Conference**	Honolulu, HI	*Apr 11*	**10 Aug 11**
14–18 May†	**12th Spacecraft Charging Technology Conference**	Kitakyushu, Japan 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)**	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 Contact: Prof. V. Peshekhonov, +7 812 238 8210, elprib@online.ru, www.elektropribor.spb.ru		
18–20 Jun†	**3rd International Air Transport and Operations Symposium (ATOS) and 6th International Meeting for Aviation Product Support Process (IMAPP)**	Delft, the Netherlands Contact: Adel Ghobbar, 31 15 27 85346, a.a.ghobbar@tudelft.nl, www.lr.tudelft.nl/atos		
19–21 Jun	**AIAA Infotech@Aerospace Conference**	Garden Grove, CA	*Jun 11*	**6 Dec 11**
25–28 Jun	**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** **43rd AIAA Thermophysics Conference**	New Orleans, LA	*Jun 11*	**17 Nov 11**
27–29 Jun†	**American Control Conference**	Montreal, Quebec, Canada Contact: Tariq Samad, 763.954.6349, tariq.samad@honeywell.com, http://a2c2.ort/conferences/acc2012		
11–14 Jul†	**ICNPAA 2012 – Mathematical Problems in Engineering, Aerospace and Sciences**	Vienna, Austria Contact: Prof. Seenith Sivasundaram, 386/761-9829, seenithi@aol.com, www.icnpaa.com		
14–22 Jul	**39th Scientific Assembly of the Committee on Space Research and Associated Events (COSPAR 2012)**	Mysore, India Contact: http://www.cospar-assembly.org		
15–19 Jul	**42nd International Conference on Environmental Systems (ICES)**	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**	Atlanta, GA	*Jul/Aug 11*	**21 Nov 11**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
30 Jul–1 Aug	**10th International Energy Conversion Engineering Conference (IECEC)**	Atlanta, GA	*Jul/Aug 11*	**21 Nov 11**
13–16 Aug	**AIAA Guidance, Navigation, and Control Conference** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Modeling and Simulation Technologies Conference** **AIAA/AAS Astrodynamics Specialist Conference**	Minneapolis, MN	*Jul/Aug 11*	**19 Jan 12**
11–13 Sep	**AIAA SPACE 2012 Conference & Exposition**	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** **14th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference**	Indianapolis, IN	*Oct 11*	**7 Feb 12**
23–28 Sept†	**28th Congress of the International Council of the Aeronautical Sciences**	Brisbane, Australia Contact: http://www.icas2012.com		**15 Jul 11**
24–27 Sept†	**30th AIAA International Communications Satellite Systems Conference (ICSSC) and** **18th Ka and Broadband Communications, Navigation and Earth Observation Conference**	Ottawa, Ontario, Canada Contact: Frank Gargione, frankgargione3@msn.com; www.kaconf.org	*Nov 11*	**31 Mar 12**
24–28 Sep	**18th AIAA International Space Planes and Hypersonic Systems and Technologies Conference**	Tours, France	*Mar 12*	
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)		
23–25 Oct†	**Experiments and Simulation of Aircraft in Ground Proximity—A Symposium on the Occasion of the Installation of the New Moving Belt of the DNW-LLF**	Zwolle, The Netherlands Contact: Siggi Pokorn, +31 527 248520, siggi.pokoern@dnw.aero, www.dnw.aero		
5–8 Nov†	**27th Space Simulation Conference**	Annapolis, MD Contact: Harold Fox, 847.981.0100, info@spacesimcon.org, www.spacesimcon.org		
6–8 Nov†	**7th International Conference Supply on the Wings**	Frankfurt, Germany (Contact: Richard Degenhardt, +49 531 295 2232, Richard.degenhardt@dlr.de, www.airtec.aero)		
2013				
7–10 Jan	**51st AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition**	Dallas/Ft. Worth, TX	*Jan 12*	**5 Jun 13**
21–25 Jan†	**Annual Reliability and Maintainability Symposium (RAMS)**	Orlando, FL Contact: Patrick M. Dallosta, 703.805.3119, Patrick.dallosta@dau.mil, www.rams.org		
2–9 Mar†	**2013 IEEE Aerospace Conference**	Big Sky, MT Contact: David Woerner, 626.497.8451; dwoerner@ieee.org; www.aeroconf.org		
27–29 May†	**20th St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru		
14–18 Jul	**43rd International Conference on Environmental Systems (ICES)**	Vail, CO		
19–22 Aug	**AIAA Guidance, Navigation, and Control Conference** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Modeling and Simulation Technologies Conference** **AIAA Infotech@Aerospace Conference**	Boston, MA		
10–12 Sep	**AIAA SPACE 2013 Conference & Exposition**	San Diego, CA		

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

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

AIAA Courses and Training Program

DATE	COURSE	VENUE	LOCATION
2012			
21–22 Apr	**Fundamentals of Composite Structure Design**	SDM Conferences	Honolulu, HI
21–22 Apr	**Introduction to Bio-Inspired Engineering**	SDM Conferences	Honolulu, HI
21–22 Apr	**Aeroelasticity: State-of-the-Art Practices**	SDM Conferences	Honolulu, HI
21–22 Apr	**Introduction to Non-Deterministic Approaches**	SDM Conferences	Honolulu, HI
2–3 Jun	**Phased Array Beamforming for Aeroacoustics**	Aeroacoustics Conference	Colorado Springs, CO
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

**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

CHANGE IS IN THE AIR

The dialogue among the AIAA leadership at the Aerospace Sciences Meeting about "change" started at the Technical Activities Committee Workshop on Sunday and was still going strong as the Board adjourned on Friday. As you might expect from the recent *Bulletin* "Corner Office" articles, everything was on the table: conferences, journals, organizational structure, international presence, member services, educational programs, and lots more. The theme throughout was how to become more relevant to the profession and the industry while retaining our leadership as a technical society. Change is always hard. When the change needs to be as broad-based as I believe is needed to restore AIAA to the "premier" position we held for so many years, it will take great ideas, very hard work, and a willingness to let go of some very comfortable ways of doing business.

Lower down on the "change" scale, we've started the process to identify my replacement as Executive Director. The target is to have the new person on board by December 1, or sooner. The Search Committee chair is Mike Griffin, our President-Elect. We will review proposals from several executive search firms and expect one of them to be in place by April 1. Now all we need are candidates. If you have names to suggest, please pass them with contact information to our Director of Human Resources, Susan Byrd Lubert, at SusanB@AIAA.org, or to me at BobD@AIAA.org. We will ensure it gets to the search firm for follow-up action.

I've been asked, "why are you leaving now?" There are a few reasons. From a personal perspective, I will be 68 in October, our son graduates from college in May, Barb (my wife of 30+ years) is retired, and we are looking forward to spending time together doing things that we've put off for far too many years. Just as important, though, is the timing for AIAA. The change that is becoming the theme behind almost everything we are doing within AIAA needs continuity in leadership. You approved a two-year presidency to provide more continuity in that position, and Mike will start the first two-year term in May. I believe staff can provide better support if the new Executive Director and the President can work together for most of that term. I also think it will be helpful for the new Executive Director to have significant time in the job before Mike's successor takes office in 2014, and to have worked with that person during the entire President-Elect year, as I have with Mike.

Because of the new two-year term, we are not voting on a President-Elect on this year's ballot. You do have the opportunity to elect several Vice Presidents, Regional Directors, and Technical Director Board members. Please help guide our Institute by selecting our leadership—***vote***!

There's another "change" associated with the elections. For the first time, we are going completely "electronic" for voting: *we are no longer mailing ballots and election materials to every member, and we are encouraging every member to vote electronically through the website*. There are some exceptions: those who don't have email addresses on record with AIAA (we have sent paper ballots) or who request a paper ballot for any reason. The electronic system is more efficient, more cost-effective, more "green," and more accurate—and is being used widely across our sister societies.

The ballot package includes a request for a change to the AIAA Constitution, specifically to reduce the number of required Board meetings from three plus the annual Board meeting to two plus the annual Board meeting. There's some confusing terminology, so let me explain. Each year we have an Annual Business Meeting luncheon the day after the Awards Gala in May. The results of the election are affirmed and the President-Elect takes over the presidency—that is unchanged. There is also a required Annual Board meeting, usually held just prior to the Annual Business Meeting. Historically, that is when we complete the actions of the outgoing Board and recognize departing members. Immediately following the Annual Business Meeting is the first meeting of the newly elected Board—and the first of the required "three meetings in addition to the Annual Board Meeting." The second meeting of the Board has taken place in conjunction with a summer conference, usually GNC or JPC. The third meeting takes place in conjunction with the Aerospace Sciences Meeting.

The amendment to the Constitution would change the requirement for additional meetings from three to two. There aren't any plans to do that, but a team chartered by then-President Mark Lewis and headed by past president George Muellner recommended this change (among others) to give flexibility should future Boards decide to do so. One consideration is to have the Executive Committee take a more active role in governance, so that the Board members can focus more of their attention on their functional areas and on strategic planning for the Institute, rather than receiving reports on the Institute at large. The proposed amendment does not require any change to the meeting structure; it simply gives the Board the opportunity to change their meeting schedule if our events calendar changes, or for some other reason.

Finally, below is more election information about the election. We generally have between 15–20% of eligible members vote (the Constitution requires that at least 15% vote on any amendments for the results to be valid). You have the opportunity and, yes, the responsibility to help select the leaders who will guide the changes that so many of you have told me you support. With the electronic ballot and the new website, it won't take more than a few minutes. ***Vote early*** (no, you can't vote "often")—***vote NOW***.

Bob Dickman
bobd@aiaa.org

AIAA Voting Now Underway – Vote Online!

Amendment to AIAA Constitution • Board of Directors Election

Help shape the direction of AIAA with your vote – and help us "go green" by voting online!
*Read the candidate statements and cast your ballot online at **www.aiaa.org/MyAIAA**.*
(If you need a paper ballot or election booklet, let us know, and we'll send you one.)

All ballots must be received at AIAA by 9 April 2012 – Vote Today!

To Vote Online: *Visit **www.aiaa.org/MyAIAA** (full instructions appear in the AIAA ad on page B9 of this issue of the Bulletin).*
To Vote by Paper Ballot: *Request a ballot from AIAA Customer Service, and return your completed ballot to AIAA by 9 April 2012.*
Questions? *Contact AIAA Customer Service at 800.639.2422 (toll-free, U.S. only), 703.264.7500, or custserv@aiaa.org.*

AIAA
The World's Forum for Aerospace Leadership

2012 ASSOCIATE FELLOWS WERE HONORED

The 2012 Associate Fellows were honored at the AIAA Associate Fellows Dinner on Monday, 9 January in Nashville TN, in conjunction with the 50th AIAA Aerospace Sciences Meeting.

Photos of the Associate Fellows from top to bottom: Region 1, Region II, Region III, and Region IV. On the opposite page, from top to bottom: Region V, Region VI, and Region VII.

The 2012 Aerospace Spotlight Awards Gala
9 May 2012
Ronald Reagan Building and International Trade Center
Washington, DC
A night dedicated to honoring achievements in aerospace. Join us, along with the most influential and inspiring individuals in the industry, as they are recognized during this momentous celebration.
Reserve a place for your company organization and support this year's featured guests of honor including the newly elected AIAA Fellows and Honorary Fellows as well as recipients of some of the industry's most notable awards.
www.aiaa.org/awardsgala
➤ For more information, e-mail grantb@aiaa.org
12-0016_Rev

The entire group of participants with the International Student Conference Organizers and the Vice President-Education.

AIAA FOUNDATION ANNOUNCES INTERNATIONAL STUDENT CONFERENCE "BEST PAPER" WINNERS

The AIAA Foundation is pleased to announce the winners of the 2012 AIAA Foundation International Student Conference "Best Paper" Competition. Awardees were honored on 11 January 2012, at the awards luncheon of the 50th AIAA Aerospace Sciences Meeting, in Nashville, TN. Winners of the Undergraduate, Team Undergraduate and Master's categories received $1,000. The winner of the Community Outreach category received $500. The awardees were:

- **Gary Cai** and **Jason Ting**, University of Adelaide, Adelaide, Australia, in the Undergraduate Division, for their paper "Modeling and Optimization of Air Distribution Systems for Commercial Aircraft Cabins Using CFD Techniques." Mr. Cai accepted the award.
- **Nathan McKay**, **Andrew Chou**, **Daniel Becker**, **Clark Hoffman**, and **Jeffrey Walters**, University of Michigan, Ann Arbor, MI, in the Team Undergraduate Division, for their paper "Research and Development of the eXtendable Solar Array." Mr. McKay accepted the award.
- **James Paulos** and **Alan Argondizza**, Cornell University, Ithaca, NY, in the Master's Division, for their paper "Reduced Weight Hydraulic Actuation for Small Mobile Applications." Mr. Paulos accepted the award.
- **Matt H. Summers** and **Chris Karpuck**, Arizona State University, Tempe, AZ, in the Community Outreach Division for their paper "Integrating Low-Cost Rocket Science into Local Schools." Mr. Summers accepted the award.

The AIAA Foundation International Student Paper Conference invites undergraduate and graduate AIAA student members who have won their regional student conferences to present and discuss their research in a formal setting. This provides a forum for the recognition of outstanding student research, and strengthens the bonds among university engineering departments. For more information on the AIAA Foundation International Student Conference, please contact Stephen Brock at 703.264.7536 or stephenb@aiaa.org.

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.

The Western Regional Advisory Council met in January at the Microcosm facility in the Los Angeles Section. Pictured (left to right): front row, Jeff Jepson, John Rose, Dean Miller, Bruce Wilson, Emily Springer, Jane Hansen; second row: Oleg Yakimenko, Kimberly Castro, Mike Mackowski, Rich Van Allen, Sylvee Walenczewski, Eliza Sheppard, Elishka Jepson; back row: John Armstrong, Charlie Vono, Dino Roman, Ranney Adams, Karl Rein-Weston. Not pictured: Steven Cerri, Matthew Angiulo.

AIAA Voting Now Underway!

– Amendment to AIAA Constitution ***– Board of Directors Election***

Help shape the direction of AIAA with your vote – and "go green" by voting online!
Read candidate statements and cast your ballot online at www.aiaa.org/MyAIAA.
(If you need a paper ballot or candidate booklet, just ask, and we'll send you one.)

All Votes Due by 9 April 2012 – Vote Today!

To Vote Online:

1. Visit **www.aiaa.org/MyAIAA** (if you are not already logged in to **"MyAIAA"** you must do so at this point).
2. Navigate to the bottom of the page to **"Nominations & Voting"** then **"Board of Directors."** Select **"BoD Voting."**
3. When the next screen confirms your eligibility to vote, select **"Continue"** to continue the voting process.
4. Make your selections. When your ballot is correct, click **"Cast Final Ballot"** to finalize your vote. Vote by **9 April 2012.**

To Vote Using a Paper Ballot:

1. Request a paper ballot from Customer Service (see below).
2. Return your paper ballot to AIAA by **9 April 2012.**

Questions?
Contact AIAA Customer Service at **custserv@aiaa.org**, **703.264.7500**, or (toll-free, U.S. only) **800.639.2422.**

American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Suite 500,
Reston, VA 20191
www.aiaa.org

FLL + STEM = SPECIAL OLYMPICS

Karen Arnett, an Elementary Gifted Education Specialist for Chesapeake Public Schools in Chesapeake, VA, began volunteering as a mentor for Greenbrier Intermediate School's FIRST® LEGO® League team in 2003, and every year since she and John Sammons, her co-coach, have selected teams of students. Ms. Arnett has been a very involved Hampton Roads Educator Associate since 2004. She has found many ways to involve the local section in her class. Last fall, she attended the Engineers as Educators Workshop to learn how to work with professionals in different ways. This story demonstrates how educators make a difference every day.

FIRST® LEGO® League Meets STEM

A game table design, constructed with colorful plastic LEGO® bricks representing an arm bone that needs to be put into a cast, a syringe that has to separate red and white blood cells, a pacemaker that needs to be implanted, a cardiac patch that must be applied, bionic prosthetic eyes that are required to "see", and a stent that is needed to unblock a constricted artery are just a sampling of the "body" of obstacles the team of ten fifth-grade students faces on the mission table. With the motto "Keep it Simple, Silly," they design and construct an autonomous robot that works tirelessly, while they test and retest their programming until each biomedical engineering mission is consistently achieved.

Sharing a vision of engaging children in research, engineering, and experimentation, Dean Kamen, founder of FIRST (For Inspiration and Recognition of Science and Technology), and Kjeld Kirk Kristiansen, owner and deputy chairman of the LEGO Group, formed the FIRST® LEGO® League (FLL) in 1998. One goals of this partnership is to encourage the participants to work together to design, construct, program, test, and redesign robotic models and prototypes to accomplish annual topic-related missions on the game table. To be successful, elements of Science, Technology, Engineering, and Math are incorporated throughout the process. Using LEGO® NXT MINDSTORM® technology, team members adjust the number of rotations needed to move the robot forward or backward on the game table, perform light readings to guide the robot to "see" and follow lines on the table, use ultrasonic devices to determine distances between the robot and objects on the table, and utilize touch sensors to "tell" the robot to stop, go, turn, and return to base.

An overhead view of the Body Forward robot game table. Photo retrieved from http://www.firstlegoleague.org.

FLL team members are also engaged in a leading-edge Challenge topic that requires them to use critical thinking and problem-solving skills to identify a Challenge-related need or product, to research various historical and contemporary product-related issues, to identify obstacles or concerns that decrease the productivity or efficiency of that existing model, then to redesign or suggest improvements.

2010 FLL Challenge Topic: Engineering Meets Medicine

August 2012

Dear Greenbrier Intermediate School FLL team,

The Chesapeake Games, a subdivision of the Special Olympics, is an event that provides opportunities for the Chesapeake Public Schools' students with physical disabilities to participate in a variety of track and field events that showcase their personal strengths and athletic talents. Some of our students have never participated because they have physical limitations that prevent them from performing simple tasks, such as gripping and throwing a ball.

Is there anything your FLL team can do to assist our students in being active participants in The Chesapeake Games events?

Sincerely yours, Special Education Teachers

When pressed down, the team-designed LEGO® button pushes the touch sensor, which uses the NXT MINDSTORM® robot to release the catapult. (Photo courtesy of Shelley Bridenstine)

The Greenbrier Intermediate School FIRST® LEGO® League team rallied together to learn possible causes for limited movement in a person's upper extremities. An interview ensued between the team members, a prosthetics specialist, and a physical therapist.

LEGO® Team Member*: Is there a special part of the brain that controls arm movements?*

Prosthetics Specialist*: Yes, the cerebellum controls and coordinates movements like walking and swinging your arms.*

Physical Therapist*: It's like a super highway. Messages travel through the spinal cord, into the brain stem at the base of the brain, and up into the brain. Then the cerebellum sends movement orders to the body part, like your arm. If the brain is disconnected from the body part, the body part does not work properly, and the person does not have control.*

Prosthetics Specialist*: To design a device to help the children grip and throw a ball, you may want to look into assistive technologies.*

As some team members began brainstorming model designs for gripping and throwing a ball, other team members spent time with a teacher who uses assistive technology.

October 2010

Dear Mrs. Scott, School Assistive Technology teacher,

Thank you for letting us visit with you on Tuesday. From the interview, we learned a lot about how science and engineering are integrated into low-tech and high-tech assistive technologies. Now we know that students with limited physical abilities may use the low-tech devices such as pencil grips and slant boards, while some of the students use external high-tech devices such as BIGmack® switches. The simplicity of the BIGmack® switch engineering, with its colorful 5-inch surface, assists those with limited fine motor skills. We will consider ways of incorporating the BIGmack® technology into our final prototype.

Sincerely yours, Greenbrier FLL Team

Using all of the elements of STEM, along with their research, the team decided to engineer an external assistive technology device—a catapult—to simulate gripping and throwing a ball. Designs were created, PVC pipe was measured and cut, and bungee cords were stretched to create elastic potential energy. A plastic lacrosse head, to hold the ball, was duct-taped to the pivot bar. Next the team members made a large flat-surfaced button, resembling a BIGmack®, out of bright yellow LEGOs®for the students to target and push.

Jessica successfully pushes the team-designed LEGO® button to release the catapult. (Photo courtesy of Shelley Bridenstine)

But how would pushing the large button activate the catapult? Once again the team members returned to their NXT MINDSTORM® technology. A touch sensor was added beneath the button. A grip was added to the plastic lacrosse head to hold it in place until the program told it to release. When the large button was pushed, the program paused for five seconds, saying "5-4-3-2-1!" and then it activated the release on the pivot bar sending the ball flying.

The Chesapeake Games

On 8 April, the participants in the Chesapeake Games took the field. As the Greenbrier Intermediate School FLL team set up the catapult, many children, coaches, parents, and spectators watched with curiosity. Jessica was the first participant to push and activate the big yellow LEGO® button. As the countdown began, 5-4-3-2-1, everyone watched. The grip released. The ball flew! Jessica's spirits flew! There was not a dry eye on the field. The FLL team had made a difference in the life of a little girl.

The Greenbrier Intermediate School FIRST® LEGO® League team had combined research with elements of science, LEGO® NXT® technology, the process of engineering, and math skills to mitigate a problem that many people are facing today. They had met the Body Forward Challenge.

For more information, contact FIRST® LEGO® League at http://www.firstlegoleague.org; Virginia/DC FIRST® LEGO® League at http://www.vadcfll.org.

The Greenbrier Intermediate School FIRST® LEGO® League team, along with Jessica, a Chesapeake Games participant, pose with their blue PVC pipe catapult. (Photo courtesy of Shelley Bridenstine)

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.

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 are due to AIAA by **1 July 2012**. Any AIAA member in good standing may be a nominator and strongly are urged to read award guidelines carefully to view nominee eligibility, page limits, letters of endorsement, etc.

AIAA members may submit nominations online after logging into **www.aiaa.org** with their user name and password. You will be guided step by step through the nomination entry. If preferred, a nominator may submit a nomination by completing the AIAA nomination form, which can be downloaded from **www.aiaa.org**. For further information on AIAA's awards program, please contact Carol Stewart, Manager, AIAA Honors and Awards, carols@aiaa.org or 703.264.7623.

OBITUARIES

Associate Fellow Davis Died in January

Don D. Davis, Jr. died 2 January 2012. Mr. Davis was an AIAA member for more than 50 years.

In 1944, he earned a Bachelor of Science in Electrical Engineering with distinction at the University of Nebraska. He earned a Master's of Science in Aeronautical Engineering from the University of Virginia in 1952.

Mr. Davis served in the Army during World War II, on special assignment at the Langley Research Center of the National Advisory Committee for Aeronautics. Following the war, he continued employment at NACA and later NASA at Langley from 1944 to 1974, when he retired as chief of the Space Applications and Technology Division.

Mr. Davis was a member of the Engineers Club of the Virginia Peninsula, AIAA, Historical and Archaeological Society of Ft. Monroe, National Association of Retired Federal Employees, and Sigma Chi Fraternity.

Mechanical Engineer Ord Died in January

George R. Ord, a mechanical engineer who developed the oxygen pressure regulator, the key component that allowed astronaut John Glenn to breathe when he became the first American to orbit the Earth nearly 50 years ago, died on 22 January. He was 94 years old.

Mr. Ord served as an Army Air Forces captain during World War II, where he went on reconnaissance missions in Europe. When he returned to the United States, Mr. Ord enrolled in engineering school at Case Institute of Technology, before teaming up with longtime partner John Carleton Goodell. In 1957, the partners cofounded Carleton Controls Corp., a company that produced precision pneumatic pressure and flow control components used in space vehicles, aircraft, submarines and guided missiles.

When NASA launched Project Mercury in the late 1950s, Mr. Goodell was working for a company that was approached about its possible involvement with the project. They submitted a proposal for a pressure regulator and beat out seven others that were competing for the job after Mr. Ord submitted plans for a far less complicated and more reliable device Air Research, which held a contract for part of the project.

In the historic Mercury mission, the regulator invented by Mr. Ord effectively sealed the visor on the astronaut's helmet to prevent a loss of oxygen from the suit. When an astronaut closed the visor, the regulator tripped the valve and allowed oxygen to flow from a very high pressure bottle so breathing was possible.

In 1994, Mr. Ord was presented an award for Outstanding Aerospace Achievement by AIAA. He was inducted into the Niagara Frontier Aviation and Space Hall of Fame in 2003. He retired in 2008. Mr. Ord was an AIAA Senior Member.

53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference
20th AIAA/ASME/AHS Adaptive Structures Conference
14th AIAA Non-Deterministic Approaches Conference
13th AIAA Gossamer Systems Forum
8th AIAA Multidisciplinary Design Optimization Specialist Conference

23–26 April 2012
Sheraton Waikiki
Honolulu, Hawaii

REGISTER NOW!

www.aiaa.org/events/sdm

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Paul Zarchan
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April 2012, 900 pages, Hardback
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Oleg Yakimenko
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Eleven Seconds into the Unknown: A History of the Hyper-X Program
Curtis Peebles
Library of Flight
2011, 330 pages, Paperback
ISBN: 978-1-60086-776-7
AIAA Member Price: $29.95
List Price: $39.95

Basic Helicopter Aerodynamics, Third Edition
John M. Seddon and Simon Newman
AIAA Education Series
Published by John Wiley & Sons, 2011, 3rd Edition, 264 pages, Hardback
ISBN: 9-781-60086-861-0
AIAA Member Price: $49.95
List Price: $74.95

Gas Turbine Propulsion Systems
Bernie MacIsaac and Roy Langton
AIAA Education Series
Published by John Wiley & Sons, 2011, 368 pages, Hardback
ISBN: 9-781-60086-846-7
AIAA Member Price: $84.95
List Price: $119.95

18th AIAA/CEAS Aeroacoustics Conference (33rd AIAA Aeroacoustics Conference)

4–6 June 2012
Antlers Hilton
Colorado Springs, CO

Synopsis

The AIAA/CEAS Aeroacoustics Conference has established itself as the premier international forum for the field of aeroacoustics. It offers scientists and engineers from industry, government, and universities an exceptional opportunity to exchange knowledge and results of current studies and to discuss directions for future research. The program's technical content will include theoretical, numerical, and experimental contributions that describe original research results and/or innovative design concepts.

American Institute of Aeronautics and Astronautics (AIAA)

AIAA is the world's largest technical society dedicated to the global aerospace profession. With more than 35,000 individual members worldwide, and 90 corporate members, AIAA brings together industry, academia, and government to advance engineering and science in aviation, space, and defense. The Institute continues to be the principal voice, information resource, and publisher for aerospace engineers, scientists, managers, policymakers, students, and educators.

Council of European Aerospace Societies (CEAS)

CEAS includes the thirteen leading European professional aerospace societies, representing 35,000 members: Association Aéronautique et Astronautique de France, Asociación de Ingenieros Aeronáuticos de España, Associazione Italiana di Aeronautica e Astronautica, Central Aerohydrodynamic Institute Russian Aerospace Society, Deutsche Gesellschaft für Luft- und Raumfahrt, e.V., Hellenic Aeronautical Engineers Society, Finnish Society of Aeronautical Engineers, Netherlands Aerospace Association, Polish Society of Aerospace Sciences, Romanian Association of Aeronautics and Astronautics, Royal Aeronautical Society, Swedish Society for Aeronautics and Astronautics, and Switzerland Association for Aeronautical Sciences. CEAS supports the European aerospace community by promoting the highest standards of professional expertise and by facilitating the resolution of key issues that extend beyond the constraints of competitive commercial scenarios.

Special Events

Sunday Welcome Reception

Sunday, 3 June, 1800–1930 hrs

A networking reception will be held on Sunday evening. Tickets are included in registration where indicated. Additional tickets are available for purchase for $65.

Accompanying Persons Program

Monday, 4 June, 0900–1000 hrs

Come have some coffee and meet up with other accompanying persons in the group. The hotel concierge, or a representative from the Colorado Springs Convention & Visitors Bureau, will be there to give suggestions of where to go and what to see, and to assist with making arrangements to plan your day.

Networking Lunch

Monday, 4 June, 1230–1330 hrs

Lunch is included in your registration fee where indicated. Network with your fellow attendees. Additional tickets are available for $45.

Tuesday Awards Dinner

Tuesday, 5 June, 1900–2200 hrs

This year's awards dinner will be held at the Antlers Hilton. Tickets are included in registration where indicated. Additional tickets are available for $95.

Second Workshop on Benchmark Problems for Airframe Noise Computations (BANC-II)

Thursday and Friday, 7–8 June 2012

Sponsored by the Aeroacoustics and Fluid Dynamics Technical Committees, the BANC-II workshop will address the computations of unsteady flow and noise radiation for a select set of airframe noise configurations for which experimental data are already available or are expected to be available in the near future. The BANC-II Workshop will build upon the foundation of the BANC-I Workshop to enable a more definitive assessment of the state of the art, including gap areas in the computations and measurements of airframe noise, as well as include a substantially stronger collaborative element involving multiple organizations from the outset.

Objectives of the BANC-II workshop are to:

1) Provide a forum for a thorough assessment of simulation-based noise-prediction tools in the context of airframe configurations including both near-field unsteady flow and the acoustic radiation generated via the interaction of this flow with solid surfaces.
2) Identify current gaps in physical understanding, experimental databases, and prediction capability for the major sources of airframe noise.
3) Help determine best practices, and accelerate the development of benchmark quality datasets.
4) Promote future coordinated studies of common configurations for maximum impact on the current state of the art in the understanding and prediction of airframe noise.

For more information, please visit https://info.aiaa.org/tac/ASG/FDTC/DG/BECAN.aspx. The workshop is a separate registration fee and does not include conference attendance.

Conference Proceedings

Conference proceedings are 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 them. For those registering on site, you will be provided with instructions at that time.

Register on Our Website

Visit the website at **www.aiaa.org/Aeroacoustics2012** and select "Register Now" to access the secure online registration form. You must use a credit card to register online. A PDF registration form is also available on this Web page. Print, complete, and then mail or fax with payment to AIAA. Address information is provided.

Registering in advance saves conference attendees up to $200. Valid payment must be received with your registration form in order to be processed. Advance registration forms must be received by **30 May 2012**. Those registering after that date must register online or on site. Professionals registering at the nonmember rate will receive a one-year AIAA membership.

Cancellations must be received in writing no later than **21 May**. There is a $100 cancellation fee. Registrants who cancel beyond this date or fail to attend will forfeit the entire fee. For questions, call 703.264.7500 or (toll-free, U.S. only) 800.639.AIAA (2422).

	Early Bird	**Standard**	**On Site**
	By 7 May	8 May–1 June*	2–6 June

*All faxed or mailed registration forms must be received prior to **30 May 2012**. To receive the standard price, those registering after 30 May must do so online.

Option 1: Full Conference with Online Proceedings

	Early Bird	Standard	On Site
Member (AIAA/CEAS)	$755	$855	$955
Nonmember	$910	$1010	$1110

Includes Sunday evening opening reception, Monday lunch, Tuesday awards dinner, and single-user access to online proceedings.

Option 2: Full-Time Undergraduate Student

	Early Bird	Standard	On Site
Member (AIAA/CEAS)	$20	$30	$40
Nonmember	$50	$60	$70

Includes attendance to conference sessions only.

Option 3: Full-Time Undergraduate Student with Tickets

	Early Bird	Standard	On Site
Member (AIAA/CEAS)	$225	$235	$245
Nonmember	$255	$265	$275

Includes Sunday evening opening reception, Monday lunch, and Tuesday awards dinner.

Option 4: Full-Time Graduate or Ph.D. Student

	Early Bird	Standard	On Site
Member (AIAA/CEAS)	$60	$70	$80
Nonmember	$90	$100	$110

Includes attendance at conference sessions only.

Option 5: Full-Time Graduate or Ph.D. Student with Tickets

	Early Bird	Standard	On Site
Member (AIAA/CEAS)	$265	$275	$285
Nonmember	$295	$305	$315

Includes Sunday evening opening reception, Monday lunch, and Tuesday awards dinner.

Option 6: Full-Time AIAA/CEAS Retired Member

	Early Bird	Standard	On Site
	$40	$50	$60

Includes Sunday evening opening reception, Monday lunch, and Tuesday awards dinner.

Technical Co-Chair, AIAA
Florence V. Hutcheson
NASA Langley Research Center

Technical Co-Chair, CEAS
Sjoerd Rienstra
Eindhoven University of Technology

Administrative Chair
Dimitri Papamoschou
University of California, Irvine

Option 7: Group Discount (Advance Only)

	Early Bird	Standard	On Site
	$680 per person	$680 per person	N/A

10% discount off early-bird member rate for 10 or more from the same organization who register and pay at the same time with single form of payment. Includes Sunday evening opening reception, Monday lunch, Tuesday Awards Dinner, and single-user access to online proceedings. Complete typed list of registrants along with completed individual registration forms and a single payment must be received by the Form Registration Deadline of **30 May 2012**.

*Option 8: Continuing Education Course with FREE** Conference Registration*

	Early Bird	Standard	On Site
Member (AIAA/CEAS)	$1278	$1378	$1478
Nonmember	$1355	$1455	$1555

**Registration fee includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings. (Course is subject to change.)

Option 9: BANC-II Workshop

	Early Bird	Standard	On Site
Member (AIAA/CEAS)	$250	$350	$450

Registration fee Includes workshop participation only. Conference registration sold separately.

Extra Tickets

Sunday Opening Reception	$65
Monday Lunch	$45
Tuesday Awards Dinner	$95
Extra Online Proceedings	$170

Conference Registration Hours

Saturday, 2 June 2012	0715–0815 hrs (PD Course only)
Sunday, 3 June 2012	1500–1900 hrs
Monday, 4 June 2012	0700–1800 hrs
Tuesday, 5 June 2012	0700–1800 hrs
Wednesday, 6 June 2012	0700–1600 hrs
Thursday, 7 June 2012	0700–1000 hrs (Workshop only)

Hotel Reservations—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

AIAA Programs

AIAA Continuing Education Course

Let AIAA Continuing Education courses (formerly Professional Development) pave the way to your continuing and future success! As the premier association representing professionals in aeronautics and astronautics, AIAA has been a source for continuing the aerospace professional's education for more than sixty years. AIAA is committed to keeping aerospace professionals at their technical best, and offers the best instructors and courses to meet the professional's career needs.

On 2–3 June at the Antlers Hilton, AIAA will be offering a Continuing Education course in conjunction with the AIAA/CEAS Aeroacoustics Conference. Please check the conference website for up-to-date information regarding the course.

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. 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.

room at the designated hotel listed in this Preliminary Program 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!

AIAA has made arrangements for a block of rooms at the conference venue in downtown Colorado Springs:

Antlers Hilton Colorado Springs
Four South Cascade
Colorado Springs, CO 80903-1685
Phone: 719.955.6204

Rates are $129–$159 depending on type of room and view. Rooms will be held until **9 May** or until the block is full. Please mention AIAA when you make your reservations by phone to be included in this block. Be sure to make your reservations early to avoid missing the discounted rate.

For the standard block, visit: **http://www.hilton.com/en/hi/groups/personalized/C/COSCSHF-AIAA12-20120601/index.jhtml?WT.mc_id=POG**. Group Name: 2012 AIAA/EAS Aeroacoustics Conference; group Code: AIAA12

Government Block: There are a small number of rooms available at the federal government per diem rate. Please use the link below to make your reservation. Proper identification will be required to show you are a U.S. federal government employee. Visit: **http://www.hilton.com/en/hi/groups/personalized/C/COSCSHF-AIAGOV-20120601/index.jhtml?WT.mc_id=POG**. Group Name: 2012 AIAA/EAS Aeroacoustics Conference; group Code: AIAGOV.

Things To Do In Colorado Springs

Discover more than 50 exciting and unique attractions in Colorado Springs, such as Pikes Peak, U.S. Olympic Training Center, Garden of the Gods Park, The Pikes Peak Cog Railway, Cheyenne Mountain Zoo, Cave of the Winds, Manitou Cliff Dwellings, Royal Gorge Bridge, Seven Falls, Flying W Ranch, the U.S. Air Force Academy, and many more.

Your taste buds will be delighted that you've come to Colorado Springs. The wide range of exquisite restaurants in Colorado Springs range from high-end sophistication and superb elegance to rustic outdoor suppers, great wood-fired pizza, and casual sidewalk cafes. Colorado Springs is famous for our sunny skies and low humidity, making outdoor patio dining a relaxing and inviting experience. You'll be happy to see casual and family restaurants all over town opening their doors and setting out tables and chairs for al fresco diners. The unique Colorado Springs atmosphere doesn't quit after dessert is served, because there's no shortage of nightlife in Colorado Springs. With great clubs and concerts, and night spots ranging from dive bars to opulent wine-tasting rooms, some places even serve up delicious food until the wee hours of the morning.

Visit the Colorado Springs Convention and Visitors Bureau website to plan your stay: **www.visitcos.com**.

Conference Certificate of Attendance Available

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

U.S. Technology Regulations

U.S. nationals (U.S. citizens and permanent residents) are reminded that it is their responsibility to comply with ITAR and Technology Transfer restrictions. Visit www.aiaa.org for more details.

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, a valid student ID is also required.

For complete conference information, please visit www.aiaa.org/Aeroacoustics2012.

Program-at-a-Glance

Saturday, 2 June 2012

0815–1700 hrs
Continuing Education Course

Sunday, 3 June 2012

0815–1700 hrs
Continuing Education Course

Monday, 4 June 2012

0800–0900 hrs
Keynote Address - The Impact of Farassat's Formulations Nearly 40 Years On
Speaker: Dr. K.S.Brentner, The Pennsylvania State University, University Park, PA

0900–1230 hrs
Acoustics/Fluid Dynamic Phenomena I
Airframe Noise I
Computational Aeroacoustics I
General Acoustics I
Integration and Flight, Community Noise
Jet Noise I
Turbomachinery and Core Noise I

1230–1330 hrs
Monday Networking Lunch

1330–1730 hrs
Acoustic/Fluid Dynamic Phenomena II
Airframe Noise II
Computational Aeroacoustics II
General Acoustics II
Jet Noise II
Propeller and Rotor Noise I
Turbomachinery and Core Noise II

Tuesday, 5 June 2012

0800–0900 hrs
Keynote Address - Stochastic Simulation of Turbulent Broadband Noise
Speaker: Dr. Roland Ewert

0900–1230 hrs
Acoustic/Fluid Dynamic Phenomena III
Active Noise Control
Computational Aeroacoustics III
Duct Acoustics I
Jet Noise III
Jet Noise IV
Sonic Boom / Sonic Fatigue

1330–1730 hrs
Aeroacoustic Windtunnel Design & Technology
Airframe Noise III
Computational Aeroacoustics IV
Duct Acoustics II
Interior Noise/Aero-Vibro-Acoustics
Jet Noise V
Propeller and Rotor Noise II

1800–2000 hrs
Tuesday Awards Dinner

Wednesday, 6 June 2012

0800–0900 hrs
Keynote Address - Use of LES in Aeroacoustics
Speaker: Dr. Sanjiva Lele

0900–1230 hrs
Advanced Testing Techniques I
Airframe Noise IV
Computational Aeroacoustics V
Duct Acoustics III
Jet Noise VI
Jet Noise VII
Propeller and Rotor Noise III
Turbomachinery and Core Noise III

1330–1730 hrs
Advanced Testing Techniques II
Airframe Noise V
Computational Aeroacoustics VI
Heritage E
Duct Acoustics IV
Jet Noise VIII
Propeller and Rotor Noise IV
Turbomachinery and Core Noise IV

Thursday 7 June 2012

0800–1300 hrs
BANC-II Workshop*

Friday 8 June 2012

0800–1300 hrs
BANC-II Workshop*

*Workshop participation is a separate registration fee and is not included in the regular conference registration.

For the complete technical program agenda, visit www.aiaa.org/aeroacoustics2012

28th Aerodynamic Measurement Technology, Ground Testing, and Flight Testing Conference including the Aerospace T&E Days Forum
30th AIAA Applied Aerodynamics Conference
4th AIAA Atmospheric and Space Environments Conference
6th AIAA Flow Control Conference
42nd AIAA Fluid Dynamics Conference
43rd AIAA Plasmadynamics and Lasers Conference
43rd AIAA Thermophysics Conference

25–28 June 2012
Sheraton New Orleans
New Orleans, LA

Synopses

General

The AIAA Summer Fluids Conferences are held each year to provide a forum for technical exchange and interaction among scientists, engineers, and professionals from industrial, governmental, and academic technical communities who participate in scientific research and development in the aerospace engineering and fluid dynamics disciplines. Selected fluids-oriented AIAA conferences collocate with the AIAA Fluid Dynamics Conference on a rotating basis each summer to provide conference attendees with an opportunity to interact with unique groups of professionals from diverse, and yet interrelated, technical disciplines.

In summer 2012, the AIAA Summer Fluids Conferences offer eight collocated AIAA conferences that are organized and prepared by individual AIAA Technical Committees. Thus, conference attendees are presented with a broad array of sessions and paper topics from which to choose within the context of the eight collocated conferences. In addition to the technical sessions offered by the conferences, special Plenary Sessions and Award Lectures present conference attendees with additional opportunities to meet and interact with many of the world's premier technical experts in their respective fields of research and study.

28th AIAA Aerodynamic Measurement, Ground Testing, and Flight Testing Conference including the Aerospace T&E Days Forum

The 28th AIAA Aerodynamics Measurement, Ground Testing, and Flight Testing Conference is a partnership of the Advanced Measurement Technology Technical Committee (AMTTC), the Ground Testing Technical Committee (GTTC), and the Flight Testing Technical Committee (FTTC). The conference will feature technical talks and papers on the science, technology, and application of aerodynamic measurements, ground testing, and flight testing, from basic research, to measurements for understanding complex flows, to facility development, to system test, and from research laboratories to test facilities and the lessons learned. This year's conference will feature a special Aerospace T&E Days Forum in which high ranking officials from the U.S. Department of Defense and NASA provide insight on Command Level T&E Policy and Building and Maintaining Test Capabilities in Uncertain Times. There will also be a special plenary lecture for the winner of the AMTTC's AMT Award.

Aerospace T&E Days Forum

This year the Aerospace T&E Days Forum's theme is "Dealing With Uncertain Futures: Challenges and Solutions." Most of us are used to planning in a fiscally constrained environment. However, the challenges of planning under resource constraints are magnified when the budgeting environment becomes very uncertain as it is today. This is also occurring at the same time that we are developing and fielding systems of increasing complexity and capability. As we enter an era of austerity compounded with rising uncertainty due to economic, political, and social uncertainties, we must develop new strategies for maintaining the world-class test and evaluation capabilities we have in the United States, so we can continue to develop and test research, military, and commercial systems. Despite the challenges, we also have many opportunities. The purpose of this forum is to discuss: 1) the challenges that the acquisition and test and evaluation communities face now and in the future, and 2) potential solutions to those problems. The forum will consist of two moderated panels of acquisition, technical, and test and evaluation leadership from the aerospace domain; the first panel will focus on the challenges and the second on the solutions. Each panel member will speak for 15–20 minutes and then questions from the audience will be fielded.

30th AIAA Applied Aerodynamic Conference

The 30th AIAA Applied Aerodynamics Conference provides a forum for the presentation and discussion of technical material in diverse areas of theoretical, computational, and experimental applied aerodynamics. Conference sessions will focus on technical topics in the areas of wind-tunnel and flight-testing aerodynamics; unsteady aerodynamics; subsonic, transonic, supersonic, and hypersonic aerodynamics; sonic boom mitigation; high angle of attack and high lift aerodynamics; CFD high lift prediction; low-speed low-Reynolds number aerodynamics; bio-inspired aerodynamics; airfoil/wing/configuration aerodynamics; propeller/rotorcraft/wind-turbine aerodynamics; weapons and store separation aerodynamics; aerodynamic design methodologies; optimization methods in applied aerodynamics; active flow control; vortical/vortex flow; unmanned aerial vehicle designs/tests; propulsion aerodynamics; missile/projectile/guided-munitions aerodynamics; aerodynamic-structural dynamics interaction; and application of CFD methods to aerodynamic configurations validated against experimental data.

4th AIAA Atmospheric and Space Environments Conference

The 4th AIAA Atmospheric and Space Environments Conference provides a forum for the presentation and discussion of scientific and technical information concerning interactions between aerospace systems and the atmospheric/space/planetary environment. Technical sessions will focus on both atmospheric and space environments and their effects on aircraft and spacecraft. Atmospheric topics begin with a session on wake vortex effects, followed by a review of activities under NASA's Aviation Safety Hazard Mitigation Program.

A joint session with the Applied Aerodynamics TC covers topics related to atmospheric environment and dynamics. A parallel track is focused in aircraft icing topics including CFD modeling, wind tunnel testing, and natural environment studies. Two special sessions are planned within this track: An update of NASA's Icing Research Tunnel capabilities (joint with the Ground Testing TC) and a panel session of the Aircraft Icing Research Alliance to share information on current activities and allow for feedback from attendees. Space environments as simulated in the laboratory will be be addressed also in a separate session. All technical sessions are arranged to provide an opportunity for researchers and professionals to share information and experiences, thereby increasing their technical benefit for all attendees.

6th Flow Control Conference

The 6th AIAA Flow Control Conference is a biennial event held in conjunction with the Fluid Dynamics summer meeting. It is a forum for all aspects of flow control technology, emphasizing the multidisciplinary interaction among a diverse range of research disciplines with a common basis in fluid dynamics. Technical sessions range from sensing and actuation technology to applications of flow control across a wide spectrum of flow regimes including vortical flows, boundary layers, shear layers, wakes, separated flows, laminar separation bubbles, high-speed flows, and internal flows. Invited papers and presentations will be in special sessions on Closed-Loop Flow Control and Flow Control Actuators. A Progress in Flow Control poster session rounds out the conference with an informal discussion on recent developments and applications of flow control.

42nd AIAA Fluid Dynamics Conference

The 42nd AIAA Fluid Dynamics Conference includes papers covering all aspects of fluid dynamics, particularly those relevant to aerospace applications. Topics range from basic research to applied technology and include novel experimental, theoretical, and computational investigations and interdisciplinary approaches that provide new insight into flow physics. The conference is collocated with others to enable close interaction among a broad range of research disciplines. Conference sessions will feature concentrations on low-speed and high-speed flows, instability and transition, turbulence, vortex dynamics, reacting and multiphase flows, micro/nano-scale flows, unsteady aerodynamics, wind energy, and flow control. The keynote lecture of the Fluid Dynamics Conference will be presented by the recipient of the 2011 AIAA Fluid Dynamics Award.

43rd AIAA Plasmadynamics and Lasers Conference

The 43rd Plasmadynamics and Lasers Conference will address current basic/applied research in the areas of plasmadynamics, lasers, electromagnetics, diagnostics, and related topics in nonequilibrium reacting flows. Contributed papers will describe contemporary experimental, analytical, and computational efforts. The program will include recent fundamental scientific advancements as well as many interdisciplinary contributions describing state-of-the-art technical developments and milestone achievements. Conference sessions will focus on plasma and laser physics/chemistry/kinetics, plasma diagnostics, plasma materials processing and environmental applications, space plasma physics and applications, plasma propulsion, laser devices and applications, laser optics and fluid-optics interactions, weakly ionized gas physics and applications, and MHD energy conversion science and technology with a wide-ranging international perspective. The program will also incorporate an invited lecture by the recipient of the Plasmadynamics and Lasers Award.

43rd AIAA Thermophysics Conference

The 43rd AIAA Thermophysics Conference includes papers covering all aspects of heat transfer and thermophysics. Session topics range from basic research and development to applied and advanced technology, including novel experimental and computational observations, interdisciplinary papers that bridge theoretical and experimental approaches and papers that provide innovative concepts and analyses. Technical topic areas relate to thermal energy and heat transfer in aerospace and mechanical engineering applications. The Thermophysics Award Lecture features an invited lecture by the 2012 Thermophysics Award recipient. Additionally, the AIAA Thermophysics Technical Committee will present Best Paper Awards in both the Professional and Student Categories (with the student receiving a monetary award).

Special Events

Sunday, 24 June

Young Professional Networking Reception

The evening social provides a great chance for young professional members of the Institute, professionally employed members under the age of 36, to meet other members, network, and make new contacts. Join the AIAA YP Committee for food, drinks, and relaxed socializing.

Monday, 25 June

1000–1100 hrs

Accompanying Persons Meet and Greet

An informational meet-and-greet session will be held at the Sheraton New Orleans for accompanying persons of conference attendees. Coffee and tea will be served. A hotel concierge representative will answer questions about New Orleans.

Conference General Chair
Steven C. Dunn
Jacobs Technology Inc., ROME Group
NASA Langley Research Center

Technical Program Chairs

28th Aerodynamic Measurement Technology, Ground Testing, and Flight Testing Conference including the Aerospace T&E Days Forum

Aerodynamic Measurement Technology Technical Program Chair
Paul M. Danehy, Research Scientist
Advanced Sensing and Optical Measurement Branch

Ground Testing Technical Program Chair
Amber Favaregh, Senior Research Engineer
ViGYAN, Inc.

Flight Testing Technical Program Chair
Thane Lundberg
Edwards Air Force Base

Aerospace T&E Days Forum
Major General David J. Eichhorn
Kirtland Air Force Base

Co-Subcommittee Chairs
Ralph Grimit
Raytheon Company

Thomas Yechout
U.S. Air Force Academy

30th AIAA Applied Aerodynamics Conference
Steven L. Morris
Engineering Systems Inc. (ESI)

Brian E. McGrath
Johns Hopkins University
Applied Physics Laboratory

Kenrick Waithe
Gulfstream Aerospace

4th Atmospheric and Space Environments Conference
Nelson W. Green
Jet Propulsion Laboratory

Marcia Politovich
National Center for Atmospheric Research

6th AIAA Flow Control Conference
James W. Gregory
The Ohio State University

42nd AIAA Fluid Dynamics Conference
Darren L. Hitt
University of Vermont

43rd AIAA Plasmadynamics and Lasers Conference
Ronald J. Litchford
NASA Marshall Space Flight Center

43rd AIAA Thermophysics Conference
Jennifer Batson
Lockheed Martin Space Systems Company

Diane Pytel
Lockheed Martin Space Systems Company

1900–2030 hrs
World War II Museum Reception
From the beaches of Normandy to the sands of Iwo Jima, The National World War II Museum's exhibits are a blend of personal accounts, artifacts, documents, photographs, and original film footage. The stories of the dozens of amphibious landings and the thousands of men and women who made Allied victory in World War II possible are told through three floors of exhibit space. In addition, special exhibits draw on the Museum's own collections, as well as relevant traveling exhibits to illustrate and explore the war that changed the world. The museum reception is included where indicated. Additional tickets may be purchased for $75 via the registration form or at the AIAA on-site registration desk.

Tuesday, 26 June

1200–1400 hrs
Awards Luncheon: "Design/Build/Fly Competition Presentation"
The Tuesday Awards Luncheon will be held in the Napoleon Ballroom. Admission is included in the registration fee where indicated. Additional tickets may be purchased for $40 via the registration form or at the AIAA on-site registration desk. The Fluid Dynamics Award, the Applied Aerodynamics Award, the Thermophysics Award, the Theoretical Fluid Mechanics Award, and the Plasmadynamics and Lasers Award will be presented at the luncheon.

Wednesday, 29 June

1200–1300 hrs
Exhibitor Luncheon
Come and have lunch with the exhibitors in Napoleon Ballroom. Admission is included in the registration fee where indicated. Additional tickets may be purchased for $40 via the registration form or at the AIAA on-site registration desk.

Special Sessions

Monday, 25 June, 0800–0900 hrs
Opening Plenary Session

Monday, 25 June, 1730–1830 hrs
Fluid Dynamics Award Lecture

Tuesday, 26 June, 0800–1200 hrs
Aerospace T&E Days Forum
This year's theme is "Dealing With Uncertain Futures: Challenges and Solutions".

0800–1000 hrs
"Establishing Policies to Enhance Test and Evaluation Support to Acquisition Programs": This panel will discuss current DoD and Air Force policies relative to how acquisition programs engage with test and evaluation organizations to support their requirements. Discussion will include current policy as regards to use of government and/or industry test and evaluation capabilities. Finally, panelists will discuss recommendations for policy changes to further enhance effectiveness/efficiency of test support.
Panel Moderator: Robert (Bob) Arnold, Chief Technologist, 46th Wing, Eglin AFB
Speakers: MG David Eichhorn, AFOTC/CC; LG Janet Wolfenbarger, SAF/AQ (Invited); LG CD Moore, AFMC/CV (Invited)

1000–1200 hrs
"Building and Maintaining Test Capabilities in Uncertain Times": This panel will discuss planning for the test and evaluation of technically advanced and complex systems in an era

of downsizing, encroachment, and other uncertainties. Panelist topics may include investment strategies (e.g., technology, facilities and people), policy changes, process improvements, partnerships, and other methods to deal with declining budgets and uncertain futures.

Panel Moderator: Eileen Bjorkman, Chief Technologist, Air Force Flight Test Center, Edwards AFB

Speakers: Dennis O'Donoghue, The Boeing Company – BT&E; Jaiwon Shin, NASA Headquarters; Vice Admiral David Architzel, Commander, Naval Air Systems Command

Tuesday, 26 June, 1200–1400 hrs
Awards Luncheon
"Design/Build/Fly Competition Presentation"

The AIAA/Cessna Aircraft Company/Raytheon Missile Systems - Student Design/Build/Fly Competition provides a real-world aircraft design experience for engineering students by giving them the opportunity to validate their analytic studies. Student teams design, fabricate, and demonstrate the flight capabilities of an unmanned, electric powered, radio controlled aircraft that can best meet the specified mission profile. The goal is a balanced design possessing good demonstrated flight handling qualities and practical and affordable manufacturing requirements while providing a high vehicle performance. The winning team from the 2012 competition will provide a presentation discussing their winning design. The AIAA Applied Aerodynamics, Aircraft Design, Design Engineering and Flight Test Technical Committees jointly form the basis for the DBF governing committee.

Tuesday, 26 June, 1730–1830 hrs
Plasmadynamics and Lasers Award Lecture

Wednesday, 27 June, 0800–0900 hrs
Thermophysics Award Lecture

Wednesday, 27 June, 1730–1830 hrs
Aerodynamic Measurement Technologies Award Lecture

Thursday, 28 June, 0800–0900 hrs
Applied Aerodynamics Award Lecture

Drag Prediction Workshop

Computational Fluid Dynamics (CFD) is a valuable tool in the design and understanding of aerodynamic vehicles. Advances in computer technology are allowing CFD to be used earlier in the design process and to provide better understanding of the flow physics. The solution accuracy and limitations need to be well understood to advance the acceptance and confidence in CFD as a design and optimization tool.

The Drag Prediction Workshop (DPW) series will assess and advance the state-of-the-art computational methods as practical aerodynamic tools for aircraft force and moment prediction. Results will be solicited from the international CFD community to evaluate and demonstrate the accuracy and limitations of the solvers and gridding techniques in use. Standard practices that improve the accuracy of results will be solicited and promoted. Areas needing additional research and development will be identified.

Geometries will be chosen to advance the goals of the workshop with state-of-the art wind tunnel data available whenever possible. Configuration complexity will be of industrial relevance to demonstrate the state of the art, but of limited scope to encourage the greatest possible participation.

An impartial forum for evaluating the effectiveness of existing computer codes and modeling techniques using Navier-Stokes solvers will be provided and a statistical assessment of the state of the art of CFD for aerodynamic predictions will be developed. Promotion of the results through publication will be encouraged and made available to the CFD community on the Web.

This workshop is a separate registration fee and does not include conference registration.

Exhibits

Don't miss this exciting exhibition featuring displays on internal and external aerodynamics, airfoil and vehicle design, hypersonics, instrumentation, and other industry-related fields. AIAA is sponsoring this collocated conference and exhibition with eight technical disciplines. Companies from all over the world will have products available for hands-on demonstrations. Meet qualified buyers and showcase your new product offerings and state-of-the-art technologies. This exhibit will give your company the opportunity to interact with many of our conference attendees who work closely within this market. If this is your niche, this is your chance to mingle with your current customer base, meet industry partners, and attract new clients.

Visit the Exhibit Hall, located in the Napoleon Ballroom, during the following hours:

Tuesday, 26 June	1000–1700 hrs
Wednesday, 27 June	1000–1700 hrs
Lunch Reception	1230–1330 hrs

Cyber Café (Internet Access)

There will be computers with complimentary Internet access in the Exhibit Hall (Napoleon Ballroom) for conference attendees during the following hours:

Monday, 25 June	0700–1800 hrs
Tuesday, 26 June	0700–1800 hrs
Wednesday, 27 June	0700–1800 hrs
Thursday, 28 June	0700–1230 hrs

Complimentary Internet access is provided in the hotel rooms at the Sheraton New Orleans for conference attendees booking within the AIAA room block. AIAA cannot guarantee complimentary Internet access for those attendees who book rooms outside the block.

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.

Conference Sponsorship Opportunities

When your brand is on the line, AIAA sponsorship can raise the profile of your company and put you where you need to be. Available packages offer elevated visibility, effective marketing and branding options, and direct access to prominent decision makers from the aerospace community. Contact Cecilia Capece at ceciliac@aiaa.org or 703.264.2570 for more details.

Registration Information

All participants are urged to register on the AIAA website at **www.aiaa.org/NewOrleans2012**. Registering in advance saves conference attendees time and up to $200. A check made payable to AIAA or credit card information must be included with your registration form. A PDF registration form is available on the AIAA website. Print, complete, and mail or fax with payment to AIAA. Address information is provided.

Early-bird registration form PDFs must be received by **29 May 2012**. All faxed or mailed PDFs registration forms and payments must be received before **21 June 2012** in order to be processed. Those wishing to register at the Standard price after **21 June** must register online. Preregistrants may pick up their materials at the advance registration kiosk.

Online registration will remain open through the conference. All those not registered by **21 June 2012** who wish to register by PDF may do so at the on-site registration desk at the on-site price. All nonmember registration prices include a one-year AIAA membership. If you require more information, please call 703.264.7502 or e-mail feliciaa@aiaa.org.

Cancellations should be made no later than **11 June 2012**. There is a $100 cancellation fee. Registrants who cancel beyond **11 June 2012** or fail to attend the conference will forfeit the entire fee. If you require more information, please call 703.264.7500.

Registration fees are as follows:

	Early Bird	**Standard**	**On Site**
	By 29 May	30 May–22 Jun*	23 June

*Standard prices available online through **22 June**. All PDF registration forms including payment must be received by **21 June** in order to receive standard pricing.

Option 1: Full Conference with Online Proceedings

Member	$695	$795	$895
Nonmember	$850	$950	$1050

Includes Monday off-site event, Tuesday awards luncheon, Wednesday lunch, and single-user access to online proceedings (all conferences).

Option 2: Full-Time Undergraduate Student

Member	$20	$30	$40
Nonmember	$50	$60	$70

Includes conference and exhibits participation only (no food functions or proceedings included).

Option 3: Full-Time Undergraduate Student with Networking

Member	$185	$195	$205
Nonmember	$215	$225	$235

Includes Monday off-site event, Tuesday awards luncheon, and Wednesday lunch (no online proceedings included).

Option 4: Full-Time Graduate or Ph.D. Student

Member	$60	$70	$80
Nonmember	$90	$100	$110

Includes conference and exhibits participation only (no food functions or proceedings included).

Option 5: Full-Time Graduate or Ph.D. Student with Networking

Member	$225	$235	$245
Nonmember	$255	$265	$275

Includes Monday off-site event, Tuesday awards luncheon, and Wednesday lunch (no online proceedings included).

Option 6: Full-Time AIAA Retired Member

AIAA Member	$40	$50	$60

Includes Monday off-site, Tuesday awards luncheon and Wednesday lunch (no online proceedings included).

Option 7: Group Discount

Per person	$626	$626	N/A

Discount off member rate for 10 or more people from the same organization who register and pay at the same time with a single form of payment. Includes all catered events and single-user access to online proceedings. A complete typed list of registrants, along with completed individual registration forms and a single payment, must be received by the preregistration deadline of **21 June**.

*Option 8: Continuing Education Registration**

AIAA Member	$1248	$1348	$1448
Nonmember	$1325	$1425	$1525

(*CE Registration fee includes course and course notes; full conference participation: admittance to technical and plenary sessions, receptions, luncheons, and online proceedings.)

Option 9: Drag Prediction Workshop Only

AIAA Member	$250	$350	$450

*Includes workshop participation only. Conference registration sold separately.

Extra Tickets

Monday World War II Museum Reception	$75
Tuesday Awards Luncheon	$40
Wednesday Lunch Exhibit Reception	$50
Online Proceedings	$170

Conference Registration Hours

Saturday, 23 June	0700–0815 hrs
(Course and Workshop Registration only)	
Sunday, 24 June	1500–1900 hrs
Monday, 25 June	0700–1700 hrs
Tuesday, 26 June	0700–1700 hrs
Wednesday, 27 June	0700–1700 hrs
Thursday, 28 June	0700–1230 hrs

Hotel Reservations

AIAA has arranged for a block of rooms at the Sheraton New Orleans. The conference rate is $199 for single or double occupancy. These rooms can be booked by calling 800.782.9488 and identifying that you are with the AIAA conference, or by using the online links provided below:

Regular conference attendees: **www.starwoodmeeting.com/Book/scaia1**
Government attendees: **www.starwoodmeeting.com/book/aiaagov**

Room rates are subject to a general sales tax of 13% plus a $3.00 occupancy tax. The rooms will be held for AIAA until **25 May 2012** and then released for use by the general public at the prevailing rates. A deposit of one night room and tax is required when booking your reservation. A major credit card can be used to secure the reservation. *Federal Government Employees*—A portion of the room block is available at the federal government per diem rate. This rate is available to federal government employees only. You must show valid government ID upon check-in.

City Information

New Orleans, known as the "Crescent City," is one of the most famous cities in America. From the French Quarter to the Garden District, New Orleans offers some of the best dining and entertainment in the world. Music filters into the streets and parks as you walk along and enjoy the sights and sounds.

Conference Certificate of Attendance Available

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

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.

AIAA Continuing Education Course

Let AIAA Continuing Education courses (formerly Professional Development) pave the way to your continuing and future success! As the premier association representing professionals in aeronautics and astronautics, AIAA has been a source for continuing the aerospace professional's education for more than sixty years. AIAA is committed to keeping aerospace professionals at their technical best, and offers the best instructors and courses to meet the professional's career needs.

On 23–24 June at the Sheraton New Orleans, AIAA will be offering Continuing Education courses in conjunction with the AIAA Summer Fluids Conferences. Please check the conference website for up-to-date information regarding the courses. Register for any course and attend the conferences for FREE!

Perturbation Methods in Science and Engineering *(Instructor: Joseph Majdalani, Professor, Mechanical and Aerospace Engineering, University of Tennessee 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, irrespective of their research discipline. 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. Unlike numerical solutions that can be acquired using canned packages and/or commercial solvers, 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 not only a desirable tool, but rather 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.

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This course on the space environment and its effects on systems 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.

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This short 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 briefly to highlight the cost and risk reduction potential of the altitude test. A brief 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 in detail and will be a major subtext throughout the course. The critical measurements that are typically 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 present course attempts to couple computational theory and practice by introducing a multistep modeling paradigm from which to base thermal analysis. The first 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 CHT course is also designed around an array of practical examples and employs real-time InterLab sessions. The overall goal of the CHT course is to form unison of theory and practice, emphasizing a definitive structure to the analysis process. 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).

AIAA Programs

Program-at-a-Glance

28th Aerodynamic Measurement Technology, Ground Testing, and Flight Testing Conferences including the Aerospace T&E Days Forum Technology and Ground Testing Conference
Advances in Conventional Force, Moment and Pressure Measurements
Advances in Particle Based Measurement Techniques
Emerging Flight Test Technologies
Flight Test Infrastructure
Flight Test Programs and Methods
Fluid Dynamic Investigations using Advanced Aerodynamic Measurement Techniques
Ground Testing Advancements and Simulation
Ground Testing Advancements and Simulations II
Ground Testing Process and Facility Improvement/Sustainment
Improved Flight test Methods
Invited Session - Design of Experiments Used in Aerodynamic Testing
Pressure Sensing Technologies
Spectroscopic Measurements 1: Path Averaged Techniques
Spectroscopic Measurements 2: Spatially Resolved Techniques
Surface Shear, Heat Flux, Shape and Temperature Measurement

30th AIAA Applied Aerodynamics Conference
Active and Passive Flow Control
Aerodynamic Design Methodologies I
Aerodynamic Design Methodologies II
Aerodynamic-Structural Dynamics Interaction
Airfoil/Wing/Configuration Aerodynamics I
Airfoil/Wing/Configuration Aerodynamics II
Applied Analytical/CFD with Correlation to Experimental Data I
Applied Analytical/CFD with Correlation to Experimental Data II
Bio-inspired Aerodynamics
Environmentally Friendly and Efficient Aerodynamics and Enabling Technology
High Angle of Attack and High Lift Aerodynamics
Icing Aerodynamics
Innovative Aerodynamic Concepts and Designs
Low Speed, Low Reynolds Number Aerodynamics I
Low Speed, Low Reynolds Number Aerodynamics II
Low-Re FSI
Missile/Projectile/Guided-munition Aerodynamics
Optimization Methods in Applied Aerodynamics
Other Topics in Applied Aerodynamics
Propeller/Rotorcraft/Wind Turbine Aerodynamics I
Propeller/Rotorcraft/Wind Turbine Aerodynamics II
Sonic Boom Mitigation
Special Session: CFD High Lift Prediction Workshop Follow-on I
Special Session: CFD High Lift Prediction Workshop Follow-on II
Transonic, Supersonic, & Hypersonic Aerodynamics
Unmanned Aerial Vehicle Designs/Tests
Unsteady Aerodynamics I
Unsteady Aerodynamics II
Vortical/Vortex Flow
VSTOL/STOL Aerodynamics
Weapons Carriage and Store Separation
Wind Tunnel and Flight Testing Aerodynamics

4th Atmospheric and Space Environments Conference
Atmospheric Environment and Dynamics
Ice Crystal Icing & Instrumentation
Ice Protection Systems & Icing CFD
Icing Aerodynamics
Icing Weather Forecasting
NASA Aviation Hazard Safety Mitigation Program
NASA IRT New Cooling System; Calibration and Simulation
SLD and Icing Physics
Space Environment Laboratory Simulation
Wake Vortex Studies

6th AIAA Flow Control
Active and Passive Flow Control
Actuator Development and Characterization
Bluff Body Wake Control
Boundary Layer Control
Closed-Loop Flow Control I (Invited)
Closed-Loop Flow Control II
Flow Control Sensors
High-Speed Flow Control
Laminar Separation Bubble Control
Plasma Actuators
Plasma and Lasers for Propulsion
Plasma and MHD Flow Control
Separation Control I
Separation Control II
Shear Layer Flow Control
Turbomachinery Flow Control
Vortex Flow Control

42th AIAA Fluids Dynamics Conference
Aero Optics
Algorithms for Fluid Structure Interaction
Atmospheric Environment and Dynamics
Bio-inspired Aerodynamics
Boundary Layer Control
Cartesian and Overset CFD Methods
CFD Applications I
CFD Applications II
CFD for Reacting Flows
CFD Methods
Combustion
Complex Flows
Compressible Transition and Flow Control
Crossflow Instability and Transition
Drops, Bubbles and Particles
Experimental Methods
Facility Studies and Characterizations
Fluid Structure Interaction
Fundamental Physics of Instability and Transition
Global Stability
High-Order Methods in CFD
Hypersonic Transition I
Hypersonic Transition II
Hypersonic Turbulence
Innovative CFD Algorithms
Large Eddy Simulation
Locomotion, Swimming and Flying
Low-Re FSI
Low-Re Gusts and Unsteadiness
Low-Re low-AR Wing Physics
Low-Re Vortex Physics
Micro/Nano-Scale Fluid Dynamics
Multi-disciplinary CFD

Numerical MHD/Plasmadynamics
Numerical Simulation of Boundary-Layer Transition and Separation
Numerical Simulation of Turbulence
Roughness-Induced Transition
Shock-Boundary Layer Interactions I
Shock-Boundary Layer Interactions II
Shocks I
Shocks II
Solution-Adaptive CFD Methods and Uncertainty Quantification
Theoretical Fluid Dynamics Analyses & Models
Turbomachinery & Engines
Turbulence Experiments and Applications
Turbulence Modeling and Applications (I)
Turbulence Modeling and Applications (II)
Turbulent Jets and Mixing
Wind Turbines

43rd AIAA Plasmadynamics and Lasers Conference
Aero Optics
Lasers
MHD for Re-Entry Vehicles
MHD Power Generation
Numerical MHD/Plasmadynamics
Plasma and Lasers for Propulsion
Plasma Diagnostics and Experimentation
Plasma-Assisted Combustion and Plasma Kinetics (invited)
Plasma-Based Flow Control (invited)

43rd AIAA Thermophysics Conference
Ablation I
Ablation II
Aerothermodynamics I
Aerothermodynamics II
Complex Flows
Computational Heat Transfer
DSMC
Experimental Heat Transfer
Heat Transfer I
Heat Transfer II
Nonequilibrium Flows I
Nonequilibrium Flows II
Nonequilibrium Radiation I
Nonequilibrium Radiation II
Propulsion & Combustion
Surface Catalysis
Thermal Management
Thermal Protection Systems

18th AIAA International Space Planes and Hypersonic Systems and Technologies Conference

Tours, France
Vinci International Congress Centre of Tours
24–28 September 2012

Abstract Deadline: 12 April 2012

Synopsis

The 18th AIAA International Space Planes and Hypersonic Systems and Technology Conference will provide a forum for international discussion and exchange of information about leading-edge research and development activities associated with space planes and hypersonic atmospheric flight vehicles and the technologies underpinning these capabilities. The conference will consist of overviews of national programs from Asia, Australia, Europe, and North America; programmatic summaries of major ongoing activities; invited lectures by distinguished researchers; technical oral and poster presentations; and panel discussions on current issues and future directions. In addition, technical tours will give the opportunity to visit the most advanced hypersonic test facilities in France.

In keeping with the objectives of this conference, the organizers are soliciting papers from space plane and hypersonic programs and technologists from the international community. Papers are solicited in the following topic areas:

- Planned and ongoing space plane and hypersonic vehicle programs
- Advanced launch vehicle and hypersonic atmospheric flight vehicle concepts
- International collaboration approaches working to advance concepts and capabilities
- Commercial space tourism concepts
- Flight testing techniques, results, and lessons learned
- Re-entry vehicle systems and technologies
- Aerodynamics and aerothermodynamics of spaceplanes and hypersonic vehicles
- MHD and plasma aerodynamic flow control techniques
- Plasma-assisted combustion techniques
- Rocket, ramjet, scramjet, and other advanced propulsion systems, including component technologies (e.g., inlets, combustion systems, fuel injection concepts, ignition and flameholding concepts, nozzles)
- CFD development, validation, and application
- High-temperature materials
- Hot structures and thermal protection systems
- Thermal management techniques including active cooling concepts and systems
- Flight control and trajectory optimization techniques
- Health monitoring and management technologies
- Ground facilities and test techniques including diagnostics development
- History of space planes and hypersonic vehicle activities
- Relevant educational initiatives and workforce development activities

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David Stallings, Emeritus
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Gennaro Russo, Italy
g.russo@cira.it

Abstract Submittal Procedures

Abstract submissions will be accepted electronically through the AIAA website at **www.aiaa.org/hypersonics2012**. Once you have entered the conference website, log in, click "Submit a Paper" from the menu, and follow the instructions listed. The website is open for abstract submittal. The deadline for receipt of abstracts via electronic submittal is **12 April 2012**.

If you have questions regarding the submission criteria or questions about AIAA policy, please contact Institute Administrator Ann Ames at anna@aiaa.org. If you have any difficulty with the submittal process, please e-mail ScholarOne Technical Support at **ts.acsupport@thomson.com** or call 434.964.4100 or (toll-free, U.S. only) 888.503.1050.

Questions pertaining to the abstract or technical topics should be referred to the corresponding Technical Program Chair. Authors will be notified of paper acceptance or rejection on or about **29 May 2012**. Instructions for preparation of final manuscripts will be provided for accepted papers.

Abstract Submittal Guidelines

Submittals should be approximately 1,000 words (5–6 pages in length with 12-point font, including cover page, figures, tables, and text) and in the form of an extended abstract or draft paper; draft papers are encouraged. Submittals must describe clearly the purpose and scope of the work, the methods used, key results, contributions to the state of the art, and references to pertinent publications in the existing literature. The submittal should include figures and data that support the results and contributions asserted. Both abstracts and final papers should address the accuracy of the numerical, analytical, or experimental results adequately. Abstracts will be reviewed and selected based on technical content, originality, importance to the field, clarity of presentation, and potential to result in a quality full paper. As such, abstracts should describe clearly the work to be included in the full paper, its scope, methods used, and contributions to the state of the art. The abstract must include paper title, names, affiliations, addresses, and telephone numbers of all authors.

Please Note: Be sure that all of your submission data—authors, keywords, title and abstract file—is accurate before finalizing your submission as no modifications can be made to this data after the submission site closes.

"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.

Duplicate Publishing

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.

Final Manuscript Guidelines

An Author's Kit containing 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 **6 September 2012**.

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.

Why Submit a Paper?

Networking
Build your professional network and interact with peers during your paper presentation.

Worldwide Exposure

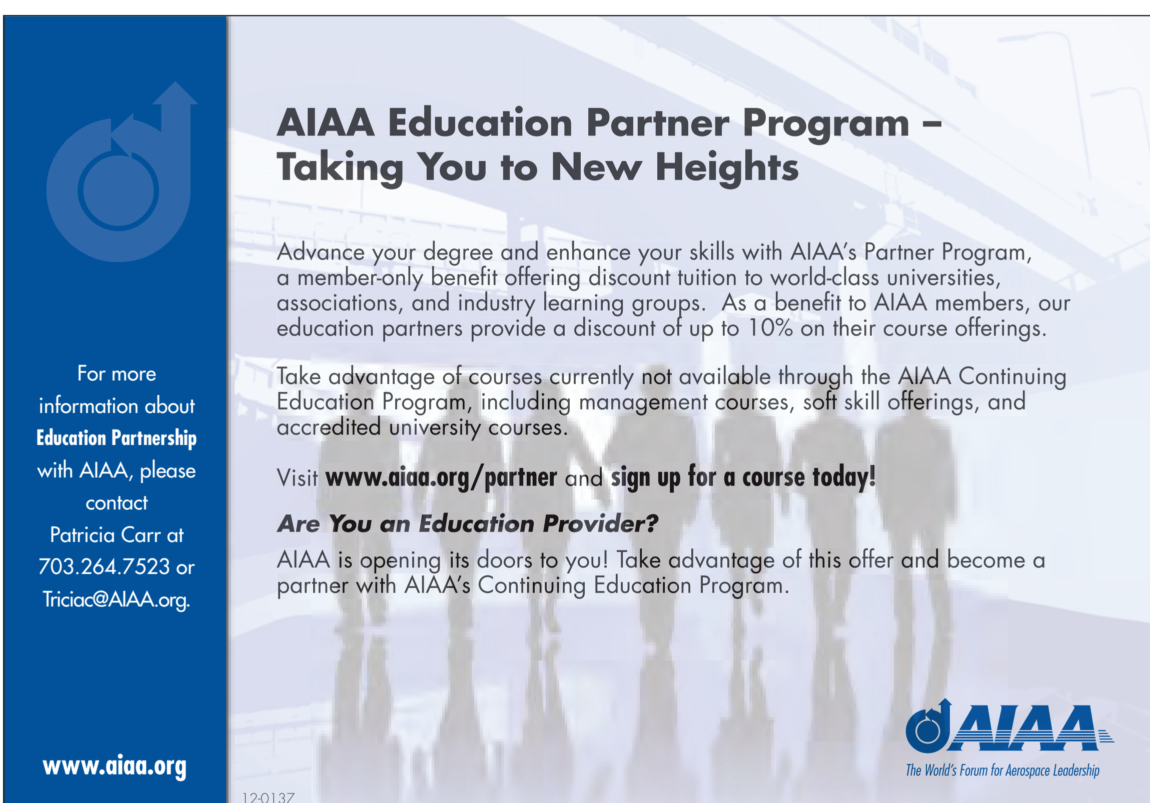
Your paper will be added to the AIAA Electronic Library, the largest aerospace library in the world. More than two million searches are performed every year with 150 institutions as subscribers!

Respect

AIAA journals are cited more often than any other aerospace-related journal, and their impact factor is ranked in the top ten. Publishing with AIAA ensures that your name is connected with the most prestigious publications in the aerospace field.

Praise

Receive recognition from your peers for your presentation (or if your student paper is considered for the best student paper award).



Upcoming AIAA Professional Development Courses

21–22 April 2012

The following Continuing Education classes are being held at the 53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference; the 20th AIAA/ASME/AHS Adaptive Structures Conference; the 14th AIAA Non-Deterministic Approaches Conference; the 13th AIAA Gossamer Systems Forum; and the 8th AIAA Multidisciplinary Design Optimization Specialist Conference in Honolulu, Hawaii. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

SDM Course and Conference Registration Fees

To register, go to **www.aiaa.org/SDM2012.**

	Early Bird by 26 Mar 2012	*Standard (27 Mar–20 Apr)*	*Onsite (21–22 Apr)*
AIAA Member	$1260	$1360	$1460
Nonmember	$1338	$1438	$1538

Fundamentals of Composite Structure Design **(Instructor: Rikard Heslehurst, Senior Lecturer, School of Aerospace, Civil and Mechanical Engineering of the University College, UNSW at the Australian Defense Force Academy)**

This seminar has been developed specifically for engineers who require some fundamental understanding of the structural design requirements for composites. The application of composite materials is discussed initially in terms of the constituent component material properties and manufacturing processes based on the design requirements analysis. The tailoring of structural properties through lamination and fiber orientation placement are discussed in relationship to strength of materials issues and load/deformation response. The design development of the laminate is based on design outcomes and how fiber/resin systems and ply orientation is determined to achieve these design outcomes. This seminar will cover the design requirements of stress analysis for the design detail such as joints, structural stiffening against instability, and other structural discontinuities. Other aspects to be covered include environmental and longevity aspects, certification, and in-service support issues.

Introduction to Bio-Inspired Engineering **(Instructor: Chris Jenkins, Head of Mechanical & Industrial Engineering, MSU, Bozeman, MT)**

The primary purpose of this course is to inform engineers and other technical professional in the use of bio-inspired engineering (BiE) to expand the design space of possible solutions to technical problems. We do that by first understanding how nature solves problems. Then, and at least as important, is learning how to translate biological knowledge into engineering practice. Even though the domain of biology is vast and new discoveries occur daily, much is known about biological solutions. Turning this knowledge into technical solutions is the challenge we face—it is also the focus of considerable attention in modern BiE, and hence this course as well.

Aeroelasticity: State-of-the-Art Practices **(Instructors: Dr. Thomas W. Strganac, Texas A&M University, College Station, TX; Dr. Carlos E. S. Cesnik, University of Michigan; Dr. Walter A. Silva, NASA Langley Research Center; Dr. Jennifer Hegg, NASA Langley Research Center; Dr. Rick Lind, University of Florida; Dr. Paul G. A. Cizmas, Texas A&M University; Dr. Gautam SenGupta, The Boeing Company; John Lassiter, NASA Marshall Space Flight Center)**

Recently, there has been a renewed interest in aeroelasticity arising from high performance aerospace systems, multiple control surface configurations, and pathologies associated with nonlinear behavior. This course provides a brief overview of aeroelasticity and examines many new "fronts" currently being pursued in aeroelasticity that include reduced-order models, integrated fluid-structural dynamic models, ground vibration testing, wind tunnel tests, robust flutter identification approaches for wind tunnel and flight test programs, aeroservoelasticity, and aeroelasticity of very flexible aircraft. The course will emphasize current practices in both analytical and experimental approaches within industry and government labs, as well as advances as pursued by these organizations with the support of university research.

Introduction to Non-Deterministic Approaches **(Instructor: Dr. Ben H. Thacker, Director, Materials Engineering Department, San Antonio, TX; Dr. Michael P. Enright, Principal Engineer, Materials Engineering Department, San Antonio, TX; Dr. Sankaran Mahadevan, Professor, Civil, Environmental and Mechanical Engineering, Vanderbilt University, Nashville, TN; Dr. Ramana V. Grandhi, Professor, Department of Mechanical and Materials Engineering, Wright State University, Dayton, OH)**

This course is offered as an introduction to methods and techniques used for modeling uncertainty. Fundamentals of probability and statistics are covered briefly to lay the groundwork, followed by overviews of each of the major branches of uncertainty assessment used to support component and system level life cycle activities, including design, analysis, optimization, fabrication, testing, maintenance, qualification, and certification. Branches of Non-Deterministic Approaches (NDA) to be covered include Fast Probability Methods (e.g., FORM, SORM, Advanced Mean Value, etc.), simulation methods such as Monte Carlo and Importance Sampling, surrogate methods such as Response Surface, as well as more advanced topics such as system reliability, time-dependent reliability, probabilistic finite element analysis, and reliability-based design. An overview of emerging non-probabilistic methods for performing uncertainty analysis will also be presented.

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.

Aeroacoustic Course and Conference Registration Fees

To register, go to **www.aiaa.org/Aeroacoustics2012.**

	Early Bird by 7 May 2012	*Standard (8 May–1 Jun)*	*Onsite (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.

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.

Fluids Course and Conference Registration Fees

To register, go to **www.aiaa.org/NewOrleans2012.**

	Early Bird by 29 May 2012	*Standard (30 May–22 Jun)*	*Onsite (23–24 Jun)*
AIAA Member	$1248	$1348	$1448
Nonmember	$1325	$1425	$1525

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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

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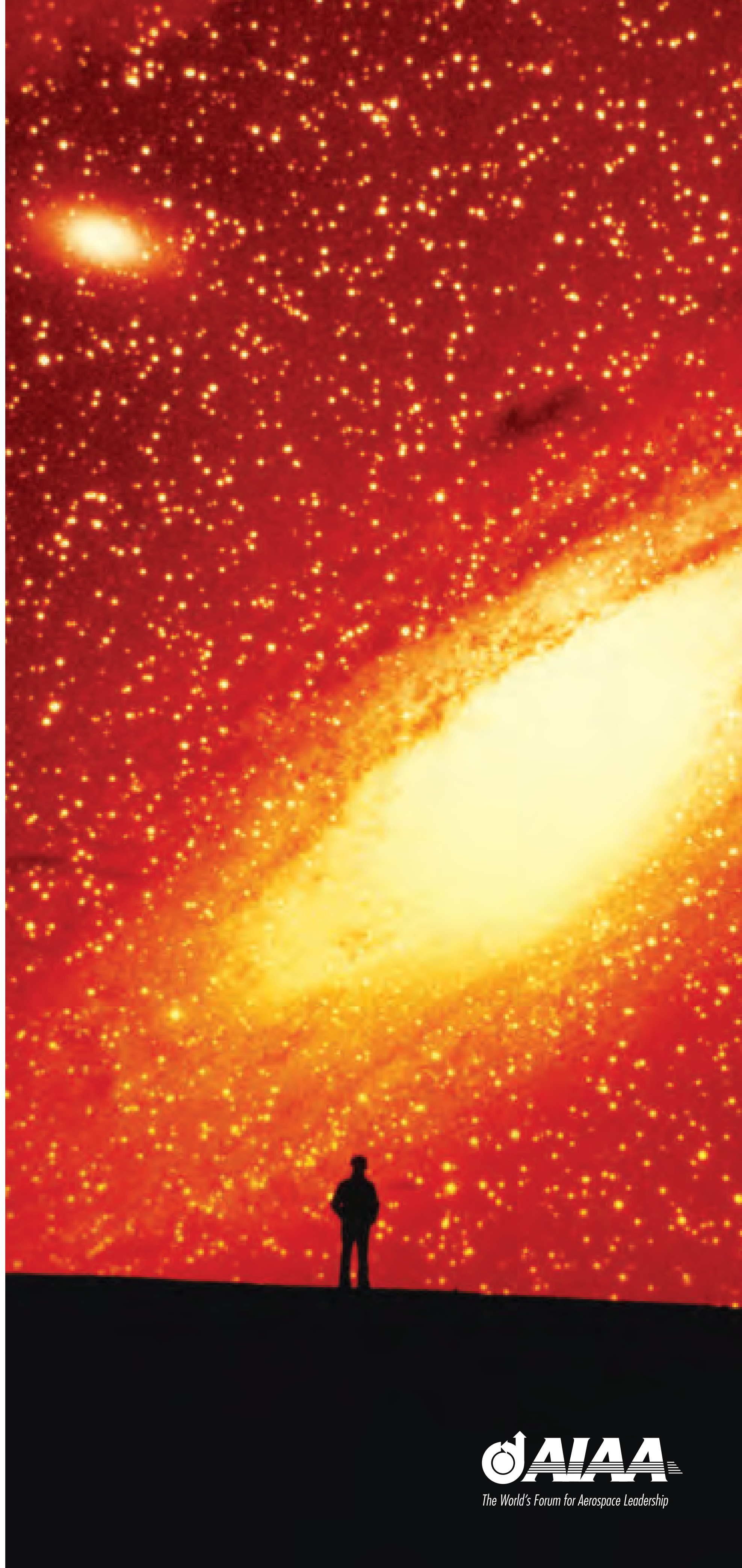

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