March 2013

AEROSPACE AMERICA

Stormy outlook for weather satellites

A conversation with Sean O'Keefe

New thrust for solar electric propulsion

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AEROSPACE AMERICA

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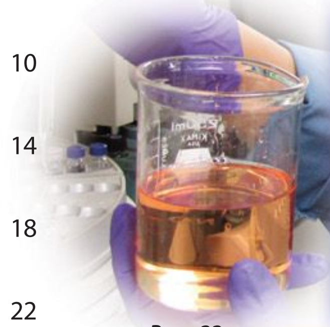
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NASA's GOES satellite provided vital, timely information about superstorm Sandy. For more information about our weather satellites, please turn to the story beginning on page 30.

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Commentary

Navigating the fiscal cliff redux

Two of the three elements that constituted the January 1 'fiscal cliff' featured in last month's editorial have yet to be navigated—raising the debt limit and budget sequestration. Deadlines for their resolution were "kicked down the road" to this month, and the *Aerospace America* editorial urged our politicians to negotiate solutions. However, the diametrically opposed views expressed by President Obama in his State of the Union address and by Republican Senator Marco Rubio's response do not bode well for a successful outcome. Compromise is obviously essential, but can compromises be found that might overcome the political barrier to a viable future?

Recent successes in resolving knotty aerospace issues may inspire some degree of optimism for the larger U.S. fiscal scene. One of the longer lasting of these is the debate over satellite export regulations. The Strom Thurmond National Defense Authorization Act (NDAA) of 1999 placed all satellites, their technology, and their components on the U.S. Munitions List. The initial rationale for doing so, which was the largely unsupportable premise that the Chinese military was benefiting from information released during failure investigations of several U.S. satellites launched on Chinese rockets, was subsequently attributed to purely political motives. Whatever the rationale, during the following decade the U.S. satellite industry was decimated and the negative effects on national security far outweighed any positive ones. But after seemingly endless negotiations between Congress and the administration, a mutually acceptable compromise resulted in the NDAA of 2013, which repealed the damaging elements of the 1999 NDAA and restored a viable framework for U.S. satellite development and production.

Another major controversy arose in the U.S. space exploration program when President Obama cancelled the Constellation project, which focused on development of next-generation space launch systems to succeed the shuttle, and proposed to fund commercial launchers instead. This was bitterly opposed by influential members of Congress, who not only saw their constituencies suffering from the cancellation but also were justifiably concerned about the paucity of commercial launch experience. Nevertheless, suitable compromises were reached; we now have both an apparently healthy NASA Space Launch System program along with an equally healthy Orion crew exploration vehicle development, and a demonstrated (and funded) commercial cargo launch capability that is actively moving toward carrying humans.

The James Webb Space Telescope represents another success in the face of what had appeared to be insurmountable differences over its financial and schedule problems. Originally funded as the Next Generation Space Telescope in 1996 with a budget of $1.5 billion and a projected launch date in 2011, it is now budgeted at $8.8 billion and is expected to be launched in 2018. The international project was successfully steered past an almost incredible series of obstacles, most notably strong congressional opposition that included mandating a massive external review and a threat of U.S. withdrawal.

Although these examples of successful compromise are limited to a tiny fraction of the federal structure, they may provide some hope that agreement can indeed be reached on the much more important issues that we face in the coming weeks.

Jerry Grey
Editor-at-Large

Printing your next vehicle

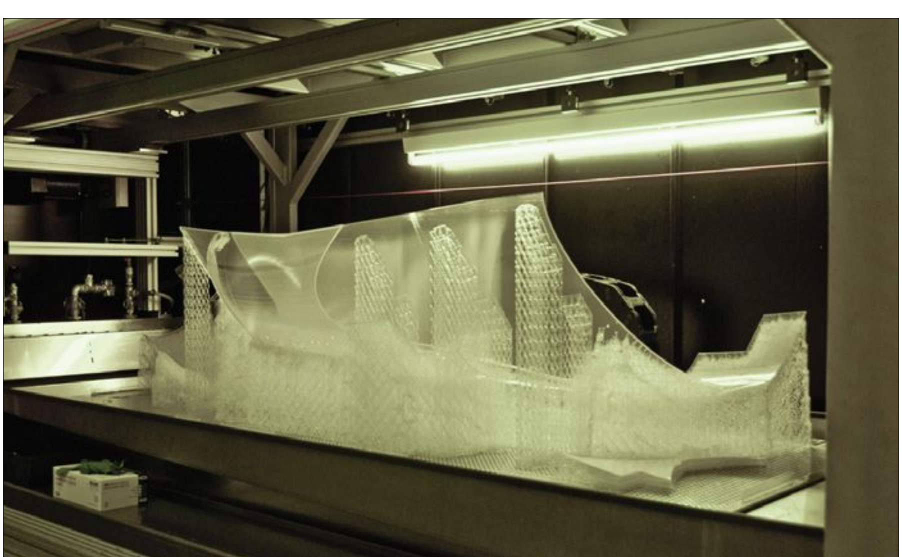
Areion is the world's first race car created in great part through 3D printing.

THE FORMULA GROUP T, BASED IN Leuven, Belgium, is not one of the most successful race car manufacturers in the world. Its competitive automobile, the Areion, came in 52nd out of 102 competitors in the Formula Student races held last summer throughout Europe—a respectable if not exactly headline-grabbing result.

But the Areion is a rather special vehicle. Most of the car, including all of the body, has been made from 3D printing—also known as 'additive manufacturing'—a process that creates a 3D shape from a digital model by laying down successive thin layers of a material. This process could have a profound impact on the future of aircraft and spacecraft manufacturing.

The body of the Areion was constructed layer by layer in a liquid polymer that hardens when struck by a laser beam. Most 3D printing uses the 'selective laser sintering' process—a fast, cost-effective, and extremely accurate manufacturing method where a high-powered laser is used to fuse small particles of composite or metal particles into layers, which are built up repeatedly until the final shape is achieved.

The promise of 3D printing has been known for some time, but only now are the initial applications for aerospace manufacturing becoming clear. Among the most significant aspects of the Areion is that it has proved to be robust in challenging environments—confounding skeptics who have doubted the durability of 3D printed assemblies. The race car weighs just 280 kg.



Additive manufacturing is the process of making objects from 3D model data by joining materials layer by layer. Engineers went from initial shell design to a fully finished 3D printed car body in just three weeks.

In 2011 researchers from the University of Southampton in the U.K. flew one of the first 3D printed aircraft, the SULSA (Southampton University Laser Sintered Aircraft), a remotely piloted plane whose entire structure has been printed, including wings, integral control surfaces, and access hatches.

Removing constraints

According to Jim Scanlan, a professor in the University's Computational Engineering and Design Research group, "The flexibility of the laser sintering process allows the design team to revisit historical techniques and ideas that would have been prohibitively expensive using conventional manufacturing. Another design benefit laser sintering provides is the use of an elliptical wing planform. Aerodynamicists have for decades known that elliptical wings offer drag benefits. The Spitfire wing was recognized as an extremely efficient design, but it was notoriously difficult and expensive to manufacture. Again, laser sintering removes the manufacturing constraint associated with shape complexity, and in the SULSA aircraft there is no cost penalty in using an elliptical shape."

Like the Areion, the SULSA is a relatively modest object—an electrically powered aircraft with a 2-m wingspan and a top speed of nearly 100 mph.

But European aircraft manufacturers are working on much more ambitious 3D printed projects.

Airbus plans to build complete airliners with 3D printers by 2050. According to Bastian Schaefer, a cabin engineer with Airbus, the company has been working for the last two years on a future cabin concept from which has sprung the idea of building the entire frame on a 3D printer the size of a hangar. According to Airbus: "That probably sounds like a long shot, since the biggest 3D printers today are about the size of a dining table. But the Airbus design comes with a roadmap, from 3D printing small components now, through to the plane as a whole around 2050."

Additive and freeform concepts

In October 2012, Airbus, the National Laser Centre of South Africa's Council for Scientific and Industrial Research, and South African aerospace manufacturer Aerosud signed an agreement to research the application of titanium powder-based additive manufacturing concepts for producing large and complex aerospace components.

South Africa is one of the world's largest producers of mined titanium ore. According to some estimates, the process can save up to 65% in manufacturing costs, while reducing waste, lowering emissions levels, and providing parts at a much faster rate than is currently possible. As part of the agreement, Aerosud is building a R37-million laser-based part-forming machine that it plans to complete by the middle of this year.

Airbus is not alone in acquiring additive manufacturing capabilities. In November 2012, GE Aviation announced it had acquired Morris Technologies and its sister company, Rapid Quality Manufacturing of Cincinnati, which have been producing components for GE Aviation using additive techniques for several years. The companies have made lightweight parts for remotely piloted air systems and components for the CFM International LEAP jet engine, which GE Aviation and Snecma (SAFRAN) of France are producing jointly.

And NASA Langley has been researching electron beam freeform fabrication, or EBF3. This technology is similar to selective laser sintering but uses electron beam guns to manufacture metallic structures, to allow space missions to build parts and tools in space. A prototype has been tested in zero gravity, and there are now plans for NASA to build a smaller machine for testing on the ISS.

In 2011 researchers from the University of Southampton flew one of the first 3D printed aircraft, the SULSA, an RPV whose entire structure has been printed, including wings, integral control surfaces, and access hatches.

Slow adoption

But there are considerable technical and regulatory hurdles to be overcome before 3D printed components and structures regularly find a place on board airliners, military fast jets, and spacecraft. Given the potential gains available with 3D printing, its integration within the supply chain has been relatively slow.

There are several reasons. The U.K.'s Technology Strategy Board, part of the government's Dept. for Business, Innovation and Skills, suggests: "The reasons for slow adoption include high cost, inconsistent material properties, lack of applicable industry standards, unexpected pre- and post-processing requirements, and the failure to exploit the new design freedoms offered."

Another key challenge is controlling the amount of energy required to power large-scale 3D printers. Lasers need large amounts of power, and some of the savings derived from producing structures without the waste that accompanies milling and grinding could be lost if the power requirements are not carefully managed.

So the introduction of 3D printed assemblies into operation is likely to appear first in small-scale airframe interior components—safety belt buckles, seat components, and interior structures.

Competitive edge

But 3D printing research is just one of several new advanced manufacturing techniques that are being jointly targeted by European governments and industry to ensure the EU retains a competitive edge in an increasingly tough aerospace manufacturing market. According to the European Association of the Machine Tool Industries, European demand for current machine tool consumption represents just 24% of the global demand for machine tools, against 66% for the Far East (with China accounting for 45% of the global market). The Americas represent just 11% of the market.

Manufacturing is currently responsible for only 15.6% of EU gross domestic product, though four-fifths of its exports. As part of the European Commission's plans to reverse the relative decline of manufacturing in the continent it has set out a series of

(Continued on page 25)

Improved cosmetics, no new substance

In the nation's capital, leaders on both sides of the aisle have improved the atmospherics of their ongoing debate over fiscal problems, but perhaps only temporarily. "Things are more cordial than they were even a few weeks ago," said a Capitol Hill aide, but maybe not by much. While the cosmetics have improved, no one in either party is pushing a realistic solution to the deficits and debt that continue to drag the nation in the direction of insolvency.

At press time, the Senate was expected to pass, and President Barack Obama was saying he would reluctantly sign, the 'No budget, no pay' legislation enacted by the Republican-controlled House of Representatives. The measure suspends debate on the national debt ceiling for three months but specifies that Congress must enact a traditional budget during that period, something it has not done since 2009. If no budget is passed, the bill stipulates, lawmakers will no longer be paid.

Republicans see the bill as a smart move because it avoids conflict, temporarily at least, while simply calling on the legislative branch to do its job. To Democrats, the measure is a ploy.

Rep. Virginia Foxx

No one in Washington appears to have noticed that the 'no pay' provision violates the 27th Amendment to the U.S. Constitution, which reads: "No law, varying the compensating for the service of the Senators and Representatives, shall take effect, until an election of Representative shall have intervened." The amendment has a long history, having been proposed in 1789 but not passed until 1992, and its purpose was to prevent lawmakers from *raising* their salaries.

In a world of bumper stickers and split-second sound bites, 'No budget, no pay' has high appeal to conservatives. Rep. Virginia Foxx (R-N.C.) said in a statement:

"It is downright embarrassing that the United States Senate has failed to pass a budget for almost four years. Every North Carolina family and small business has to contend with the realities of budgeting, and Washington should be no exception. In fact, politicians should not get paid if they fail to do their most basic job—passing a budget." Foxx reminded constituents that, "Our country and job market are mired in $16.4 trillion dollars of debt." But the Senate is not alone in not having recently passed a budget: neither house of Congress has done so.

On the other side of the aisle, 'No budget, no pay' was a "joke" to Rep. Nancy Pelosi (D-Calif.) and a "political gimmick" to Rep. Steny Hoyer (D-Md.). Both cautioned that the measure merely perpetuates uncertainty.

Women in combat

Secretary of Defense Leon Panetta announced January 24 that the armed forces will lift their ban on women serving in front-line combat roles. This will open about 230,000 additional assignments to women in the U.S. military, who currently number about 1.4 million active-duty members. Women make up about 14% of the forces.

"Women have shown great courage and sacrifice on and off the battlefield, contributed in unprecedented ways to the military's mission, and proven their ability to serve in an expanding number of roles," Panetta told reporters. "The department's goal in rescinding the rule is to ensure that the mission is met with the best qualified and most capable people, regardless of gender." The president, who directed Panetta to make the announcement, called the change "another step toward fulfilling our nation's founding ideas of fairness and equality."

Women have served as pilots and crew on combat aircraft since 1994. They fly fighters, bombers, and attack helicopters. The Air Force got its first woman commander of a combat wing last June when Col. Jeannie M. Leavitt took command of the 4th Fighter Wing at Seymour Johnson AFB, North Carolina. Leavitt is a command pilot with 2,500 hr in the F-15E Strike Eagle and flew combat missions in Iraq and Afghanistan.

Col. Jeannie Leavitt is the first woman to command a U.S. fighter wing.

Secretary of Defense Leon Panetta

Women began to pull duty aboard warships, including Arleigh Burke-class guided missile destroyers and nuclear-powered aircraft carriers, in 1993. The Navy got its first woman skipper of a combat ship in 1998 when Cdr. Maureen A. Farren took command of the USS Mount Vernon (LSD 39), an amphibious dock landing ship. The Pentagon opened submarine duty to women in 2011.

But until now, the nation's close-quarters combat arms—armor, artillery, infantry, combat engineers, special operations, including Army Green Berets and Navy SEALs—have been off limits to women.

Many Americans balk at the thought of a woman being shot in close combat or blasted by a bomb—even though it has happened in Iraq and Afghanistan. What may be even worse, said defense analyst and author Norman Polmar in a telephone interview, could be "women being captured, tortured, or even mutilated by enemies who believe women unacceptable as opponents."

Other serious objections come from those who question whether a woman can handle certain tasks, such as lugging a 100-lb rucksack and rifle on a forced march. In an experiment conducted last summer that was aimed at gathering data, two first-ever female lieutenants underwent the Marine Corps Infantry Officer Course and failed to complete the program, along with 26 of the 107 male lieutenants. One of the women failed the combat endurance test at the beginning of the course. In an op-ed piece last year, Capt. Katie Petronio, herself a Marine officer, posed a question on many minds: "Can women endure the physical and physiological rigors of sustained combat operations, and are we willing to accept the attrition and medical issues that go along with integration?" Petronio wrote that women are not clamoring for jobs in the infantry. Rep. Duncan Hunter (R-Calif.) called the Panetta announcement "totally out of left field."

Opponents of new combat roles for women always have ammunition within easy reach. An example: a 2010 Navy survey showing that 9% of enlisted women are pregnant at any given time, creating enormous logistical concerns.

Supporters of the change argue that women are already deployed throughout the battlefield and in harm's way and that their transition into close-quarters combat is "inevitable," to quote Rep. Tammy Duckworth (D-Ill.), a former UH-60 Black Hawk helicopter pilot who lost both legs and damaged her right arm when she sustained combat wounds in Iraq on November 12, 2004. Added Duckworth, "This decision to allow women to serve in combat will allow the best man or woman on the front line to keep America safe." Lawrence Korb, a Washington-based defense analyst, told *USA Today* the change is "the right thing to do."

Panetta's announcement came as something of a surprise in Washington just as the Pentagon boss was preparing to retire to his farm in Monterey, California. When we went to press, the Senate was preparing to take up the administration's nomination of Vietnam combat veteran and former Sen. Chuck Hagel (R-Neb.) to replace Panetta as Defense Secretary. And as President Obama was gearing up for an intense push on sweeping legislation planned for early in his second term, he shook up his White House staff, installing a new team largely made up of familiar faces, officials moved from other positions in his administration. As his new chief of staff Obama named Denis R. McDonough, a longtime aide and currently the principal deputy national security adviser.

Military matters

The Marine Corps announced that Gen. James N. Mattis, the head of U.S. Central Command, or Centcom—responsible for military operations in Iraq and Afghanistan—will retire this spring. Mattis, nicknamed 'Mad Dog,' is a visible and vocal Marine known for speaking out in colorful and undiplomatic style. Although he is beloved within the Marine Corps, observers think Mattis's blunt facade and blunter speech—"be polite, be professional, but have a plan to kill everybody you meet"—caused him to be passed over for the job of commandant of the Marine Corps when Gen. James Amos took that job in 2010.

Mattis is being dismissed because of differences over Iran with White House security advisor Tom Donilon. In contrast to the hawkish Donilon, and like many military officers, Mattis is hesitant to take military action to

Rep. Tammy Duckworth

Gen. Lloyd James Austin III

neutralize Iran's nuclear development program without first studying the consequences that would follow.

Army Gen. Lloyd J. Austin III was named to replace Mattis.

Another four-star Marine, Gen. John Allen, who is finishing his stint as U.S. commander in Afghanistan, has been cleared of allegations of sending potentially inappropriate emails to a civilian woman linked to the scandal that ousted David Petraeus as CIA director, according to U.S. defense officials. As most observers expected, complaints about Allen's email activity were 'unsubstantiated,' said the Pentagon's inspector general.

It is unclear whether the administration plans to revive its nomination of Allen to be supreme allied commander of U.S. and NATO forces in Europe.

Everyone in Washington knows that huge cuts in defense spending lie ahead, one way or another. Among conservatives in the nation's capital, the selection of Hagel and the dismissal of Mattis are signals of a White House plan to hasten defense spending cuts in a way that some fear would leave the nation with a 'hollow' military. Supporters of these actions call them 'routine.'

Dreamliner dilemma

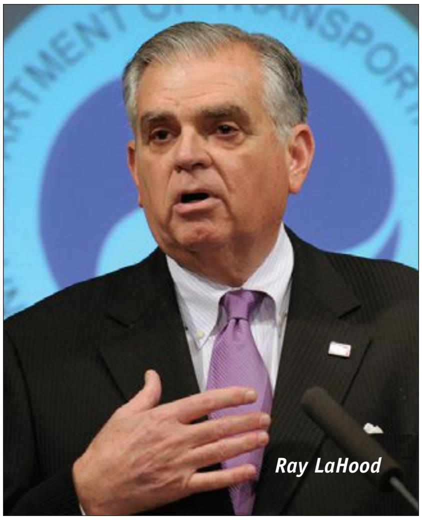
Secretary of Transportation Ray LaHood was in the limelight in January when the FAA grounded the Boeing 787 Dreamliner because of battery problems while assuring the public that the 787 is safe.

LaHood, 67, is a former Illinois congressman (1995-2009) and Republican who had been in the transportation job since the start of Obama's first administration but announced that he will be stepping down from his position. He entered office without a long résumé on transport matters. FAA administrator Michael Huerta reports to LaHood. The National Transportation Safety Board, which has been investigating the 787's issues and is headed by Deborah A.P. Hersman, is an independent agency that cooperates with LaHood's department.

In the words of *Seattle Times* reporter Kyung M. Song, LaHood found himself "sounding combative at times" when he and Huerta talked to reporters about a January 7 fire aboard a Japan Airlines 787 at Boston's Logan International Airport and another incident that occurred only 48 hours later. In the second mishap, a lithium-ion battery sprayed overheated electrolytes, forcing an All Nippon Airways 787 to make an emergency landing. LaHood bristled at a reporter's suggestion that he and Huerta lack technical expertise and defended both his assertion that the plane is safe and the decision to ground it.

"On the day we announced the planes were safe, they were," LaHood said. A reporter pressed him over his and Huerta's declaring that the 787 was safe to fly *after* the first incident occurred. Said LaHood: "I'm not doing these hypothetical look-backs. We did what we did."

Some critics blame the travails of the 787 on the FAA's certification process. Although there is no indication oversight was lacking in the 787



Ray LaHood

On January 4 a JAL 787 suffered an onboard fire at Logan Airport.

mishaps, the chronically understaffed FAA often has to rely on a planemaker to generate the data that are used to certify an aircraft for flight.

Rep. Rick Larsen (D-Wash.), who represents the district where most Boeing aircraft are assembled, says that the 787 probably has a bright future but adds that Congress may want to review the FAA approval process. “Right now, Congress’ job is to let the FAA do its job and do it well,” Larsen told Alwyn Scott of Reuters.

“I think the FAA was correct in issuing the airworthiness directive and grounding the plane so they could get a full handle on the problem,” Larsen added. “As we move forward, in Congress we’re probably going to look at certification issues as part of the general budget process.”

The NTSB on January 24 released preliminary findings in its investigation of the Logan incident. The battery that caught fire shows evidence of short-circuiting and a chemical reaction known as ‘thermal runaway,’ in which an increase in temperature causes progressively hotter temperatures, NTSB investigators said. Unfortunately, investigators don’t know why this happened or how to prevent it, raising the prospect that a ‘fix’ could take time.


Rep. Rick Larsen

“The expectation in aviation is to never experience a fire on board an aircraft,” NSTB boss Hersman told reporters. “We have to understand why this battery resulted in a fire when there were so many protections that were to be designed into the system.”

The FAA’s grounding of the 787 applies to six airframes operated in the U.S. by United Airlines. Authorities in other countries followed the FAA’s lead and grounded all 50 Dreamliners operating worldwide.

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

Robert F. Dorr’s latest book is Mission to Tokyo.

Sean O'Keefe

You're the top man of EADS North America. Tell us how EADS was affected by the failure of its proposed merger with BAE Systems.

The merger attempt brought several positives. One of those was an in-depth review of our strategy in Europe, in the U.S., and globally.

When the merger didn't work, did you—EADS and EADS North America—take a look at its weaknesses and then move to turn its failure into something positive?

Absolutely. We're doing that right now, going through that internal debate, discussion. The failure gave us the opportunity to rethink the assumptions behind what we were attempting to do and decide whether they are still valid in today's market conditions. It also helped energize all of us to introduce an entirely different governance and shareholder structure. As a result, EADS will no longer have the appearance of government control. There will be government shareholders, but they will represent a distinctly minority position on the new board of directors.

This is a major reversal. Every director of EADS Group—the corporation—will be independent, all elected at an annual meeting of shareholders, and will operate the company like every other company, without being under the influence of governments. Our new board of directors, our new governance, will be formed at the EADS annual meeting this month.

So would you say the failure of the merger freed up your corporation to do that?

Positively. It could not have been done had we not attempted to do the merger. It made us do something about the government/shareholder ambiguity of how EADS was organized when first formed in the late 1990s. We want to continue to be respectful of the national interests of Britain, Germany, Spain, and every one of the governments that have strong views of how EADS and EADS North America should operate in the marketplace. But at the same time, no nation-state should be in position to veto EADS operational decisions, except in the case of national security considerations.

What's next for the new EADS board of directors?

It will lay out our strategic alternatives, defining the market focus areas we want to be in and those we do not want to be in. It will lay out the choices we can make on how to do that. How we structure ourselves will be dependent on how our strategy emerges. The board will meet two or three times until May or June to come up with the right alternatives.

Tell us more about the background of all this.

EADS was formed as an amalgamation of a number of national aerospace and defense firms that were pulled together to create a pan-European focus on three sectors: aerospace, defense, and space. At that point, there was a lot of spirited discussion that BAE Systems, which had just evolved from British Aerospace into BAE, would be a very strong candidate to be part of the original European amalgamation. It just didn't come together, so the new EADS simply pushed on with what it was. And that was a major undertaking, one that very significantly altered the nature of industrial relations in Europe. It got away from the focus on national industrial complexes and more into a broader Eurozone kind of mindset.

"…no nation-state should be in position to veto EADS operational decisions, except in the case of national security considerations."

By the mid-2000s, EADS had evolved into a global player on the commercial aircraft side, with Airbus, and in its space and defense elements. Our purpose was no longer just getting our internal nationalistic interests together in a pan-European corporation, but competing on a broader stage, a global stage. And we have been doing that.

Elaborate on that, please.

The evolution of the EADS group provided the foundation and the mass and scale and reach on a global basis that had not existed before in every one of its sectors—aerospace, defense, and space. Eurocopter [an EADS subsidiary] is a prime example. Eurocopter products account for about half of all the commercial sales of helicopters in the U.S., and represent the lion's share of the market in the rotary wing business across the globe. About 70% of all the rotary-wing assets of the Coast Guard are Eurocopter assets.

Are all EADS subsidiaries active in the U.S. too?

Our subsidiaries, besides Eurocopter, are Airbus for commercial aircraft and services, Astrium for space products and services, and Cassidian for defense systems radar, cyber security, and communications networks. All are represented here in the United States in some way, shape, or form. For example, Airbus America will open an assembly line in Mobile, Alabama, in April to build fixed-wing A320 aircraft for airlines, and will become a much greater force and presence in the United States.

Where does EADS North America play in all this?

Our focus is on the U.S. government. We do business with the DOD, *Interview by James W. Canan*

NASA, Homeland Security, the Coast Guard. We represent all elements of the EADS operating divisions in working with, contracting with, and delivering products and services to the United States government. For EADS, the significance of the BAE merger was the opportunity to do more in the government market space.

EADS has always been more of a commercial company in every one of the areas we have been talking about—aircraft, space, helicopters. But we have been looking to expand our presence in the U.S. government market space and to change our commercial-to-government ratio, which is about 75:25, sometimes more like 80:20. We saw the merger as a chance to change the ratio to more like 60:40, or even maybe 50:50.

How would the merger have accomplished that?

EADS would have been about 60% of the size of the merged companies, BAE about 40%. The merger would have given EADS, in combination with BAE, a very strong foothold in the government markets around the globe. It would have done the same for BAE on the commercial side.

Where does EADS North America play in all this now? What is your strategy, your leadership outlook?

I am one of a dozen members of the EADS Group Executive Committee, which was organized by Tom Enders, the CEO of the corporation. All four operating divisions of EADS are represented on that committee, plus the functional leaders, the CFO, the head of sales and marketing strategy, and so forth. So I am one of that group. We meet on a regular basis to think through all of the corporation's strategic alternatives. Lots of other smart folks—a broad collection of our colleagues—are also thinking them through.

What are the big issues before the committee?

To define our challenges and set our strategies to meet those challenges. Tom Enders wants us to have a wide-open discussion and debate about all that. How do we look at the market? What are we doing, and what should we do, to be as competitive as we can on a global basis? EADS has always harbored a strong interest in the U.S. market, because of its sheer size. It is a huge, huge marketplace on every front, in every dimension you can think of, government and commercial. So we must devise a corporate strategy that takes into consideration the top market in the world.

Again, did the failure of the BAE/EADS merger make all of you more aware of the U.S. and global market opportunities and challenges?

Positively. Does it mean we are going to be much more U.S.-centric? Possibly. EADS is still primarily a pan-European company, but the failure of the merger attempt brought a new and heightened awareness that we are much bigger than that, that we are a

Sean O'Keefe was appointed CEO of EADS North America in November 2009 and chairman of the board in March 2012. His responsibilities include directing EADS activities in the U.S., developing strategic partnerships with U.S. companies, and enhancing the participation of EADS in the U.S. marketplace, including the development, growth, and management of large-scale defense acquisition programs.

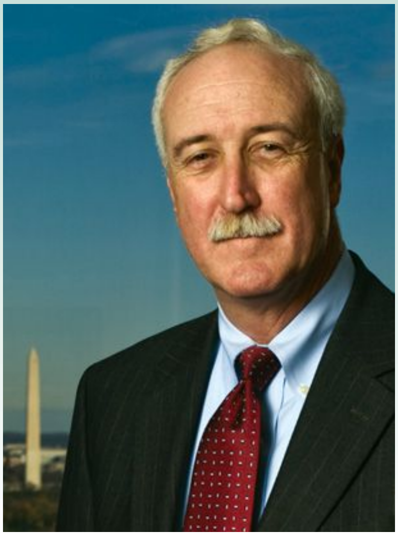
Prior to joining EADS North America, O'Keefe was vice president of General Electric in its technology infrastructure sector. From 2005 to 2008, he served as chancellor and CEO of Louisiana State University. Previously, he served in the administration of President George W. Bush as deputy assistant to the president, and deputy director of the OMB. From December 2001 to December 2004 he served as NASA administrator.

O'Keefe also served in President George H.W. Bush's administration as comptroller and chief financial officer of the Defense Dept., and as Secretary of the Navy.

He holds a B.A. from Loyola University in New Orleans and an M.A. in public administration from the Syracuse University Maxwell School of Citizenship and Public Affairs, where he served as the Louis A. Bantle professor of business and government policy from 1996 to 2001.

From 1993 to1996 he was professor of business administration, assistant to the senior vice president for research, and dean of the graduate school at Pennsylvania State University.

O'Keefe is a fellow of the National Society of Public Administration and of the International Academy of Astronautics, and serves on numerous corporate and nonprofit boards of directors. Among his many honors are the Distinguished Public Service Award, presented by President George W. Bush and Secretary of Defense Richard Cheney in 1993.



global player on all fronts, that we are a global company. It really changed our focus.

That's an interesting distinction. What do you mean by it?

There are some companies out there that say if you want to buy my product, I'll send it to you anywhere on the globe. Other companies say we've got to go beyond that single-product approach, we've got to be in that market space, be part of it, not just sell a particular product in it.

General Electric is an example. Their global focus wasn't arrived at simply because people all over the globe wanted to buy light bulbs. It happened because GE's strategy was to offer a wide array of products and services that grew over time, and to position the company around the world, making it a real global competitor on multiple market fronts. That's where we see ourselves now—in that same kind of evolutionary process.

"We know now that it is critical for us to be inside of, to be part of, the global market space, not simply selling into it."

Can you tell us how you yourself feel about where and how EADS North America should operate in the U.S.?

I have publicly enunciated the view that all of us harbor in the EADS leadership, which is that the U.S. market is one that must be reckoned with, one that we must address, because of its sheer size and import. And how we decide we want to participate in the U.S. market space—and all across the globe—is what we're wrestling with right now. My responsibility, and I'm expected to deliver on it, is to provide perspective on how dynamic the U.S. market is and to recommend how to facilitate access of the entire EADS Group into the whole range of the U.S. market—commercial and defense—on a solidly competitive basis.

Considering BAE's greater emphasis on the defense market, will the anticipated retrenching of that market have less effect on EADS North America than it might have had on a merged EADS/BAE company? In other words, does the failure of the merger free EADS from being caught up—trapped, if you will—in the U.S. defense drawdown?

You bet. No question, the overwhelming fiscal challenges that the U.S. federal government is confronting right now are a factor in our considerations. We have to think that they will result in a redefinition of spending priorities. In all my incarnations in public and private service, I've never seen anything like this. It is absolutely breathtaking in terms of the sheer nature of the challenge. But when it's all over with, when all is said and done, the market will either be really big or just plain big. It will still be big no matter what.

I'm talking about the entire federal market space, not just defense, everything. It will be affected by the fiscal cliff, the possible sequestration, debt limit extension issues, tax code provisions, all those things converging. But in the end it will still be an extremely large market for us to participate in. We want to be sure we're not missing any opportunities to compete in the parts of the market that will be substantially redefined.

Talk more about that.

The question is, do we want to get into hot competitive contests with other major competitors around the U.S. and around the globe in market spaces that are shrinking and not showing any real prospects, or do we want to take advantage of new market developments that may emerge from all this. And there's a bunch of them. One that is everybody's favorite at the moment is the unmanned aerial vehicle market, whether small drones or big ones. That market is significant, with any number of variations. Some elements of it may be expanding, others may not grow that much. It's really hard to tell right now.

"We want to be sure we're not missing any opportunities to compete in the parts of the market that will be substantially redefined."

Any other examples?

One is cyber security. I'm not signaling that it's an area we'll be focusing on, only that it's the kind of market we have to watch for. How do we define that market space? It has multiple definitions. Again, one part may grow and another may not go anywhere. We have got to understand and differentiate among the various segments and subsegments.

Does the administration's shift of emphasis in defense from Europe to the Pacific region play into your strategic thinking?

Absolutely. The shifting emphasis of the national security agenda of the United States makes us place a much more concentrated focus on the Pacific. It means looking at how to traverse extraordinary distances with affordable assets. All of a sudden, it makes our opportunities to provide fixed-wing assets much more interesting and compelling. We're well known for our aerial tankers. We're out there delivering them every day, in different nation-states, to perform the tanker missions. And there will be greater emphasis on those assets in the future because of the vast distances we're talking about covering. The Pacific region is a big, big place.

The same goes for cargo-carrying aircraft, I suppose.

Yes, and we build plenty of those, everything from the high-end A400M that has exceptional cargo/airlift capability, all the way through to smaller aircraft for local and regional airlift. We have moved the dominant produc-

"The shifting emphasis of the national security agenda of the United States makes us place a much more concentrated focus on the Pacific."

tion facility for our C212 small cargo aircraft to Indonesia. The Indonesian government flies them to deliver supplies and other assets and resources to the nation's far-flung island provinces. The C212 is a very ubiquitous airlifter and a very valuable asset to Indonesia. Why build them somewhere else? Build them right there. But Indonesia isn't the only market by any means. We sell hundreds and hundreds of C212s around the world.

Has production begun in Indonesia?

Yes. C212s are moving through the production line there now. They are indicative of the greater attention being given to the Pacific region, and its size. The same goes for several of our EADS cargo aircraft that the U.S. is looking to deploy out there.

But it's not just aircraft we're talking about here, where EADS is involved. For example, the U.S. Navy is planning to homeport littoral combat ships in Singapore, as part of the new emphasis on the Pacific. We've got radars built by the EADS subsidiary Cassidian aboard those ships, which will be all over the place in the Pacific.

What about the disaggregation of satellites that many in the space community believe is the coming thing in U.S. space policy and operations—switching from big all-purpose satellites to networks of small, single-purpose satellites. Will EADS be part of that, with its Astrium subsidiary?

It is a little early to say. More to come on that. Where will the major emphasis be? On telecom? Data entry from space? What? An awful lot of sorting out needs to be done. But EADS North America intends to have a major role in U.S. space. For the first time ever, we have made a major investment here in the United States in the satellite services market, in which Astrium Americas does all of our space activity, everything from launch vehicles to rockets to building satellites to fabricating modules and parts and pieces of a wide variety of equipment for space exploration.

Just what is Astrium Americas?

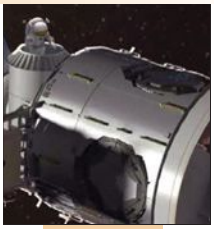
It came about as the result of several acquisitions which were merged to become Astrium Americas, a U.S. subsidiary of EADS North America. It is the operating division for all of the EADS space production and services activities conducted in the U.S.—government and commercial. And it is expanding. We now have a much more dominant position here in the U.S. than we've ever had before.

Amid all the restructuring, strategizing, and market analysis, there must be much uncertainty in EADS R&D circles. What's going on there?

One of the members of the EADS Group Executive Committee, along with me, is the chief technical officer, the equivalent of a chief technology officer here in the U.S., in terms of his focus on and attention to the R&D dimensions of what the group does, writ large. He runs half a dozen research and technology centers called Innovation Works [IW]. We have just established the newest of the IW centers in the U.S., at California Polytechnic Institute in San Luis Obispo. Cal Poly has a pretty extensive reach into a number of different technologies and material research dimensions that we view as widely applicable to multiple parts of the divisions of the EADS Group. There are five other IW centers, in Europe, China, and India.

Those centers must be waiting for new cues, new directions from the top now.

Yes, and it's coming. Once we see a firm definition of our new strategy, it will clearly have a big R&D input. Our strategy is in the making. We are enthusiastic.



Delivering on a promise to Columbia's explorers

In the skies today we saw destruction and tragedy. Yet farther than we can see, there is comfort and hope. In the words of the prophet Isaiah, "Lift your eyes and look to the heavens. Who created all these? He who brings out the starry hosts one by one and calls them each by name."

Mankind is led into the darkness beyond our world by the inspiration of discovery and the longing to understand. Our journey into space will go on.

—President George W. Bush, February 1, 2003

On the day shuttle Columbia's crew perished returning from a U.S. scientific expedition to space, President Bush comforted the astronauts' grieving families, and vowed that "the cause in which they died will continue." Ten years later, the crew of Columbia would not recognize the nation's space program. Today, few Americans know where we are bound in space, when we will get there, or why we are going. Many think that with the shuttles gone, our nation's space program has effectively ended.

True, four or five Americans visit and work aboard the international space station each year. But we won't reach the ISS again with crewed commercial rockets until 2015 at the earliest. NASA's heavy-lift ride to orbit, the Space Launch System (SLS), will not make its first test flight until 2017. The deep-space Orion craft it will carry will not transport a crew until after 2020. Astronauts are no closer to deep space than they were a decade ago.

Three years ago, President Obama directed NASA to mount a piloted asteroid expedition by 2025. At its current pace, the agency will not have the necessary knowledge or hardware to execute such a mission by that target date. What NASA desperately needs is consensus on near-term goals for clear progress toward deep space *in this decade*. They must be practical, carry an affordable price tag, and yet demonstrate real movement toward exciting, ambitious exploration in the 2020s. We can reverse our decline in space with a fresh commitment to near-term action.

How are we doing?

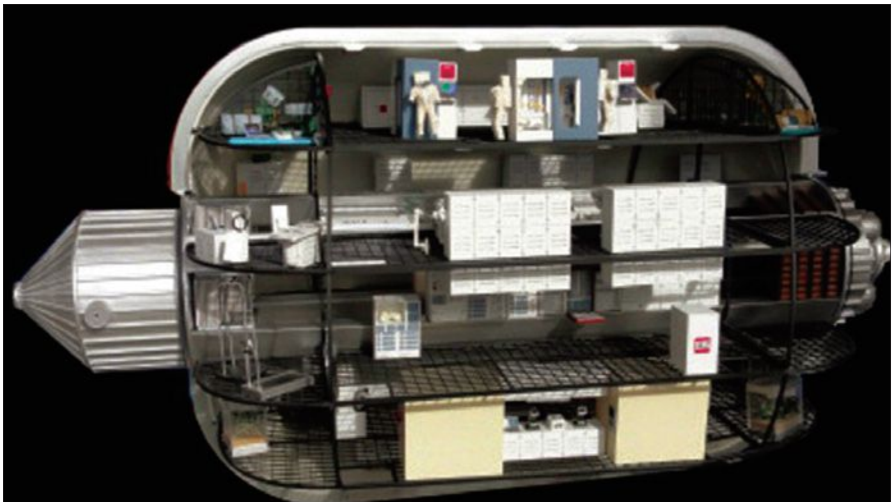
Declining budgets and White House-congressional wrangling over space policy have hindered NASA's progress toward the asteroid expedition goal. An enabling, dedicated search program to find attractive near-Earth asteroid (NEA) targets has yet to materialize. Orion and the SLS, even if ready by 2020, will not have the endurance and performance to reach nearby asteroids, which typically require round-trip times of six months or more. A practical NEA expedition will also need a small habitat for consumables and extra living space. The vehicle will require augmented propulsion and solar power systems, and its crew will need new spacesuits as well as mobility and anchoring gear for NEA surface exploration.

There are a few positive signs. NASA and the B612 Foundation signed a Space Act agreement to support the latter's privately funded deep-space Sentinel NEA search telescope. But B612 has just begun to raise the estimated $400 million for Sentinel. Although designed primarily for planetary defense, the telescope will also provide NASA with a sizeable catalog of candidate asteroid targets.

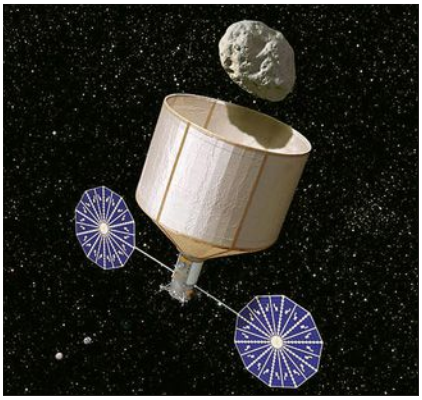
The agency announced a $17.8-million agreement in January with Bigelow Aerospace to explore the feasibility of attaching the firm's inflatable module to the ISS. The Bigelow expandable activity module, or BEAM, would expand the station's storage and habitation space, and is one candidate for providing deep-space Orion crews with more elbow room.

New ideas

As the government's discretionary budget declines, NASA managers fear that continued lack of action on beyond-LEO exploration could lead to cancellation of the entire deep-space effort. Anxious to avoid a repeat of Constellation's sorry denouement, the



Inflatables like the Bigelow Expandable Space Module, after testing at ISS, may serve as deep-space habitats for sorties throughout translunar space, and on piloted near-Earth asteroid expeditions. Image courtesy Bigelow Aerospace.



ARM, evaluated by the Keck Institute for Space Studies, could place about 500 tons of ancient, resource-rich asteroidal material in translunar space. ARM would be a robotic component of NASA's prospective plans for establishing astronaut explorers in translunar space in the 2020s. The 7-m asteroid could serve, in addition to the Moon, as a major focus for astronaut activity on sorties near the Earth-Moon L2 point. Credit: Keck Institute for Space Studies.

agency is said to be seeking near-term steps it can take to advance its human spaceflight timetable.

Reports surfaced late last year that NASA would propose to the White House creation of a deep-space outpost near the Earth-Moon L2 Lagrange point. Although official plans depend on the president's 2014 budget proposal (delayed until this month), the bare outline discussed by NASA observers centers on a crew-tended 'line shack,' comprising a habitat, docking port, and propulsion module, delivered to EM L2 by the SLS. Orion crews would visit the outpost for several weeks at a time, engaging in remote sensing, radio astronomy, and telerobotic operation of rovers on the lunar far side. Hardware, consumables, and propellant could be built and delivered by international partners or commercial launch services.

NASA would use such a mobile outpost to gain deep-space experience in advance of NEA missions planned for the later 2020s. In addition, EM L2 would provide a gravitationally advantageous jumping-off point for other destinations beyond the Moon. Expeditions could follow to the EM L1 point (between Earth and Moon), Sun-Earth L2 (about a million miles beyond Earth), and eventual voyages to nearby NEAs and the lunar surface.

A major criticism of a translunar outpost is that proposed activities there do not justify the expense and risk of astronaut visits. NASA must identify some challenging mission in translunar space to engage its crews and bridge the decade or more before NEA or lunar expeditions can begin. Current policy rules out the Moon's surface, so NASA is now examining another target to fill the vacuum: astronaut visits to a small, roughly 500-ton asteroid returned to a safe high orbit around the Moon or EM L2.

Asteroid retrieval mission

NASA Administrator Charlie Bolden told a National Research Council committee in mid-December 2012 that meeting the president's 2025 asteroid goal does not necessarily mean astronauts must travel a great distance. Observers took this to mean that Bolden's team was considering the merits of a robotic asteroid retrieval mission (ARM), proposed nearly a year ago by the Keck Institute for Space Studies (this author was a study team member and wrote about the concept in *Aerospace America*. See "Snaring a piece of the sky," May 2012, page 18).

The Murchison CM2 carbonaceous chondrite meteorite, recovered after it fell in Australia in September 1969, represents the type of asteroid material of high value to science and industrial use of space resources. Murchison contains 12% water, 22% iron, aromatic hydrocarbons, and amino acids; an asteroid of similar composition would make an attractive target for sampling and retrieval. Courtesy Chip Clark, Smithsonian Institution.

The ARM concept proposes that a solar electric spacecraft capture and transport a 7-m-diam., 500-ton NEA back to translunar space for astronaut exploration. Orion crews aboard the L2-based translunar vehicle would visit the NEA repeatedly, returning valuable information for science, planetary defense, and the future use of space resources. The returned NEA would anchor NASA's translunar science and commercial activities for a decade, until the U.S. is ready for voyages to larger NEAs, Phobos, Deimos, and Mars.

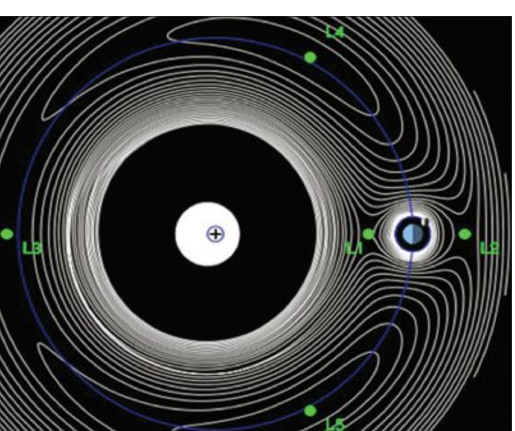
The asteroid retrieval concept is a timely one for the agency's human spaceflight program. NEA search telescope technology has improved and soon will enable NASA to discover and characterize small NEAs as they make close approaches to Earth. Solar electric propulsion technology has also matured—a 40-kW, xenon-fueled system is now capable of transporting a 500-ton asteroid into a high, safe lunar orbit. Finally, NASA plans to have astronauts reaching translunar space in the mid-2020s, at just the right time to explore, dissect, and exploit hundreds of tons of ancient asteroid material, rich in volatiles, metals, and organic compounds.

Recent presentations to NASA and the European space community by the KISS study leaders have outlined how an ARM mission would unfold. First, a low-cost, ground-based search program would identify about five suitable small asteroids annually. From that set, NASA would select a 7-m, 500-ton NEA with spectral properties like those of volatile-rich, carbonaceous chondrite meteorites. An Atlas V-551 booster would launch an 18-ton capture spacecraft into LEO. Deploying a pair of 10-m solar arrays, the vehicle would use five Hall-effect ion thrusters to begin an upward spiral, taking roughly two years to escape Earth completely.

The ARM craft would take about two more years to reach the target asteroid. During a three-month survey period, spacecraft sensors would examine the spin state, shape, and composition of the asteroid. Using hydrazine reaction jets to match the NEA's rotation rate (much like the Pan Am shuttle closing on the 'big wheel' station in *2001: A Space Odyssey*), the craft would deploy a rib-and-fabric capture mechanism whose maw is wide enough to engulf the object.

The spacecraft would then maneuver to pass the extended bag over the object. Closing shut like the legs of a spider, retracting limbs would restrain the asteroid within the fabric envelope and position it against a thrust ring. Using just 300 kg of RCS fuel to despin the 500-ton mass, the craft would then reactivate its ion thrusters to begin the long transit to the Earth-Moon system.

After a 2- to 6-year voyage, the craft would combine a lunar gravity assist and solar-electric power to achieve a high lunar orbit. This 'distant retrograde orbit' is stable against loss of control for a century or more; even then, orbital perturbations could only culminate in a lunar impact. Another layer of safety stems from the carbonaceous asteroid's small size and low physical strength, like that of dried clay: An errant 7-m asteroid would break up harmlessly in Earth's atmosphere. (Only NEAs larger than 30-40 m can survive atmospheric entry to cause damage.)



Lagrange Points in the Earth-Moon system: L2 (at right) provides direct viewing of the lunar farside about 60,000 km beyond the Moon's orbit. Credit: SpudisLunarResources.com.

A valuable grab bag

A number of valuable benefits would be returned with the captured asteroid. First, NASA would position in translunar space a new destination that *requires* astronaut presence for full exploration and exploitation. Coordinated EVA and robotic activity will be necessary to unwrap, examine, and dissect the boulder-sized asteroid.

Second, for about $2.5 billion (the cost of the Curiosity rover mission), NASA obtains near-term operational experience for astronauts working around and with a small asteroid, its physical surface, its mineralogy. This experience is a valuable bridge to later, deep-space sorties to larger, more challenging and distant NEA targets, or the Martian moons.

Finally, the capture, transportation, examination, and dissection of a small NEA provides valuable knowledge about the structure and makeup of NEAs, and is in fact a deflection demonstration—insurance against a future rogue asteroid headed for Earth impact. Although solar electric propulsion is not the only option for deflection, actually moving a small NEA builds solid confidence in our ability to prevent a future catastrophe.

Commercial opportunity

'Commercial' is the current NASA watchword, and putting astronauts in close contact with 500 tons of asteroidal material opens a new and exciting economic frontier. If similar to volatile-rich carbonaceous chondrites, the raw materials could jump-start an entire industry to harvest resources such as water, metals, shielding material, and industrial chemicals. Orion crews could return multiple samples, of many kilograms each, for analysis and process development on Earth and in free fall at the ISS.

Provided with regular access to the asteroid, international partners and private companies (like asteroid mining startups Planetary Resources and just-announced Deep Space Industries) could test anchoring, sampling, and extraction techniques. A simple solar collector could deliver enough heat to drive water gently from the hydrated silicates typical of these asteroids; a 7-m object could easily contain 100 tons of H_2O. At current launch prices, that water would cost about $5 billion to deliver to LEO, and much more to the Moon's vicinity. Eventually, NASA and its partners could turn over the processing of this and other asteroidal material to private firms; the first customer would be NASA itself, buying oxygen and hydrogen propellant for use in translunar space.

There are plenty of such asteroids to go around. The NEA population contains an estimated 100 million objects 10 m in diameter or larger. If they can be tapped for a profit, rocket propellants from these NEAs could lower the cost of deep space and lunar surface access, expanding scientific exploration and opening an industrial frontier using space-derived raw materials and abundant solar energy.

Small but near-term steps

If NASA hopes to gain approval to send astronauts beyond the Moon around 2020, it should take a series of small, near-term steps to assure they will find plenty to do when they get there. First, the agency should spend a few million dollars annually to fund existing and new off-the-shelf telescopes in the search for small asteroids suitable for capture.

Completing the asteroid retrieval mission itself and delivering the goods would take about a dozen years if the effort were initiated now. NASA could quickly begin to test ARM sensors, mechanisms, and propulsion systems. At the ISS, the agency could check out grappling tools, new space suits, and resource processors. As the ARM unfolds in the latter half of this decade, NASA could step up its testing of Orion and heavy lifters to gain access to translunar space.

As the ARM craft begins its return with asteroid in tow, international and commercial partners would join NASA to establish a mobile EM L2 outpost by

This concept for a translunar vehicle (TLV), capable of moving among the Earth-Moon Lagrange points and lunar orbit, would support periodic astronaut sorties beyond the lunar far side. Visiting Orion crews would engage in lunar scientific exploration, and perhaps examine and exploit a captured asteroid in high lunar orbit. Courtesy NASA.

the early 2020s. The consortium would develop small robotic craft designed to examine, sample, and process NEA materials. Astronauts on their regular visits could step in to help those ships along when necessary.

The translunar vehicle, based at L2, and the NEA retrieval mission are synergistic efforts. Each enhances the return from the other. Although the 500-ton NEA (about the mass of the ISS) would be delivered robotically, only astronauts could fully exploit the scientific and economic potential of this unique resource in translunar space. At the same time, asteroid retrieval would supply astronauts with a decade of engrossing, challenging, and high-payoff activities beyond the Moon. Crews will encounter many unknowns in unraveling the history and potential of these strange space boulders, but grappling with such challenges is the surest way to build confidence in our ability to explore and exploit Earth-Moon space.

Planned wisely, the conjunction of robotic and human activities near EM L2 can fuel further exploration of the lunar surface, larger, more distant asteroids, and the Mars system. Instead of suffering stagnation and incremental loss of its leadership in space, the U.S. can embark now on a fascinating and inviting journey to and beyond the Moon. How better to fulfill the vow we made a decade ago to Columbia's crew?

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Public safety market offers growth for UAVs

Small UAV manufacturers in the U.S. and abroad are preparing for the emergence of a growth market in law enforcement. This follows congressional legislation directing the FAA to work toward opening up U.S. airspace to UAVs by September 2005.

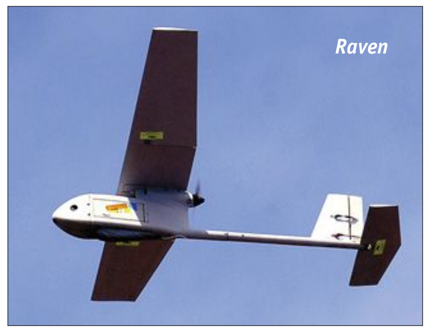
Law enforcement will not be nearly the size of the military market, which has soared in recent years to become a $6.3-billion annual market worldwide. Yet at a time when military budgets will come under pressure from U.S. fiscal austerity, a growth market is a welcome opportunity.

There is significant potential for a large number of systems that are less expensive than those used by the military. There are 18,000 law enforcement agencies in the U.S. and another 2,000 in Canada. Because operating manned aircraft is so costly, only about 2% of U.S. law enforcement agencies possess any aircraft, so there is a potentially large market serving those that have not been able to afford expensive aviation divisions in the past.

Obvious benefits

The appeal of UAVs is clear, notes Benjamin Miller, the unmanned aerial systems program director for the Mesa County, Colorado, sheriff's office, an early adopter of the technology. UAV operating expenses are considerably lower than those of manned aircraft, and agencies that have been unable to afford aviation capability can now acquire it at low cost. That capability can be used for everything from examining crime scenes to search and rescue, says Miller.

As the first major UAV market to emerge beyond the military and homeland security, law enforcement promises to provide successful companies an entry into the broader commercial market as airspace is opened in future years.



Raven

At least five major UAV companies have launched products aimed primarily at the law enforcement market. In addition, a plethora of smaller companies are pitching their own products in the hope of breaking into this sector.

Hopeful players

AeroVironment, which has dominated the mini UAV market, is offering its Raven, Puma, and Wasp aerial vehicles to border and law enforcement agencies. These aircraft have been used extensively in Iraq and Afghanistan and may be familiar to law enforcement personnel who served in the military. The Raven costs $100,000-$200,000 for a system of three UAVs with two ground control stations, initial spares, and training.

Tests of the Raven have included infrared and electrooptical payloads commonly used on UAVs as well as payloads for chemical-biological sensing and radiation detection, according to Steven Gitlin, an AeroVironment spokesman.

AeroVironment also introduced its Qube portable UAV in October 2011. The $50,000 Qube was designed specifically for public safety applications such as law enforcement and first response. It is easy to use, requires minimal training, and offers touch screen controls.

Early this year, AeroVironment will be starting a pilot demonstration program to familiarize public safety agencies with the Qube, Gitlin says. The company is currently waiting for the FAA to provide more concrete rules outlining the use of UAVs in national airspace.

In September, Aurora Flight Sciences signed an agreement with the Boston area Metropolitan Law Enforcement Council (MetroLEC) to establish a program for evaluation of the company's Skate small unmanned aerial system by the council's special weapons and tactics (SWAT) operations. MetroLEC is a consortium of more than 43 local area police departments and law enforcement agencies. This program allows MetroLEC to evaluate the utility of small unmanned aerial systems in law enforcement. Aurora will provide the Skate system and operator training as well as planning and support for SWAT operations.

Designed as a lightweight, low-cost system, Skate is able to fly as a fixed-wing platform or as a vertical takeoff and landing (VTOL) UAV. This enables it to combine the endurance of a fixed-wing UAV with the maneuverability and mission flexibility of a VTOL system.

In August 2012, Lockheed Martin Procerus Technologies unveiled a new quad-rotor small UAV designed for law enforcement, commercial, or military aerial reconnaissance in crowded areas that cannot be reached by fixed-wing aircraft. The 5-lb VTOL UAV has a mission endurance of up to 40 min.

Qube

Ghost

Israel Aerospace Industries unveiled its Ghost VTOL system in February 2011, pitching it to both the law enforcement and urban military operations markets. The 9-lb system, which can fly inside buildings, can carry a 1-lb payload for up to 30 min.

In August 2011, Boeing's Insitu unit introduced the Inceptor, a 4-lb UAV that can easily fit into the trunk of a car. The Inceptor is intended to provide public safety officials with real-time, high-resolution imagery.

Small companies have also been active, seizing some of the first sales in the emerging market. Draganfly Innovations is a Canadian company that began by selling model aircraft. It has sold its helicopter UAVs, such as the $22,000, 4-lb Draganflyer X6, to several police departments in the U.S. and Canada. Users of the aircraft include the sheriff's offices of Grand Forks County, North Dakota, and Mesa County, Colorado, and the Seattle Police Dept. The Royal Canadian Mounted Police are testing the Draganflyer X6 for uses such as enabling rapid reopening of roads after a traffic accident rather than waiting for a helicopter to do an aerial shot.

Vanguard Defense Industries, a small Texas company whose unmanned aircraft also are being used by the U.S. military, sold its $300,000 ShadowHawk UAV to the Montgomery County, Texas, police department, which has been operating it since October 2011. And Falcon UAV in Colorado has sold its Falcon system to the Mesa, Colorado, Sheriff's Dept.

Privacy issues

Privacy concerns have resulted in a flood of proposed national and local legislation that would limit the use of UAV technology. Both conservative Republicans and liberal Democrats have been active in offering provisions.

In December, Berkeley, California, took initial steps to make the city a 'no drone zone' following moves by local law enforcement to consider purchasing a UAV.

Last June, conservative Sen. Rand Paul (R-Ky.) offered S.3287, a Senate bill that would require the U.S. government to obtain a warrant before using drones in law enforcement. The only exceptions would be to patrol national borders, prevent a terrorist attack, or avoid "imminent danger to life." Rep. Ted Poe (R-Texas) offered a similar provision in the House a month later.

Rep. Edward Markey (D-Mass.), co-chair of the Bipartisan Congressional Privacy Caucus, is working to get bipartisan support for a bill offered in December that stresses serious concerns about the use of UAVs in law enforcement. "Drones should be used in accordance with privacy principles that protect Americans from unlawful surveillance and searches without their knowledge or permission," said Markey in a December 19 statement.

Shadowhawk

Draganflyer-X6

"The Drone Aircraft Privacy and Transparency Act will ensure that strong personal privacy protections and public transparency measures are in place at the beginning of the use of this new technology, not as an afterthought. I look forward to working with my congressional colleagues on a bipartisan basis to advance this important legislation to ensure that these 'eyes in the skies' don't become 'spies in the skies,'" he continued.

The Drone Aircraft Privacy and Transparency Act, which would be an amendment to the FAA Modernization and Reform Act, includes a series of new, tough restraints on UAVs. Any law enforcement surveillance would require a warrant or extreme extenuating circumstances. Law enforcement agencies would have to explain how they will minimize data collection and retention connected to any investigation of a crime. In a measure broader than the law enforcement market alone, the FAA would not be able to issue a UAV license unless the application specifies who will operate the system, where it will fly, what data will be collected, how it would be used, and for what period it would be retained. The FAA would also have to create a website that includes the times and locations of UAV flights and any data security breaches suffered by a licensee.

In addition, a police officer's offhand comment that his county's system potentially could be used to taser criminals caused a firestorm. Another police department ran into serious opposition when it began secretly testing a system in a two-year program rather than preparing the public for the introduction of an unmanned system.

Law enforcement officials in other cities that have no such plans were upset by the controversy, since they had no intention of putting these systems to such uses. Moreover, one law enforcement officer points out that tasering suspects from a UAV would not really be an effective strategy—they would not be immobilized long enough to bring in ground police to take over.

Overall, there is a serious misconception by the public about the use of UAVs in civil airspace, according to police and industry officials. There is a sense that weapons-carrying systems used against terrorists in Iraq and Afghanistan will be coming to local law enforcement. Obviously that is far from the truth.

Law enforcement and industry are working to forestall any rush to impose new legislation that could undermine the effectiveness of UAVs. The Association for Unmanned Aerial Vehicles International, an industry trade group, and the International Association of Chiefs of Police both released voluntary guidelines for UAV use in recent months. The guidelines put forward in August urged that police UAVs not be equipped with any weaponry and that they be painted in a way that makes them highly visible. Any flights should be for a legitimate public safety mission and must be documented as such. Any images captured by a UAV should not be retained unless they are required as criminal evidence or for training. Those images should be open for public inspection.

The key will be to show what UAVs can do to serve the public in safety roles, says Gitlin. The problem is that "the only voices that are audible are the ones that fear the worst," he says. "As UAVs start saving lives and protecting property, more people will see these systems are beneficial."

Security and safety

The privacy debate is not the only potential obstacle to the development of the law enforcement UAV market. There also are concerns about the security and safety of the vehicles following the successful demonstration of GPS spoofing technology. (Spoofing involves the creation of false civil GPS signals that then allow a hacker to take control of the aerial vehicle and enable him to steer a new course for the UAV.)

The DHS will play an important role in shaping the market for law enforcement UAVs. It has already done so by providing grant support for the purchase of UAVs by many local law enforcement departments. The department has provided grants that have paid for most of the UAVs purchased by local U.S. law enforcement so far.

DHS also sees its role as providing expertise in the selection of UAVs. In September, the department's Science and Technology Directorate launched the Robotic Aircraft for Public Safety project. The directorate asked companies to provide small fixed- and rotary-wing UAVs weighing less than 25 lb and integrated sensor payloads for a fly-off to determine their applicability to border security, law enforcement, fire, and search and rescue.

This program offers to provide important guidance in the market as public safety officials with little expertise in unmanned systems seek to acquire them. The UAVs will be evaluated for both performance and safety.

✈✈✈

Law enforcement officials are confident that with increasing experience in the use of UAVs, the vehicles will prove extremely useful.

"There are growing pains" in the adoption of these systems, says Miller. Yet their efficacy will ultimately prove itself, in areas ranging from search and rescue to crime scene reconstruction.

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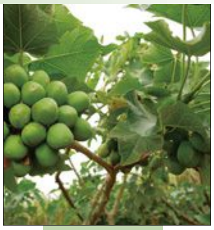


Making spaceflight greener

A MAJOR CHALLENGE FOR SPACEFLIGHT organizations worldwide is to replace as far as possible today's most commonly used liquid monopropellant, hydrazine, which has the chemical formula N_2H_4.

First used as a propellant in WW II to power Nazi Germany's Me-163 Komet rocket-powered fighter, hydrazine has fueled a wide range of spacecraft thrusters since the 1960s. However, it has a big disadvantage in that it is difficult to handle. This adds to the cost of missions that employ hydrazine (or several commonly used hydrazine derivatives) as a monopropellant or bipropellant fuel. Today these include most missions involving satellites and other spacecraft with thrusters of 1 N, 5 N, and 22 N, as well as those of 100 N or more.

Highly toxic, carcinogenic, and corrosive to living tissue, hydrazine can partially evaporate at room temperature. It can also ignite at relatively low temperatures, according to scientists at NASA Marshall. This makes fueling of spacecraft with hydrazine a dangerous, expensive, and time-consuming business. Everyone performing the fueling must wear a spacesuit-like outfit called a self-contained atmospheric protective ensemble, or SCAPE suit, as it is known in the spaceflight industry.

Because of hydrazine's high toxicity—which affected three U.S. astronauts aboard the Apollo-Soyuz mission as their capsule neared splashdown on July 24, 1975—any hydrazine fueling activity in a given facility requires the entire building to be evacuated while the work takes place. As a result, all other work on the spacecraft must stop while it is being fueled. Since the hydrazine fueling process entails six to eight different operations, it substantially slows other preparation work on the spacecraft.

In addition, says Randy Lillard, program executive for NASA's Technology Demonstration Missions Program, hydrazine's potential lethality means those who do the fueling must have a large support team in place, and substantial safety infrastructure, to prevent accidents and respond immediately to any fueling incidents. Up to 30 medical and other staff members are needed as backup personnel to support fuelers loading hydrazine into a spacecraft.

The GPIM spacecraft uses a Ball Aerospace BCP 100 platform.

Looking for replacements

In the 1990s, the Air Force Research Laboratory (AFRL) in the U.S. and researchers in Sweden independently began investigating how hydrazine might be replaced by cheaper, safer, and far less toxic spacecraft fuels that could also offer higher specific impulse values. For a fuel with a higher specific impulse, a lesser fuel flow would produce the same thrust force as hydrazine in a given time, or the same amount of fuel flow would produce a greater force.

AFRL and the Swedish researchers both identified a promising avenue of green-fuel research that focused on energetic ionic liquids (EILs). These fuels were stable at room temperature, required catalytic substrates to ignite, and burned at flame temperatures in the 1,600-1,900-C range, producing strong exothermic reactions.

The Swedes and AFRL used different routes to develop their respective green monopropellants. The European researchers used an EIL based on the salt ammonium dinitramide dissolved in water to develop a fuel now known as LMP-103S. This fuel, after igniting catalytically, burns with a flame temperature of 1,600 C. In the U.S., AFRL developed an EIL-based fuel that uses a different salt and is liquid at room temperature. Called AF-M315E, it has a much lower freezing point than hydrazine, although—somewhat inconveniently—it turns into a stable, noncrystallizing glass at very low temperatures such as those found in the vacuum of space.

Is AF-M315E the answer?

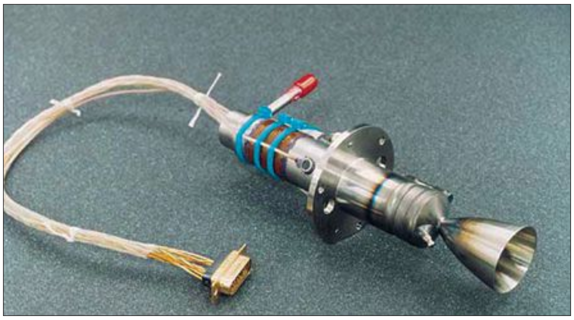
Extensive AFRL ground testing of AF-M315E established that it had a much lower vapor pressure at room temperature than did hydrazine. This meant the fuel produced very little discernible vapor at room temperature when its container was open to the air, another valuable quality. AF-M315E was also found to be far less carcinogenic, corrosive, and toxic than hydrazine.

In addition, AF-M315E did not ignite explosively, but only burned with a mild flame, when cooked in a fire. Its flame temperature in a strong exothermic reaction was about 1,800 C, yielding higher performance than hydrazine, which burns with a flame temperature of about 880 C. Like hydrazine, the fuel burned strongly only when passed over a catalytic substrate. Lillard says the proprietary catalyst used for AF-M315E took many years to develop and was "the next big hurdle" after the AFRL researchers figured out that the fuel was substantially nontoxic and much safer to handle than hydrazine.

All this was very promising. Should AF-M315E be found suitable as a hydrazine replacement for any thruster class, fueling would become a simple operation requiring much less safety infrastructure and only two or three backup staff for the fuelers, according to Lillard. The fuelers themselves would not need to wear SCAPE suits. In all likelihood there would be no need to evacuate the building during fueling, and other spacecraft preparation and loading tasks could continue throughout the process.

Ground testing using instrumented heavy thrusters also established that AF-M315E was not only about 45% denser than hydrazine, but also that its specific impulse density was about 10-15% greater. This meant AF-M315E had a volumetric impulse nearly 50% greater than that of hydrazine, according to Lillard. Assuming AF-M315E is found to be a suitable monopropellant for spaceflight-quality hardware, its higher specific impulse will mean "you can either reduce [fuel] mass or keep the mission in orbit longer for the same mass," he says.

In addition, AF-M315E's low vapor pressure enables the use of comparable or thinner tank thicknesses, which optimizes the amount of fuel available. However, one significant difference between AF-M315E and hydrazine, according to Lillard, is that while the older fuel does not corrode ferrous metals, AF-M315E is slightly corrosive to them. Accordingly, any missions using AF-M315E would need to store the fuel in nonferrous tanks in the spacecraft and burn it in thrusters made from nonferrous materials such as titanium, iridium, or rhenium. This would also be true of a successor fuel under development by AFRL that would have an even better specific impulse but be just as stable and nontoxic.



Aerojet, a member of the GPIM project, is a major manufacturer of small thrusters. This is a 22-N hydrazine thruster made by the company.

Should the U.S. space industry be able to demonstrate that a fuel such as AF-M315E can reliably and safely replace hydrazine in any of its current uses as a monopropellant for spacecraft thrusters, the results could have great economic significance, says Lillard. In the past few years, about 75% of the thrusters manufactured have been 1-N thrusters, 15% of them 5 N, 10% 20 N, and 5% of them 100 N and above. "The bulk of the thrusters built are small thrusters, which form part of almost every satellite's on-orbit propulsion system," he says.

Green Propellant Infusion Mission

In August 2012, NASA obtained authority to proceed with a technology demonstration of the high-performance AF-M315E 'green' propellant. After conducting a solicitation and peer-review selection process, NASA chose the Green Propellant Infusion Mission (GPIM) proposal from a team led by Ball Aerospace.

AF-M315E was just one of the propellants the company considered. "We went through and made the selection that we think makes the most sense for the U.S. spacecraft industry and went with it," says Ball's Chris McLean, principal investigator for the mission. The Air Force's long experience with the propellant was the biggest reason to choose it, he says. In addition, AF-M315E offers a 50% higher density specific impulse than hydrazine. Small satellites without room for adequately sized hydrazine tanks and thrusters will be able to carry the new AF-M315E system, he adds.

NASA then authorized the team to undertake the three-year development program to fly a mission in 2015 using a Ball spacecraft with small thrusters fueled by AF-M315E, not hydrazine.

Lillard says GPIM will fly as a sec-

An Aerojet lab technician handles the green fuel AF-M315E.

ondary payload on a launch vehicle. NASA was expecting to conclude by the end of 2012 its negotiations over the specific vehicle that would carry GPIM and the date it would fly. In addition, GPIM will itself probably include a small tertiary payload that will demonstrate other space technologies.

Using the already proven Ball Configurable Platform (BCP) 100, a spacecraft Lillard calls "ideal for propulsion demonstrations," GPIM will use 1-N and 22-N thrusters made by Aerojet, a highly experienced thruster manufacturer and a member of the GPIM project. Through its Space Technology Program, NASA will provide $45 million for the mission, and the various GPIM team members will provide additional cost-sharing.

Other members of the GPIM program are AFRL teams at Edwards AFB in California; the Air Force Space and Missile Systems Center at Los Angeles AFB, which will handle mission operations and the mission's ground segment; NASA Glenn in Cleveland, the agency's major center of rocket and jet propulsion research; and NASA Kennedy in Florida, where the launch is expected to take place.

Preparing for GPIM

Lillard says the three-year lead time provided by the GPIM mission's 2015 launch date is typical for space technology development programs. Ball and Aerojet will need to go through at least a couple of design cycles in developing the spaceflight-qualified, lightweight thrusters, tanks, and other hardware required to flight test AF-M315E. The hardware will need to be thoroughly tested in vacuum chambers, a process that probably will take 18 months overall. "Because launches are few and far between, you need to have rigor in the process," he says. As a one-shot mission, GPIM will have to work properly in space the first time.

While the hardware development and testing process continues, NASA will need to purchase the flight hardware. "The typical demonstration mission begins purchasing flight hardware 18-24 months before delivery to the launch vehicle so there is time to integrate and test the flight system," says Lillard. In addition, team members will need to deliver the GPIM package (and its unrelated hosted payload) to the launch operator some three to four months before the planned launch date, for integration into the launcher.

Once GPIM reaches orbit, the mission will test different burn durations and burn pulse patterns, says Lillard. The GPIM team will also allow the BCP 100 platform to sit for long periods between burns to demonstrate that the AF-M315E-fueled thrusters activate reliably and that the fuel burns normally after a long cold soak.

NASA's goal for GPIM is to optimize its investment in the mission by replacing hydrazine in its most common uses, says Lillard. The mission's main target in the nearer term is to demonstrate that AF-M315E can make hydrazine obsolete for one or more classes of small thruster. However, at this early date in AF-M315E's operational history, "We're not sure how high in thrust this AF-M propellant can go," he notes.

Ultimately, NASA hopes to make hydrazine obsolete for as many thruster applications as possible, but Lillard says the organization realizes "it is not possible to do a flight test of all the [potential] hydrazine replacements in one demonstration." Since the 1960s, the space industry has developed a multitude of thruster applications for hydrazine, not only as a monopropellant. It is possible hydrazine may never be completely replaced in space use.

But should AF-M315E perform as expected in GPIM, NASA expects the new fuel to stimulate the entire U.S. spaceflight industry. Successful GPIM testing with AF-M315E will lead to the U.S. industry gearing up to manufacture the propellant, build nonferrous hardware, and create thruster designs capable of storing and burning the fuel. As Lillard points out, NASA invests in space technology for three major reasons: to enable new missions, to stimulate the U.S. economy, and to provide new technologies to the spaceflight industry.

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(Continued from page 5)

strategies that it hopes will increase manufacturing's share of GDP to 20% by 2020. Some of these strategies will have an important role to play in boosting the continent's aerospace competitiveness levels over the coming decades.

Investment actions

In October 2012, EC Vice President Antonio Tajani announced a new priority investment area for the commission, called "Markets for advanced manufacturing technologies for clean production." This is in addition to the EC's long-term policy of supporting advanced manufacturing research as part of the European Strategy for Key Enabling Technologies program. A key partner in this is the European Factories of the Future Research Association (EFFRA), an industry body that advises the EC on the best ways to support new manufacturing technologies and processes within the framework of the commission's 2014-2020 'Horizon 2020' precompetitive research agenda.

The EC also set up a high-level group for key enabling technologies to recommend means for promoting advanced manufacturing in Europe. As part of this process, a network of national research and industry organizations tasked with specific areas of advanced manufacturing research has been established to develop technology platforms to validate new concepts throughout the continent.

This will build on previous commission-funded research in this area, including the 2010-2013 COMET research program. COMET has been researching machining system technologies—such as developing new generations of adaptive production systems using industrial robots rather than five-axis machine tools—that offer 30% cost-improvements over current machine tool processes. COMET is aimed specifically at aerospace and automotive industries.

Nowhere is this commitment to private-public advanced manufacturing research more widespread than in the U.K., where EU programs have been bolstered by a range of recent national investment strategies. In June 2012 the U.K.'s Dept. for Business, Innovation and Skills announced an £80-million investment package—with the government investing £25 million and industry partners led by Rolls-Royce providing other funding—for a series of collaborative research and technology projects. SAMULET II (Strategic Affordable Manufacturing in the U.K. through Leading Environmental Technology) will investigate new manufacturing processes such as the development of turbine blades with superalloys.

One technology center benefiting from this research is the Rolls-Royce Advanced Blade Casting Facility, which will help mature pioneering manufacturing concepts based on a casting process that grows a blade as a single crystal from aerospace superalloys. The government is separately investing £15 million in new capital equipment for the High Value Manufacturing 'Catapult' scheme, a long-term government investment program that accelerates the results of academic research into industrial usage.

There are now seven Advanced Manufacturing Research Centers—five in the U.K.—under development to help Rolls-Royce and other industrial partners exploit recent academic research in an industrial environment. Two of these—the Manufacturing Technology Centre (MTC) near Coventry and the Advanced Manufacturing Research Centre (AMRC) in Sheffield—are particularly important centers of dedicated aerospace manufacturing research.

The MTC is the largest of the research centers, with over 12,000 m^2 of floor space. It specializes in validating new processes for high-integrity joining, intelligent automation, advanced tooling, powder net shape manufacture, and electronics manufacture. Meanwhile the AMRC, with Boeing as a major partner, now employs a staff of over 200 and is undergoing a major expansion, with work soon to start on a design, prototyping, and testing center. The technology focus at AMRC is on advanced machining, machine characterization, programming, and measurement technologies.

Such research is key to the introduction of advanced manufacturing processes such as 3D printing, the increased use of industrial robots, and automation. Without this, Europe will not be able to deliver aircraft structures that are lighter, more durable, and less costly to produce than those of its competitors. With these research centers supported by long-term national and regional government grants, effectively safeguarded from spending cuts in other parts of government, this is one area where sustained investment in aerospace is likely to produce important efficiency gains for the continent's aircraft manufacturers.

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Factories of the Future 2020

'Factories of the Future' was set up in 2009, a €1.2-billion public-private partnership between the EC and industry. The research program focuses on the development of new and sustainable technologies highlighted by the Ad-Hoc Industrial Advisory Group to the commission, to help EU manufacturing enterprises—in particular small and medium-sized enterprises—to adapt to global competitive pressures by improving their technological base.

Research areas include new models of production systems (transformable factories, networked factories, learning factories); ICT-based production systems and high-quality manufacturing technologies (including research into increasing autonomous production lines); and sustainable manufacturing tools, methodologies, and processes producing assemblies with complex and novel materials.

With the completion of the EC's seventh framework research program this year, EFFRA has been working to continue the research within the commission's new seven-year research program, Horizon 2020. This will focus on:

- *Advanced manufacturing processes.*
- *Adaptive and smart manufacturing systems.*
- *Digital, virtual, and resource-efficient factories.*
- *Collaborative and mobile enterprises.*
- *Human-centered manufacturing.*
- *Customer-focused manufacturing.*

NASA's navigators: Outdoing themselves

As impressive as the Curiosity landing was, NASA's navigation technologists think they can do even better next time.

The Curiosity descent vehicle was equipped with a sophisticated inertial measurement unit, but mission planners still could only promise to deliver the rover somewhere within a 20 X 7-km ellipse. Once the vehicle deployed its parachute and released its heat shield, its exact landing spot was determined by the Martian winds. A camera called the Mars Descent Imager snapped photos to tell scientists where within the ellipse the spacecraft was coming down. A radar bounced signals from the surface to measure speed and altitude, and eight rockets automatically kicked on at precisely the right moment. Their job was not to steer around obstacles. It was to slow the vehicle so Curiosity could dangle blindly down to the surface on tethers. If there had been dangerous rocks or slopes below, there would have been no way to detect or steer around them.

Scientists had to see where Curiosity came down before they could decide where to drive to test out the rover's rock drill. Using orbital images, they picked a place about 400 m away and named it Glenelg (after a northern Canadian location where Precambrian rocks are exposed). The journey there was expected to take weeks, followed by many months of driving through a gap in some dark dunes to reach the main science objective of the two-year mission: the base of the 5-km-tall Mount Sharp. The mountain's rocky layers might tell scientists whether the area could have harbored life of any kind.

While Curiosity is busy leaving tracks on Mars, teams of navigation engineers led by NASA Johnson and JPL are working on technologies that might someday deliver spacecraft right to the heart of the dangerous places that tend to be the most scientifically interesting. Those teams want to leap from unpowered descents like Curiosity's to landings in which a spacecraft sees the terrain all the way down and steers around obstacles. The new sensors and algorithms could be applied not just to Mars, but also to asteroids and new destinations such as Jupiter's moon Europa. Most of those missions would be robotic, but Johnson has not given up on human missions, even as it seeks to contribute to the robotic ones as well.

Go 'smartly'

The two teams have a largely common goal: They want to use rockets to steer to a preprogrammed landing zone that would be 100 m wide instead of kilometers across. Precise navigation algorithms would be needed to avoid running out of fuel as the trajectory is corrected. At an altitude of perhaps 1,000 m, light detection and ranging instruments called lidars would snap on to scan the landing zones for hazards too small to be seen from orbit or by the craft's camera. An onboard computer would autonomously choose a safe landing spot from amid the boulders, slopes, or craters. The Johnson team, for example, thinks it can spot all hazards greater than 30 cm and stick the landing to within 3 m.

This image was taken during a flight test of JPL's Autonomous Descent and Ascent Powered-flight Testbed (ADAPT). The testbed was flown aboard a Masten Space Systems Xombie rocket. The test took place at the Mojave Air and Space Port, California, on July 9, 2012. Image credit: NASA/JPL-Caltech.

For NASA's technologists, the objective of more precise landings is not meant as a slight on the Curiosity mission. One engineer calls it an inevitable progression: "Human beings, I think, want the power over time—to say, 'Go there, exactly where we told you, and do it smartly, by yourself, spacecraft,'" says electrical engineer MiMi Aung, manager of NASA JPL's Guidance and Control Section, which helped plan the Curiosity landing.

Both teams are entering the low-altitude flight test phase of their projects, and if they succeed, they could change NASA's mission planning forever. Curiosity's science team had to pick a smooth-looking ellipse that would minimize the odds of landing on large rocks. The tradeoff for the safe arrival was the time it will take to reach the base of Mount Sharp.

California dreaming

To test a better method, JPL has begun low-altitude flights at the Mojave Air and Space Port, using a rocket it calls ADAPT, for Autonomous Descent and Ascent Powered-Flight Testbed.

At the moment, ADAPT consists of a Masten Space Systems Xombie terrestrial test rocket programmed with 'canned' Mars descent scenarios, just to see if Xombie could fly them. Engineers from Masten and JPL flew ADAPT three times, once in July and twice in August. The craft took off straight up on each flight, and at about

500 m was allowed to fall straight down 50 m to gain speed before swooping downrange as though it were descending to Mars.

"We are very relieved and happy that Xombie can fly such an aggressive trajectory, because we just didn't know walking in," Aung says. "These are three possible trajectories you might see on Mars." In the last test, on August 14, ADAPT was diverted 750 m downrange.

Ultimately, JPL wants to move away from the canned trajectories and shift control entirely to an 8-kg sensor now in development. Called the Lander Vision System, it would provide the necessary entry, descent, and landing functions all rolled into one sensor, says Aung.

Its imaging camera would photograph the terrain on the way down. Algorithms would use those images to determine the real-time position of the spacecraft relative to the desired landing site in a process called terrain relative navigation. A separate algorithm, called G-FOLD for guidance-fuel optimal large divert, would snap into action to calculate the best path toward the target. To avoid running out of propellant, a "fuel optimal solution" would be critical, Aung cautions.

Closer to the surface, the vision system's flash lidar would bounce lasers off the terrain to produce 3D maps. Hazard detection and avoidance software would use these to pick a spot for touchdown.

At each critical point, the calculations would have to be made autonomously in seconds.

G-FOLD was the key innovation, because it allows the course corrections to be calculated on a computer small enough to fit in the descent vehicle. "If you have supercomputers on the ground, you can still crank out—after an hour or two—the optimal solution, but we don't have those hours and we don't have a supercomputer," Aung says.

Next, the JPL team wants to load the G-FOLD algorithm onto a computer and install it on Xombie this year. During the flight, G-FOLD will calculate the optimal path and send it to Xombie's computer, which will steer the rocket on that route.

Xombie had several successful test flights.

Without the Lander Vision System installed, engineers would need to give the G-FOLD starting and ending points. Even with the preprogrammed points, "that's going to be pretty gutsy," Aung says. G-FOLD will need to work fast. In 2014, Aung's team plans to install the Lander Vision System on the Xombie for end-to-end tests.

When that happens, "It'll be a truly autonomous system where we don't need GPS, we don't need any information from the vehicle," Aung says.

Bad break

At NASA Johnson, engineers have been working for six years on their own precision landing system under a project called ALHAT, for autonomous landing and hazard avoidance technologies. JSC has overall management responsibility for ALHAT. Integrating the technologies, though, is a joint effort by engineers from JSC, JPL, and NASA Langley, with contributions from contractors including Draper Lab of Cambridge.

Earlier this year, the timing for the start of ALHAT flights looked as though it would coincide nicely with the attention the Curiosity mission was expected to draw to planetary landings. When Curiosity touched down on August 5, ALHAT engineers expected that by October they would be landing their low-altitude test craft

Morpheus rises just after ignition.

The Morpheus lander was built to carry the ALHAT equipment. On August 9 it rose a short distance, veered off course, and crashed.

amid a field of rocks and craters set up at NASA Kennedy to look like the Moon. It would be a key test of the low-altitude Flash Lidar built by Advanced Scientific Concepts of Santa Barbara. The lidar rapidly bounces light off the surface and measures the time of return to map features in 3D. It was adapted for real-time hazard detection with help from Langley, and it will map terrain to an 8-cm resolution, says ALHAT manager Chirold Epp.

The October tests were not to be, however.

Morpheus, the lander built by Johnson to carry the 150-kg ALHAT equipment, rose a short distance from the Kennedy launch pad on August 9, veered out of control, and crashed. It was the second attempt at a free flight after numerous flights on a tether slung from a crane. Flames flickered for a while and then Morpheus exploded. Moments earlier, in the mobile mission control shelter, controllers had noticed that the vehicle's computer stopped receiving inertial measurement unit data. The IMU had worked fine two days earlier during a soft abort caused by false indication of an engine burn-through. Without the IMU feed, the rocket could not tell up from down.

Luckily, NASA had not yet installed the ALHAT equipment. The team must decide what to do while Morpheus manager Jon Olansen investigates the mishap and tries to avoid repeating the problem, whatever it was, on the new version that will be assembled.

The ALHAT team does not want to give up on Olansen's project. "We're still planning to fly on Morpheus when they get their vehicle rebuilt and prove that they can fly at the kind of trajectory that we need to demonstrate ALHAT," says Epp. "Hopefully, that will be sometime next spring."

Epp is looking for ways to continue making progress in the meantime. "We would like to take advantage of the hazard field at KSC and fly a helicopter and collect some flash lidar data," he says. "We cannot reproduce the trajectory that Morpheus will give us, but we can collect some information and use that as test data for our systems."

He also has not ruled out trying another terrestrial rocket. "If we can find a different vehicle that can fly something similar to Morpheus, we may try to fly at least some components of it," he says.

One thing is certain: Both Olansen and Epp are anxious to try out the hazard field. The field was patterned after the Moon, right down to the size of its craters and rock piles. Epp cautions observers not to conclude that the ALHAT technology applies only to landing on the Moon. Success in the lunar hazard field would show potential for landing virtually anywhere, he says, including Mars.

"Curiosity program people eventually would like to have some kind of an ALHAT system on board so that they can go to certain regions that they're kind of afraid to go to right now. It would give them more capability, with higher probably of success in more hazardous areas," Epp says.

He also knows that at 150 kg, critics say ALHAT is much too heavy for robotic missions. "We already know how to reduce that to about 100 kg, and we believe there are ways to reduce it a whole lot more," he adds.

Once Morpheus starts flying with ALHAT, the profile will be similar to that of JPL's Xombie-based ADAPT. It will fly up about 500 m and then follow a slanting trajectory about 800 m to the ground. The big difference is this: JPL does not plan to land in a hazard field any time soon, but for JSC, that is the main purpose.

The idea is to verify that ALHAT is smart enough to decode the field. "We actually know that we put two safe areas in there, but anyplace else is not necessarily safe for that lander," Epp says. "We will turn on the Flash Lidar, and we will image the hazard field in 4 seconds, and 6 seconds later, we hope to tell Morpheus, 'You were going to the center of that field. That's not safe. Divert and go here to this safe site," he explains. "And then we will track a feature down to the ground to make sure that we stay locked onto that safe site as we're coming down."

Working at NASA Johnson, Epp is steeped in the history of the Apollo lunar missions, and he thinks they hold important lessons on how to apply the new technologies.

"If you step back to Apollo for a minute, they landed pretty much by eyeballs, as human beings, to avoid hazards. Of course Neil Armstrong didn't like where he was going down, so he actually flew the vehicle a little bit farther downrange and almost ran out of fuel," he says.

What if so much dust had been kicked up in the final 30 or so meters that it had prevented Armstrong from seeing? Therein lies a big lesson when it comes to relying on the Flash Lidar. "We don't believe you want to try to sense through that dust. Several people have talked to us about that," Epp says.

So, in addition to the Flash Lidar, Morpheus will test a Doppler lidar. It will not generate images, but it will pierce the dust well enough to measure closing velocities in three axes to an accuracy of 1 cm/sec. "That gives you such a good navigation state relative to the surface that the last 30-50 m, you can dead reckon down to the surface," Epp says.

Now all he needs is a rocket to prove it.

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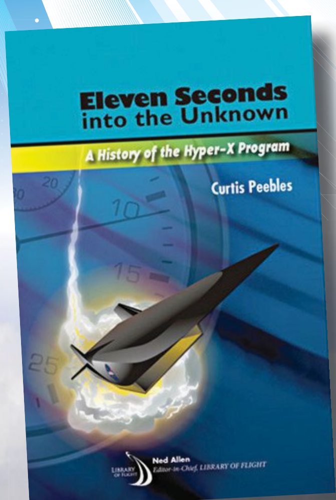

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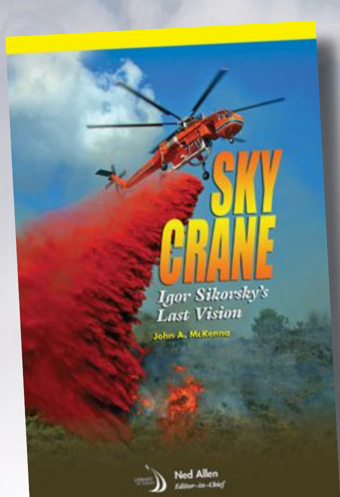

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Stormy outlook

Satellites operated by NOAA enable timely predictions of storms, flooding, and other critical hazards, allowing preparations and evacuations that save lives, health, and property in affected areas. The public has grown to rely on such capabilities and even take them for granted. Now, however, as these satellites and their military counterparts grow older, looming budget cuts threaten to create dangerous gaps in the coverage they provide.

MetOp-B waits to be encapsulated in the Soyuz rocket fairing.

by James W. Canan
Contributing writer

As superstorm Sandy headed west over the ocean last fall, Earth-scanning satellites in near-polar and geosynchronous orbits provided the images and information that enabled meteorologists to predict with spot-on accuracy the storm's path, intensity, speed, landfall areas, and impact. Sandy hit the U.S. hard, but its extensive damage to people, property, and quality of life along the east coast would almost certainly have been much worse without the timely alerts, advance preparations, and evacuations that the satellites made possible.

The performance of these so-called weather satellites, launched by NASA and operated by the National Oceanic and Atmospheric Administration (NOAA), is a prime example of the pivotal role that spacecraft play in weather forecasting and in managing many aspects of life on Earth amid the vagaries of apparent climate change. The satellites peer at the planet around the clock and transmit a constant stream of data on what is happening in the atmosphere and on land and sea, including changes in temperature, cloud formations, wind patterns, and ocean currents. Their output is the essence of sophisticated computer models that give rise to round-the-clock forecasts.

"Accurate forecasts and severe weather alerts on television and radio, on web pages, and smart phone 'apps' all rely on NOAA satellite data," declares a NOAA document. The satellites "guard the nation from unexpected severe weather such as hurricanes, winter storms, and even solar storms, and are critical to monitoring and predicting environmental events such as El Niño and La Niña, coral bleaching, ocean acidification, and algal blooms," it says.

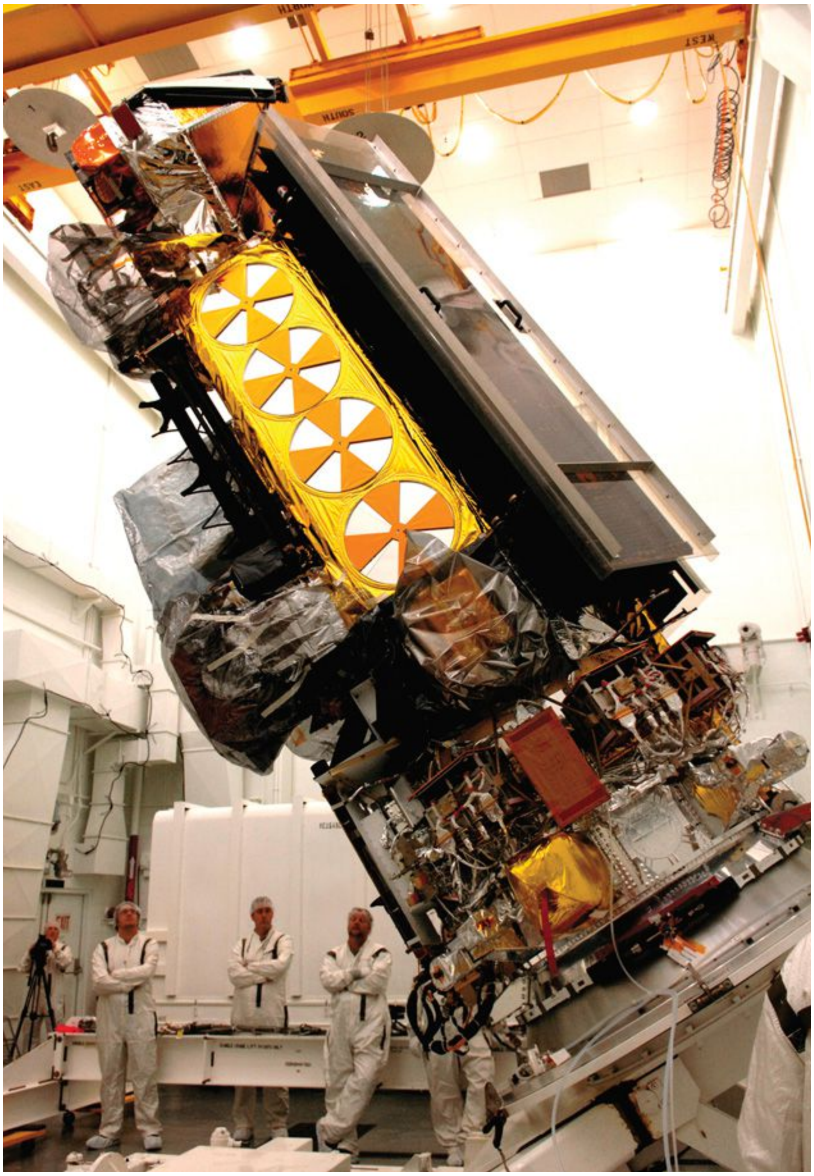
Now looms a dangerous threat to the quality of weather forecasting and of life on

for weather satellites

Earth. Some of the meteorological satellites are old and running out of time. Replacements are being developed but probably will not be deployed in time to sustain the high quality of coverage that mankind has come to rely on and take for granted. Unless forestalled, the projected gap in coverage will occur in just a few years and extend for several more. This would sharply degrade the accuracy and timeliness of weather forecasts vital to the agricultural, maritime, transportation, and energy sectors, among others, and to the nation's economy and standard of living in general.

NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) operates three geostationary operational environmental satellites (GOES) and uses data from the European Meteorological Operational, or MetOp, satellite as well. NOAA also is in charge of three Polar Operational Environmental Satellites (POES) circling the planet in north-south, low Earth orbits 540 mi. high, working in concert with Defense Meteorological Support Program (DMSP) spacecraft on similar tracks.

Procured and launched by NASA, the NOAA-operated satellites are primary producers of data for the National Weather Service's weather prediction models, which



Forecasts fostered by POES are used by the farming, energy, transportation, fishing, and tourism sectors.

provide high-confidence forecasts 2-7 days ahead. It has been estimated that timely forecasts fostered by the POES satellites alone are worth up to $8 billion a year to the farming, energy, transportation, fishing, and tourism sectors of the U.S. economy.

Imagery and funding falter

The money picture for weather satellites is not rosy. Critics warn that the multiyear dollar caps imposed by the Obama administration on programs for new geosynchronous and polar satellites likely will not allow for enough funding to cover their costs, and will result in their deferred development and deployment.

This would spell big trouble. GOES satellites spot and track severe weather, such as tornadoes and hurricanes, over the U.S. mainland. They also keep an eye on tropical storms and hurricanes over broader areas, from the west coast of Africa to the eastern and gulf coasts of the U.S., and from the far Pacific to America's West Coast. The GOES constellation, which also monitors solar activity, seems in good enough shape at the moment, but its satellites are wearing down and have been troublesome.

As Sandy approached the eastern U.S. last fall, the GOES-13 satellite covering the affected area (GOES East) faltered. Its imagery and data streams on temperatures and other phenomena became spotty. NOAA substituted the backup GOES-14 spacecraft, parked in 'orbital storage mode,' for the wayward GOES-13. If GOES-14 too had gone bad, the nation's weather observation and forecasting system would have taken a big hit.

The faulty satellite returned to operation after a troubleshooting team of engineers from NOAA, Boeing, and ITT fixed a vibration problem. But the malfunction portended more of the same in the GOES constellation and lent urgency to the GOES-R Series, a program conceived by NOAA to develop replacement satellites.

Cloudy forecast for GOES-R?

GOES-R deployment is slated to begin in late 2015. The satellites are expected to provide much sharper and more frequent images as well as greater numbers of atmospheric observations. They will also feature a new geostationary lightning mapper that will carry out, for the first time, continuous surveillance of all lightning activity throughout the Americas and adjacent oceans.

The Obama administration put a cost cap of $10.9 billion on the Lockheed Martin GOES-R program, presumably enough to pay for four new satellites and their instruments, operations, and launches through 2036. Last November the program got good marks in its mission-critical design review: Noting that "severe weather was again a major story in America this year," Mary Kicza, who heads NESDIS, said the success of the design review "gives us confidence that the GOES-R program's development is progressing well."

Even so, an independent review team (IRT), formed by the Dept. of Commerce (DOC) to examine all NOAA satellite programs, reported last summer that GOES-R still had major funding and oversight problems. The IRT gave the program slightly less than a 50/50 chance of meeting its scheduled launch date in late 2015.

At the same time, Kathryn Sullivan, deputy administrator of NOAA, cautioned Congress against shortchanging weather satellite programs in annual appropriations. Those programs "require stable budgets if they are to stay within their cost, schedule, and performance baselines," she said. "We must maintain [the] schedule to ensure that each satellite is ready for launch before its predecessor satellite reaches the end of its life; otherwise, we will have gaps in coverage that will erode the accuracy and reliability of the forecasts, watches, and warnings that our nation has come to rely upon."

JPSS takes hits

All things considered, GOES-R seems in better shape than the Joint Polar Satellite System program NOAA conceived to sustain transpolar coverage without interruption. JPSS-1, the first in this series, is scheduled for launch by early 2017, a target date that looks less and less likely as time goes by. JPSS-1 took a big budget hit early on, and its funding is only now beginning to meet initial hopes and expectations. But the damage was done. "Unfortunately, funding shortfalls have posed challenges to the [JPSS-1] satellite's development," a NOAA spokesperson says.

The administration's JPSS budget proposal for the current fiscal year put a $12.9-billion cap on the program through 2028, including money already spent on it. The administration claims that the cap will allow for full funding of the development, launch, operations, and ground systems for five satellites, but many officials and observers doubt this.

Troubled heritage

JPSS-1 also has a negative heritage. Its predecessor, NPOESS (National Polar Orbiting Environmental Satellite System), was initiated with high promise in 2002 but had a difficult, overly expensive development and was cancelled in 2010 because of unacceptable cost overruns, technical problems, and launch schedule setbacks.

NPOESS was designed as a constellation of satellites that would observe Earth continuously in early morning, midmorning, and afternoon orbits. The first satellite was scheduled for launch in 2008, a date that would have precluded a coverage gap.

At its inception, NPOESS was heralded as a joint NOAA/DOD consolidated program that would satisfy both civilian and military requirements for meteorological observations from space. NPOESS spacecraft were expected to replace and greatly improve upon the NOAA/NASA POES system and the Pentagon's DMSP satellites.

Lacking NPOESS, the DOD now plans to launch a new DMSP-19 meteorological satellite in 2014 and another, DMSP-20, if it is needed later on. But this timetable for maintaining military meteorological coverage is by no means certain. Currently operational DMSP satellites are old and may well falter sooner than expected. If that happens, the U.S. military could face a gap in weather coverage by 2014, with negative spinoff for civilian coverage as well, officials say.

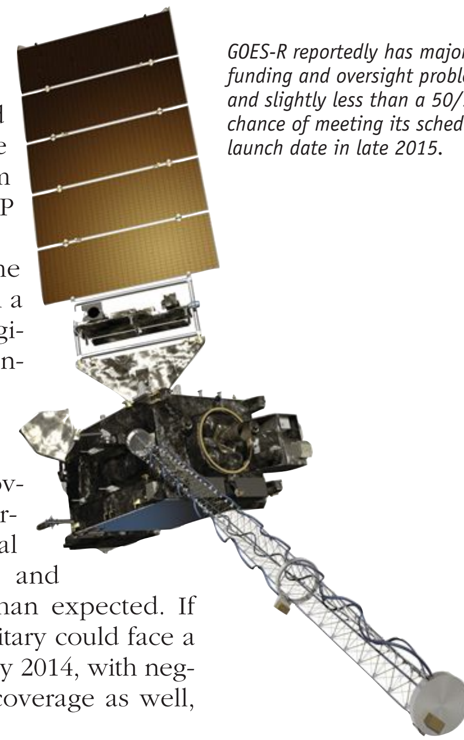
The administration had planned to ensure continuous Earth-scanning coverage by relying on DOD spacecraft for early morning observations, the European satellite for midmorning data, and JPSS for afternoon surveillance. Implementing this plan was considered critical to maintaining and enhancing the data fundamental to forecasting weather and preparing for the worst that it might bring.

Now the plan has gone to pieces. The JPSS program timetable looks dicey, and DOD has decided not to follow through in developing new meteorological satellites to replace its aging DMSP spacecraft.

NPP Suomi: A bright spot

NPOESS was not a total washout. Before it was called off, the program gave rise to the NPOESS Preparatory Project Suomi (NPP Suomi) meteorological satellite, which has lived up to its promise. Originally designed solely as a technology demonstrator to test sensors developed for NPOESS, the Suomi spacecraft was inherited by the JPSS program office and pressed into operational service as a bridge to the first JPSS satellite. Its cost is included in the $12.9 billion projected for the JPSS program as a whole.

JPSS-1 will incorporate technologies developed for Suomi. The development and launch timetable of the JPSS program, described by NASA as "the restructured civilian portion of NPOESS," remains uncertain. The Suomi satellite went into operational service in late 2011 and is expected



GOES-R reportedly has major funding and oversight problems and slightly less than a 50/50 chance of meeting its scheduled launch date in late 2015.


Electromagnetic interference testing of the NPP satellite was conducted at the Ball Aerospace facility.

to cease functioning in October 2016. Having reviewed NOAA satellite programs, the General Accountability Office predicted a gap in Earth observational coverage of 17-53 months from the end of Suomi service to the operational onset of JPSS-1.

Originally, NOAA and NASA agreed on a plan to develop, test, and launch the first and second JPSS satellites by the end of 2014 and the end of 2017, respectively. But JPSS program funding was cut, causing NOAA to stretch the development of the first JPSS satellite and transfer some of its available funds to keeping Suomi on track. As a result, JPSS-1 and JPSS-2 are not expected to go into orbit until early 2017 and late 2022, respectively.

Funding, contractors, and instruments

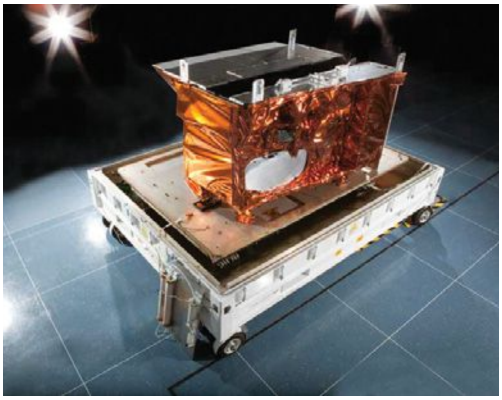
In its FY13 appropriations bill, the Senate Appropriations Committee proposed removing NOAA as the middleman for acquiring meteorological satellites. NASA has long been NOAA's purchasing agent for satellites. NOAA sets their technical and operational requirements, receives the money appropriated for their acquisition, and transfers it to NASA. As proposed by the Appropriations Committee, NOAA would continue to operate the spacecraft, but the appropriated funds would bypass NOAA and go directly to NASA.

Sen. Barbara Mikulski (D-Md.), who headed an appropriations subcommittee at the time, said the panel had become impatient with repeated cost overruns on NOAA's satellite programs, most notably JPSS. Mikulski, who now heads the full committee, also declared that DOC and NOAA "need to get their act together."

Ball Aerospace is prime contractor for the JPSS spacecraft and is under contract for the satellite's ozone mapping and profiler suite as well. NASA awarded contracts to Raytheon Space and Airborne Systems for the visible infrared imager radiometer suite (VIIRS) instrument on JPSS-1, to Raytheon Intelligence and Information Systems for the JPSS ground system, to Northrop Grumman Electronic Systems for the satellite's advanced technology microwave sounder (ATMS), and to ITT Exelis for the crosstrack infrared sounder (CrIS) instrument.

The instruments "form the backbone of space-based observations used for weather forecasting and environmental and climate monitoring," said a NASA statement in August 2012. The agency noted that the ATMS and CrIS "will be used as input for numerical weather prediction models, essential for weather forecasts beyond three days."

VIIRS will provide imagery "essential for monitoring severe weather in areas like Alaska, and for detecting and tracking volcanic ash and wildfires." It will also "gather data on a wide range of Earth's properties, including the atmosphere, clouds, radiation…clear-air land and water surfaces, and sea surface temperature," NASA noted.


VIIRS, a scanning radiometer, collects visible and infrared imagery and radiometric measurements of the land, atmosphere, cryosphere, and oceans.

Real risks, critical decisions

Raytheon has warned that downgrading the timeliness and accuracy of weather forecasting would endanger "lives, property, and critical infrastructure" and that "advance warning of extreme events would be significantly diminished, as would the understanding of storm surge and flood potential—making it more difficult to conduct safe and strategic evacuations."

Moreover, Raytheon says, "polar-orbiting satellites provide the only weather information for large swaths of the planet and are thus particularly important for overseas military operations."

GAO reported last year that NOAA "has made progress in developing its satellite system, but critical decisions and milestones lie ahead," and "the program still faces significant risks." GAO noted that "there are also potential satellite data gaps in the DOD and European polar satellite programs, which provide supplementary information to NOAA forecasts."

Following the GAO report, NOAA's meteorological satellite programs drew fire from the NESDIS-chartered IRT, headed by former Lockheed Martin executive A. Thomas Young, from the office of the Dept. of Commerce inspector general (IG), and from a Satellite Task Force (SATTF) of outside analysts formed by the NOAA Science Advisory Board. The SATTF, for example, concluded that "NOAA's budget for currently planned space systems appears to be unsustainable."

The IRT called DOC/NOAA oversight of all Earth observing satellite programs "dysfunctional," but its report was not all negative. The review panel noted that "a competent, experienced [JPSS] program office has been established" and that "despite funding challenges, good progress has been made." It also praised the program office's management of the Suomi satellite, which is said to be doing a good job of delivering data for weather forecasting.

"The success of the NOAA satellite enterprise is critical to the United States," the IRT report declared. "The program contributes to the economy, national security, and to safety and quality of life," it said. The IRT panel also criticized NOAA's oversight and management of weather satellite programs, and noted that the JPSS-1 instrumentation may have to be cut back if the satellite is to be developed and produced in time to avoid a coverage gap. It recommended that the JPSS mission be simplified to focus on weather observation and ozone monitoring.

Recommended remedies

The IRT report suggested that NOAA consider replacing the VIIRS instrument on JPSS-1 if its development continues to engender cost increases and technical problems. The VIIRS on Suomi is said to be functioning pretty well, although four of its 22 channels reportedly have problems.

NOAA's ability to manage the development and acquisition of JPSS satellites was called into question by Commerce's IG as well. The IG report recommended, among other things, that NOAA devote more resources to refining performance requirements and defining systems for JPSS-1 and JPSS-2, permanently filling key management positions in the program, and making better estimates of costs and schedules.

The SATTF report recommended that NOAA consider adopting a "distributed systems architecture" for future Earth observing satellites that would feature single-purpose instruments on many smaller satellites instead of multipurpose instruments consolidated on larger and fewer satellites, the current approach.

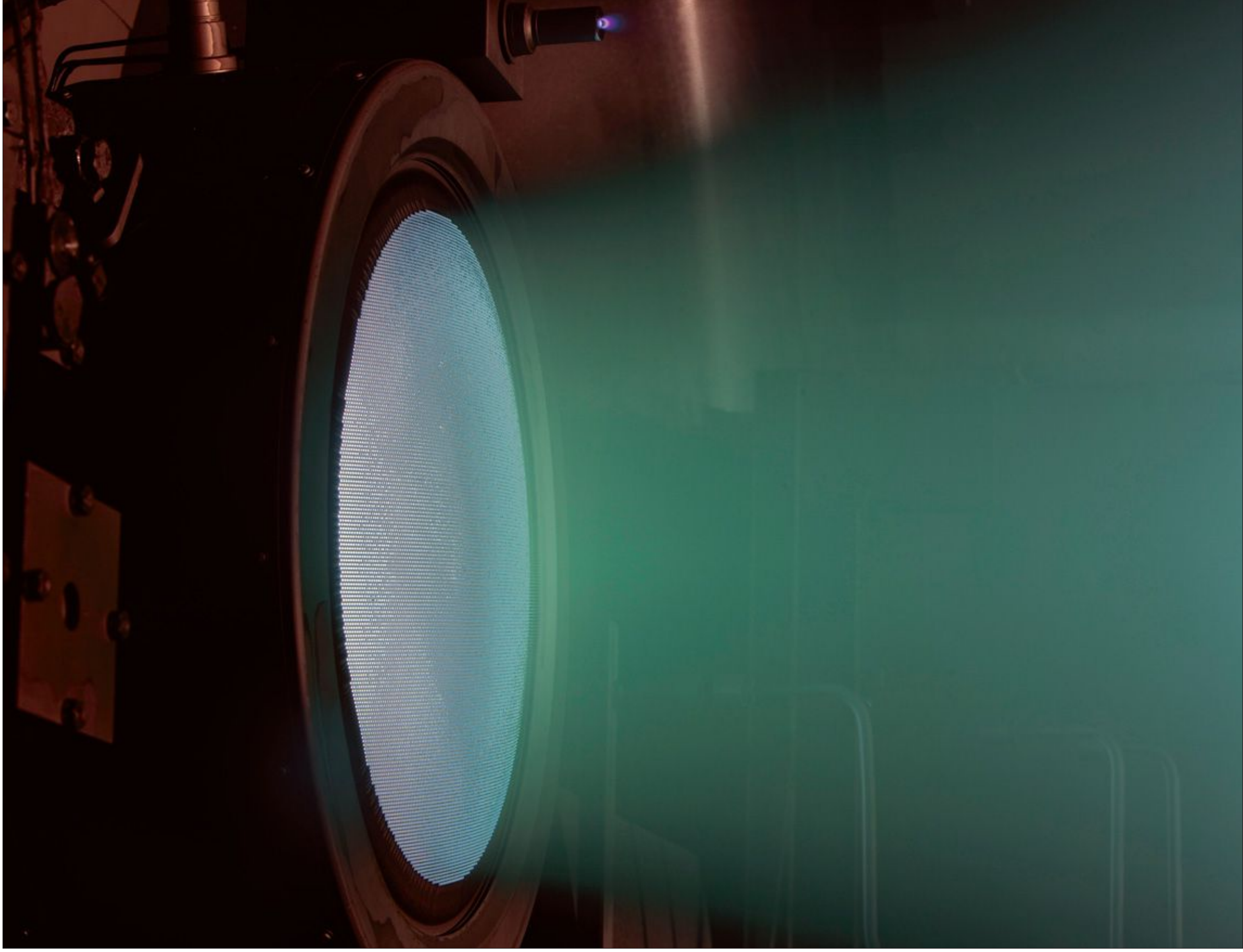
CrIS provides input for numerical weather prediction models.

In response to the flurry of critiques, NOAA restructured the JPSS program in an attempt to streamline management, come more quickly to final decisions on the design of JPSS components, devise a realistic cost estimate, and expedite the development process.

Top priority

Meanwhile, the dreaded gap in Earth observational coverage draws nearer. A NOAA spokesperson said the agency is working on plans to mitigate any such gap and will reassess them twice a year to take into account new developments in satellite programs. "The administration is committed to providing the American public with life-and-property-saving forecasts and warnings," and this is NOAA's "top priority," the spokesperson declared.

The stakes are high. As a Raytheon paper points out, the importance of timely and accurate weather forecasting "cannot be overstated," and the lack of such forecasting also "would put our nation's economy at risk."



NASA's Evolutionary Xenon Thruster (NEXT) project has developed a 7-kW ion thruster that can provide the capabilities needed in the future.

Solar electric propulsion (SEP) is a general term for a variety of systems that use solar energy to generate electricity that then is combined with a gas to provide in-space propulsion. While often perceived as a late 20th century technology, it actually was first proposed in 1906 by American rocket pioneer Robert Goddard, who conducted the first experiments with ion thrusters a decade later at Clark University, a private research university in Worcester, Massachusetts.

The most widely known form of SEP is ion propulsion (IP), perhaps most familiar to the public from the original *Star Trek* TV series and *Star Wars* films. In the former, it was described as a super-fast alien propulsion system that the starship Enterprise could not catch; in the latter, it was used by Imperial TIE (twin ion engine) fighters. While sounding exotic and fast, neither fictional representation was correct.

by J.R. Wilson
Contributing writer

History and progress

From studies beginning in the 1950s, the former Soviet Union developed two versions of SEP, known as Hall thrusters—wide acceleration zone or stationary plasma thrusters (SPT) and narrow acceleration zone or TAL (thruster with anode layer). The USSR's Meteor, launched in December 1971, was the first spacecraft to use SPT in space. Since then, more than 200 Hall thrusters have flown on Soviet and Russian spacecraft, primarily for satellite stabilization, without a single failure in orbit.

"Fundamentally, SEP is a very efficient method for doing in-state propulsion. The tradeoff for that is lower thrust," notes John Abrams, systems engineering program manager at Analytical Mechanics Associates. "It's a natural evolution to use SEP for things like LEO-to-GEO transfer, which really is a commercial business lane in that it ultimately can put those craft on a smaller launch vehicle to reduce costs. There also are a number of things that can be done once you are in orbit—orbit raising, stationkeeping, inclination change, making up for atmospheric drag.

Harnessing the power of the Sun to provide thrust for transport in space has long been a part of science fiction imagery. Now a reality after decades of development, it has found increasing use for applications ranging from station-keeping to orbit-raising. Obstacles remain, but evolving technology should enable expanding applications of this weight-saving form of energy, possibly even for manned spaceflight.

New thrust for solar electric propulsion

"SEP has been around for awhile, and the core technology is fairly well known. The problem is when it is scaled up, and the unknown risks that may occur. There also are known issues, including high-power-level processing, increasing efficiency within that power processing, the development and deployment of very large solar arrays, increasing the voltage of the arrays and of the system as a whole."

AMA was one of five companies—along with Boeing, Lockheed Martin, Ball Aerospace, and Northrop Grumman—contracted by NASA in 2011 to develop a mission concept demonstrating SEP technologies and capabilities, and the infrastructure required to affordably sustain a human presence in space. That study contract came after some 20 years of U.S. focus on SEP.

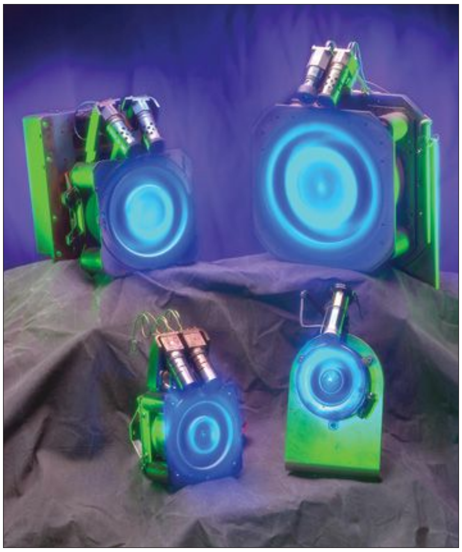
In 1992, specialists from JPL, NASA Glenn, and the Air Force Research Lab, supported by the Ballistic Missile Defense Organization (now the Missile Defense Agency), visited Soviet labs to evaluate a 100-mm-diam SPT-100 thruster. In the two decades since, Hall thrusters have flown on a variety of U.S. and European spacecraft in LEO and GEO orbit.

In 2003, ESA became the first organization to use Hall thrusters in lunar orbit, for the SMART-1 mission.

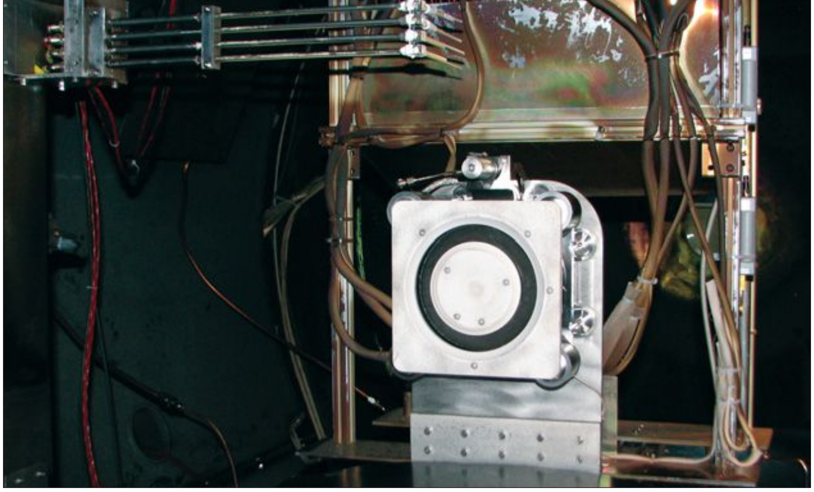
Recent efforts

The first operational flight of a U.S.-made Hall thruster did not come until 2010, using an Aerojet BPT-4000 on the military's Advanced Extremely High Frequency GEO communications satellite. The BPT-4000 produces 4.5 kW of power, the highest on any Hall thruster ever flown in space, giving the satellite orbit-raising capability and enabling it to perform standard station-keeping tasks as well.

While both types are electrostatic ion thrusters, Hall thrusters differ from IP en-

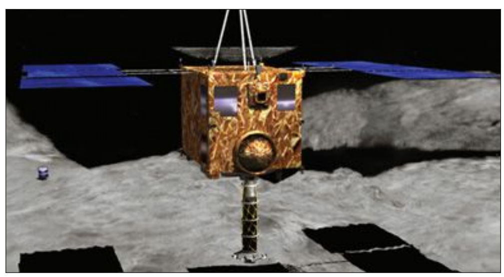


Various Soviet and Russian SPT Hall thrusters have been developed over the years.



An Aerojet BPT-4000 is in use on the Advanced Extremely High Frequency satellite.

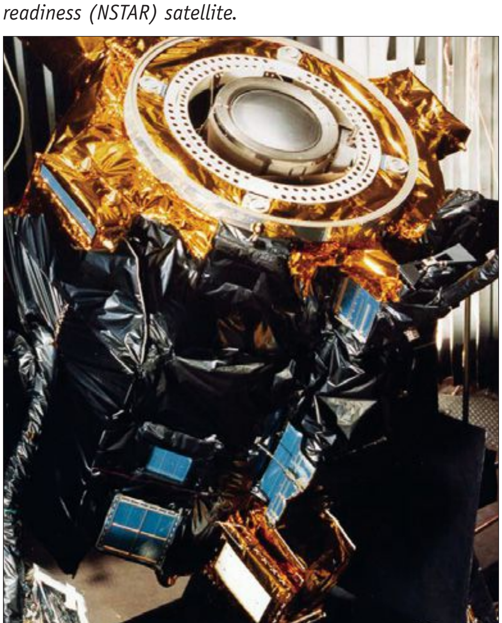
gines in how and where the electron plasma and magnetic fields interact with charged ions to produce thrust. IP uses layered grids rather than the cylindrical tube of the Hall. Both typically use xenon gas, which has no charge and is ionized by bombarding it with energetic electrons.



Japan's Hayabusa was launched in May 2003 and rendezvoused with the asteroid Itokawa in mid-September 2005.

"Hall generally have a higher thrust-to-power. If you want a rapid orbit change, then Hall thrusters are good; if you want to maximize payload and reduce propellant mass, the ion thrusters are better," says Michael Patterson, senior in-space propulsion technologist with the NASA Engineering Directorate's Space Propulsion Branch. "So there are niches for all the different technologies, depending on mission demands. And some have more than one on the same spacecraft."

Ion propulsion was tested on the SEP technology application readiness (NSTAR) satellite.



The most common way to generate electricity in space is with photovoltaic panels. The most widespread application of SEP has been on commercial GEO communications satellites (comsats), which already have large solar arrays on board.

"Ion and Hall thrusters are specific technologies that can be implemented to do that, along with the arcjet—one of the first used for GEO comsats," says NASA aerospace engineer David Manzella. "Several more are under development, including variable specific impulse magnetoplasma, dynamic pulsed plasma, etc.—a whole family of different techniques to implement SEP."

NASA made the first use of IP in space in 1964 aboard the SERT-1 (space electric rocket test-1) mission, demonstrating that it could perform successfully in space. Since then, IP has been tested on the 2.3-kW NASA SEP technology application readiness (NSTAR), the 6.9-kW NASA evolutionary xenon thruster (NEXT), the nuclear electric xenon ion system (NEXIS), the 25-kW HiPEP (high power electric propulsion) ground test, the EADS radio frequency ion thruster (RIT), and the DS4G (dual-stage 4-grid) system.

"There are emerging devices at higher power levels, such as the 7-kW NEXT," says Manzella. "They are growing in power because the need is increasing. There are evolutionary developments—larger, more efficient, higher power devices—along with much less mature alternate ideas that may offer advantages over the current state of the art.

"At the 5-kW and 10-kW level, in addition to station-keeping, they also are using them for a portion of the orbit transfer on GEO comsats, in combination with traditional fueled thrusters. Because they are low thrust, using SEP could take up to a year to get the satellite into the desired orbit. During the initial one-month checkout period, for example, they may use SEP to move the satellite, then complete it—maybe 75%—quickly with chemical thrusters."

NSTAR was the first successful demonstration of ion propulsion in interplanetary space, carried aboard NASA's Deep Space 1, launched in 1998.

In 2003, the Japanese space agency used four xenon ion engines on its Hayabusa mission to rendezvous with an asteroid, collect samples, and successfully return to Earth. Although the engines developed technical problems, an in-flight reconfiguration allowed one of the four to be repaired and complete the journey home.

The big drawbacks

In 2007, NASA used three heritage Deep Space 1 IPs on its Dawn mission to explore the asteroid Vesta and dwarf planet Ceres, firing one engine at a time to take the spacecraft on a long outward spiral to its targets. Firing continuously for four days, Dawn's ion drive is capable of accelerating from 9 to 60 mph in that period.

That, in fact, illustrates the biggest problem with SEP—and the inaccuracy of the science fiction depictions of ion propulsion: It provides an extremely low-power thrust compared to chemical engines, only slowly building speed for the full duration of an interplanetary mission. Also, because it is based on electricity generated by sunlight, the farther the spacecraft gets from the Sun, the less power a SEP engine is capable of generating.

"IP engines arguably are the most advanced form in terms of efficiency—specific impulse capability—but also the most complicated," notes Patterson, who was principal investigator for NEXT at NASA. "NEXT is under development through the Science Mission Directorate. We don't yet have a mission for it, although [NASA] Glenn has declared us Technology Level 6, which means we are ready for flight.

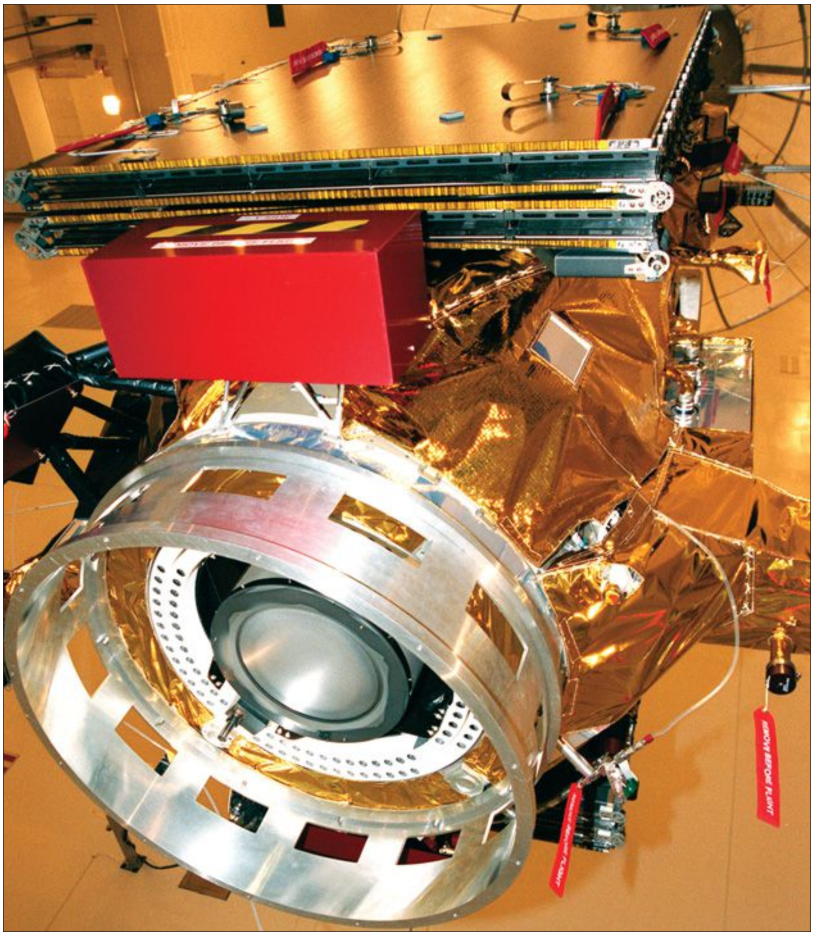
"As we speak, I'm running the prototype thruster at Aerospace Corporation to characterize the engine so we can understand the interfaces required to integrate it onto a spacecraft. We're advocating for its application on NASA and other non-NASA government and commercial missions, because it is a very capable technology. The engine just passed a throughput of 7.5 kW, which means we could have flown Dawn with one NEXT thruster."

In February 2012, NASA awarded a contract to Northrop Grumman to develop a system capable of creating 300 kW of electrical power.

"There has been a lot of work done on developing various types of thrusters, so we have focused on power generation. And the system we have developed can work with many of those thrusters, which are suitable for various missions," notes Amy Lon, Northrop Grumman SEP lead systems engineer.

"There are not a lot of issues facing low-power SEP—it's in a lot of satellites and is now a production line item. But when you get to hundreds of kilowatts for high-power SEP, there still are a lot of issues in generating and transporting that power to the thrusters."

Perhaps the one problem technology cannot solve, she adds, is distance: "If you are going to Jupiter and beyond, where solar intensity decreases, the question is what to use for your power source. In the past, nuclear has been the only reliable source for targets that far away. So Jupiter is kind of the limit for SEP."



Three heritage Deep Space 1 ion propulsion engines were used to power the Dawn spacecraft.

Generating power

For missions within the inner solar system, however, the company's use of a solar panel and Brayton engine combination that does not require football field-size solar arrays has major advantages, according to Ron Polidan, director of Northrop Grumman Science and Weather Systems.

"We are still talking to NASA Glenn and continuing to advance what we call our solar dynamics approach to power generation," he says. "NASA's Dawn is the first to use SEP as prime propulsion. If you look at NASA's use for deep space missions, because SEP works as a steady thrust, it greatly relaxes the launch window.

"I now can adjust my thrust to compensate for changes in the actual launch time. That really helps when you have to go from the Earth to some other spot where alignment is vital. SEP gives you a much easier way to compensate for the vagaries of launching."

Manned flight and other possibilities

Although Lon appears to be in a minority for now, she also sees a future for SEP in manned spaceflight.

"That's one of the foundational missions NASA has defined for SEP. One of the two architectures they have been looking at for many years is to use SEP as a tug to take astronauts from near-Earth to GEO, while the other would take astronauts from near-Earth space to Mars," she says. "For an equivalent amount of chemical propulsion to get astronauts from Earth, you would have to carry a lot of fuel, which raises issues of getting all that together into space.

"Even though SEP only provides a couple of tenths of Newtons, it is continuous—you add a little every second, so you are looking at the total acceleration you can get out of the system. The initial ramp-up to achieve the velocity you need may be slower, but eventually you get there."

Polidan believes that NASA has taken the lead in SEP, but points out that interest in it has increased throughout the world. He also sees somewhat greater advancement in civil applications of SEP than in defense applications.

"Dawn has proved it is a reliable propulsion source, and I would not be surprised to see future NASA missions using ion," he says. "We're working on our own exoplanetary mission—Starshade—and are seeking business from our other science customers. We also talk to a lot of people in academia, and a fraction of those are looking at SEP elements or missions that alleviate a lot of the problems they would have with chemical."

AMA's Abrams agrees: "In my opinion, it is less about the technologies and more about the engineering. The core technologies are there, you just need to scale the systems up to larger power levels.

"I think by the end of this decade it will be used more for commercial markets, to put GEO satellites in orbit. But I'm hoping it will be used as a methodology for human exploration in the 2020s. In the 2030s and beyond, we may go away from SEP and on to nuclear-based systems. It's still electric, just the power process is different, nuclear instead of solar—NEP."

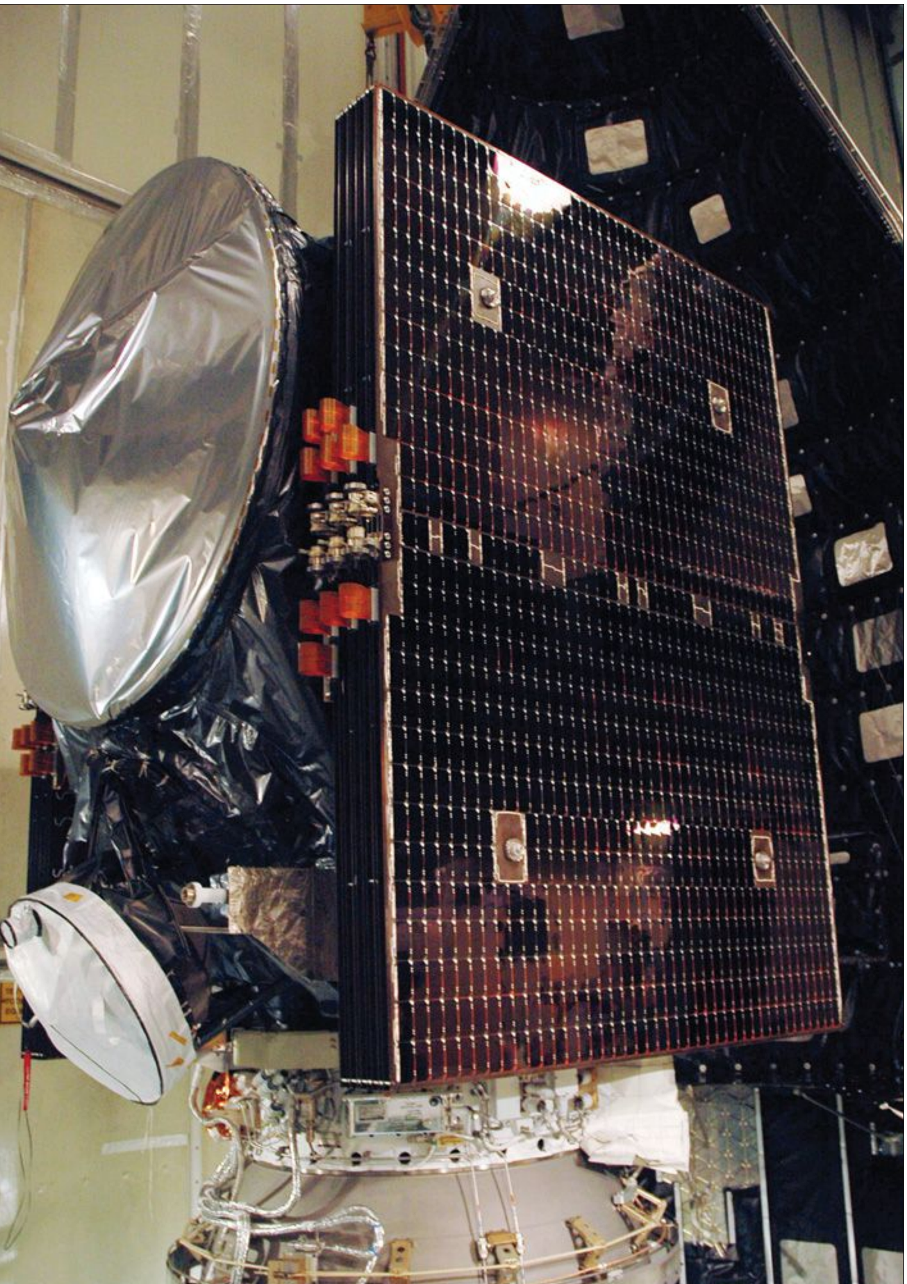
Northrop Grumman SEP program manager James Munger says one advantage to his company's approach is the direct creation of AC power. By contrast, typical photovoltaic designs generate DC current that must then be converted to AC.

"AC power is easier to transmit, and we can optimize our power generation to the particular needs of the thruster at the time," Munger explains. "The interesting thing," he continues, is that "by generating AC… we not only do not use photovoltaics, which have trouble getting large to enough to service some of the larger payloads, [but] we also can get the power out to the thrusters without using difficult electronics to convert DC power back to something the thrusters can use."

Ball Aerospace also had a different perspective during the NASA study, that of end user on their satellites rather than the builder of thruster systems or solar arrays.

"We have looked at a lot of applications, both near Earth and deep space. We want to keep our hand in with everyone

Dawn's solar array wings are folded to fit inside the nose section of protective fairing before launch. The solar arrays are used in tandem with the SEP.



developing this technology," says aerospace engineer William Deininger, Ball's principal investigator on the NASA SEP study. "For the current applications we foresee, existing technology is largely ready to fly.

"It would be nice to have thrusters at higher powers, but it depends on whether you want to increase mass, decrease time, or do both. There are cases where you can fly to a planet using chemical in 10-15 years, while SEP can reduce that roughly by half or, with the same flight time, have a larger payload."

One area where things still need to be done is lightweight solar arrays, he says, which probably are the last item to be ticked off to get into the 20-50-kW range.

"The Human Exploration Directorate at NASA are the folks proposing a 300-kW-plus thruster, which is required to deliver payloads to support missions," Deininger says. "You wouldn't use it for humans, but for habitats, fuel, food, etc. When we did studies, that was the original intent, to develop a near-term solution to taking risk out of the higher power applications and make it scalable to a 200-300-kW class."

Future outlook

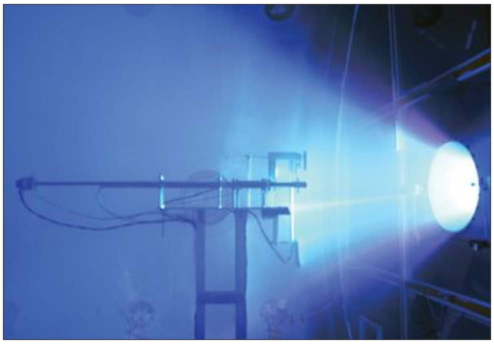
Deininger sees use of the various forms of SEP expanding through the coming decades, especially as continued R&D improves efficiencies and thrust.

"In this decade, we launched Dawn. In the next 10-20 years, I think you will see NASA's NEXT thruster applied to higher energy missions, which the thruster on Dawn couldn't [provide]. So I think some missions will select SEP for high energy needs," Deininger says.

"Hall will be used more in near-Earth [missions], where you want higher thrust to get there quickly and save on fuel requirements. We're trying to understand those, as a company, and see what we can do to help out with it. Our expectation is that these missions will be competed, and we can team with thruster partners in making those bids."

One of those new systems in development is the French highly efficient multistage plasma (HEMP) ion thruster.

"HEMP is based on traveling wave tube technology; they have brought it to a pretty good state of development in a relatively short time. Between it, ion, arc, and Hall, I think you have the main SEPs for near-term. Further out, you will have the MPD [magnetoplasmadynamic] thruster and VASIMR [variable specific impulse magnetoplasma rocket]. Those two might come to fruition in the future when systems that provide higher power are available in orbit," Deininger says, but adds that he still does not see it being used for manned missions.



In 2009, Ad Astra Rocket performed tests on the VX-200 prototype with 2 tesla superconducting magnets. They expanded the power range of the VASIMR up to 200 kW.

"Because SEP uses electrical energy to generate thrust, it is really low thrust; you want to get human crews to their destination quickly to reduce exposure to radiation. If we have megawatt thrusters that can move quickly, it might. But the most likely use is prepositioning supplies with SEP and getting humans there using chemical [engines]. You can get more mass to the Moon or Mars with a SEP system, but you can't get there fast enough for human transport."

NASA, however, is still looking at the possibility of growing the power of SEP thrusters or using their continuous acceleration capability, without the increased mass of chemical engines, for interplanetary missions later in this century.

"NASA has been developing architectures for human exploration beyond LEO; in those studies, there have been several mission concepts using very high-power SEP vehicles in a supporting role," Manzella says. "Those would be multi-hundreds of kilowatts, more than an order of magnitude greater in size and power than systems flying today.

"In fact, they would have solar arrays equal in area to those on the international space station. Because those systems are so large, it is not anticipated we would directly develop something of that size, but more intermediate-size spacecraft that would serve as stepping stones."

The nearer term

NASA has efforts under way to define what a reasonable intermediate application might be, with what Manzella says is an agreement the nominal thruster would be on the order of 30 kW. To that end, the agency is investing in the development of advanced solar arrays and systems with higher power and performance that could use them.

"That is based on the future mission pull for human exploration objectives, which are still being developed—and those could change," he adds. "But in the mid-term, having 30 kW flying by the end of the decade as a precursor to multi-hundred-kilowatt systems that would fly in the following decade.

"Because some NASA science missions are deep space, there are possibilities those might be well served by SEP, but NASA generally competes those missions, based on the science proposed. There is a regular schedule within planetary sciences, for example, for discovery, and some of the proposals they receive involve SEP. There also may be international missions that could use SEP, both science and commercial."

The use of SEP for LEO and GEO station-keeping has been satisfied for decades by low-thrust engines, while the demands of interplanetary robotic probes have demonstrated how relatively minor improvements in power can both supplement and, in some cases, even replace chemical engines. But as humans eventually return to the Moon, then move on to Mars and other interplanetary destinations, the enabling technologies that have gotten SEP to its current level will be replaced by new and more demanding developments.

"We are looking at an ion engine capability of scaling to a very high power. A downside to NEXT is that their 'conventional' design doesn't freely allow scaling to high power at specific impulse. You can build big ion engines with high power; what you want is to scale ion engines to very high power, but modest specific impulse of exhaust velocities," says Patterson.

"We call it the next-generation electric propulsion thruster, really a family of engines whose design basis is the annular geometry ion engine—going from a cylindrical shape to annular, which allows you to scale the engine. Other advantages include being able to stick another engine, like a Hall, in the middle of that and run one [engine] during parts of the mission, the other on the rest, whichever fits best. Or you can nest multiple engines, which offers simplification of manufacturing and reduced cost—four nested annular engines could accommodate a range of missions. ▲

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Out of the

25 Years Ago, March 1988

March 1 NASA announces that the NAVSTAR (Navigation Signal Timing and Ranging) GPS satellites are being used by JPL researchers to study the movements of Earth's tectonic plates in the regions of Central and South America and the Caribbean. NASA, *Astronautics and Aeronautics, 1986-90*, p. 159.

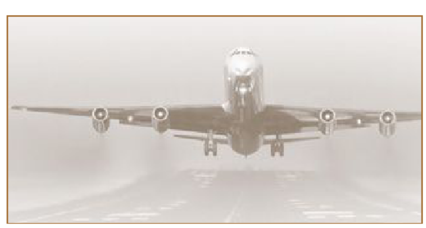
March 15 An international panel of more than 100 scientists assembled by NASA releases a report, with data gathered by satellites and ground-based instruments, stating that Earth's ozone layer is being depleted at a much faster rate than previously reported. NASA, *Astronautics and Aeronautics, 1986-90*, p. 162.

March 17-18 NASA's Gerard P. Kuiper Airborne Observatory (KAO), a modified Lockheed C-141 aircraft, is used in a flight over the Pacific Ocean to study a total solar eclipse. KAO carries a 36-in.-diam. telescope and other instruments and makes its flight from an altitude of 41,000-45,000 ft. NASA, *Astronautics and Aeronautics, 1986-90*, p. 162.

50 years Ago, March 1963

March 1 The 480-ft-diam. Stratoscope 2 balloon, carrying a 36-in. reflecting telescope mounted in a 3.5-ton stabilized gondola, flies for the first time, from the new Scientific Balloon Center at Palestine, Texas. The aim of the program is to make spectral analyses of the atmosphere of Mars. *Aviation Week*, April 1, 1963, p. 74.

March 2 Trans-Canada Air Lines flies its first service with a Douglas DC-8F from London to Montreal. Douglas claims it is the first mixed passenger/ freight jet aircraft anywhere in the world. *The Aeroplane*, March 7, 1963, p. 9.



March 11 NASA and the French National Center for Space Studies announce a cooperative U.S.-French space program to investigate the propagation of very low frequency electromagnetic waves at altitudes above 46 mi. The program involves launches of French payloads by NASA sounding rockets. Joint satellite projects based on the results are planned. *Flight International*, March 14, 1963, p. 384.

March 14 Britten-Norman, a U.K. firm on the Isle of Wight, reports the first commercial sale of an air-cushion vehicle, its Cushioncraft CC-2/003. The purchaser is Seaglide, a Jersey company that plans to use the craft for pleasure trips in the Channel Islands in summer. *Flight International*, March 28, 1963, p. 40.

March 15 An Aerobee sounding rocket lifts a 248-lb payload up to 123 mi. in an attempt to map night-sky sources of photons having certain wavelengths. *Flight International*, April 25, 1963, p. 614.

March 16 The International Aviation Exhibition opens in São Paulo, Brazil. Displays include a full-scale mockup of the North American X-15 U.S. rocket research aircraft and NASA's Mercury capsule (with X-15 pilot Robert White in attendance). Also exhibited are Russia's Tu-114 and France's Caravelle aircraft, along with planes from Brazil's air force and commercial airline sector. *Flight International*, April 25, 1963, pp. 606-607.

March 18 The Army announces it has chosen Martin Marietta of Baltimore, Md., as prime contractor for the Sprint antimissile missile. It is to be a two-stage, solid-fuel missile armed with a thermonuclear warhead. *Flight International*, March 25, 1963, p. 44.

March 21 The Titan 2 ICBM is successfully test flown for 6,500 mi. from Patrick AFB, Fla., with a General Electric Mk. 6 reentry vehicle nose-cone. The test marks the second flight with this type of nosecone. *Aviation Week*, March 25, 1963, p. 28.

March 26 Britain's Hunting H.126 jet-flap research aircraft, built by Hunting Aircraft of Luton, makes its first flight. Powering the single-seater is a Bristol Siddeley Orpheus turobjet engine built

Past

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

to Ministry of Aviation specifications for full-scale investigations of the jet-flap principle. The main advantage of the jet flap is that it permits lower takeoff and landing speeds. *Flight International*, April 4, 1963, pp. 454-455.

March 27 This date is the centenary of the birth of British aviation pioneer Sir Henry Royce who, with C.S. Rolls, produced a world-famous trade name in aircraft engines, beginning in 1906. Royce, born in 1863, started modestly in jobs such as tool-making but by the 1900s was making automobile engines. After WW I, he modified his famous Silver Ghost auto engine for use in planes; by 1915 he produced the 200-hp Eagle engine, which played a significant part in the war. From then on, he concentrated on aircraft engines. *Flight International*, March 21, 1963, p. 388; Sir Henry Rolls file, NASM.

March 28 The Saturn 1 (SA-4) booster stage is successfully flown from Cape Canaveral, Fla. This is the fourth launch of a Saturn I and the last in the initial test phase of this stage as part of Project Apollo. The main objective of this flight is to test the rocket's ability to function despite an engine failure. Thus one of the inboard engines (No. 5) is programmed to shut down 'prematurely,' about 100 sec after launch, while the burning times of the others are extended to compensate for the loss of thrust. *Aviation Week*, April 1, 1963, p. 32.

75 Years Ago, March 1938

March 1 On German Air Force Day, marked by speeches and parades, Gen. Field Marshal Hermann Goering receives his new baton from Chancellor Hitler. Goering is the new chief of staff of the air force, the nucleus of which was formed under camouflage—and in contravention of the nonrearmament clause of the Versailles Treaty—following the victory of the National Socialist party in 1933. However, the air force could not be hidden for long, and its existence was announced on March 1, 1935. Re-armament on a broad scale follows. *Interavia*, March 4, 1938, p. 2.

March 9 French parachutist James Williams jumps from a single-engined Mureaux 117 at 35,450 ft above the military airfield of Chartres and pulls his ripcord at an altitude of only 650 ft, setting a new parachute record. The time of his free fall is 2 min 50 sec. Williams has oxygen apparatus, special clothing, and an altimeter. *Interavia*, March 12, 1938, p. 10.

March 14 Extensive Navy maneuvers begin in the Pacific and include 100 battleships, 70 auxiliary vessels, 550 aircraft, 3,500 officers, and 55,000 men under the command of Adm. Claude Bloch. The exercises involve bases in Alaska, the Panama Canal, Hawaii, and the Aleutians. *Interavia*, March 16, 1938, p. 12.

March 20 Mario Stoppani of Italy, flying a CANT Z.509, claims eight records for his country, including speed over 1,000 km (250.7 mph) and over 2,000 km (248.3 mph). *Interavia*, April 5, 1938, p. 10.

March 27-29 A catapult-launched Lufthansa Dornier Do 18F sets a new world's nonstop distance record for seaplanes, flying from Devon, England, to Caravellas, Brazil, a distance of 5,215 mi. The pilot is Capt. H.W. von Engel. He breaks the previous record of 4,363 mi., set the previous December by Italian pilot Mario Stoppani. *Interavia*, April 2, 1938.

And During March 1938

—The CANT Z.509 seaplane carries out its last test flight prior to its full acceptance by the Italian airline Ala Littoria, which plans to use it for southern transoceanic services. *Interavia*, March 29, 1938, p. 5.

—Boeing registers the name Stratoliner as a trademark for its 307 all-metal, low-wing monoplane airliner. *Aviation*, April 1938, p. 38.

100 Years Ago

March 15 Renowned aviatrix Rosina Ferrario, the first woman in Italy to earn a pilot's license (and only the eighth woman in the world to do so), receives a gold medal awarded by the Gazzetta Dello Sport. Web-archive-it.com.

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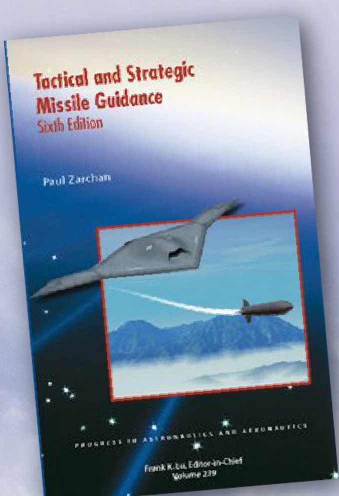

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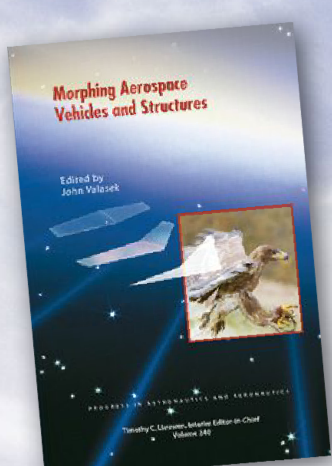

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AIAA St. Louis Section Chair Fran Youkhana presenting Todd Barber with a commemorative plaque for speaking at the December Event. See page **B10** for details.

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Meeting Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
2013				
2–9 Mar†	**2013 IEEE Aerospace Conference**	Big Sky, MT (Contact: David Woerner, 626.497.8451; dwoerner@ieee.org; www.aeroconf.org)		
19–20 Mar	**Congressional Visits Day**	Washington, DC (Contact Duane Hyland, duaneh@aiaa.org)		
25–27 Mar†	**3AF-48th International Symposium of Applied Aerodynamics Aerodynamics of Small Bodies and Details**	Saint-Louis, France (Contact: Anne Venables, secr.exec@aaafasso.fr, www.3af-aerodynamics2013.com)		
25–28 Mar	**22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar** (Dec) **AIAA Balloon Systems Conference** **20th AIAA Lighter-Than-Air Systems Technology Conference**	Daytona Beach, FL	*May 12*	**5 Sep 12**
8–11 Apr	**54th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** (Jan) **21st AIAA/ASME/AHS Adaptive Structures Conference** **15th AIAA Non-Deterministic Approaches Conference** **14th AIAA Dynamic Specialist Conference** **14th AIAA Gossamer Systems Forum** **9th AIAA Multidisciplinary Design Optimization Conference**	Boston, MA	*Apr 12*	**5 Sep 12**
10–12 Apr†	**EuroGNC 2013, 2nd CEAS Specialist Conference on Guidance, Navigation and Control**	Delft, The Netherlands (Contact: Daniel Choukroun, d.choukroun@tudelft.nl, www.lr.tudelft.nl/EuroGNC2013)		
15–19 Apr†	**2013 IAA Planetary Defense Conference**	Flagstaff, AZ (Contact: William Ailor, 310.336.1135, william.h.ailor@aero.org, http://www.pdc2013.org)		
23–25 Apr†	**Integrated Communications Navigation and Surveillance 2013**	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.i-cns.org)		
24–26 Apr	**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, siggi.pokoern@dnw.aero, +31 527 248520, http://gss2013.dnw.aero)		
8 May	**2013 Aerospace Spotlight Awards Gala**	Washington, DC		
13–16 May	**Reinventing Space Conference**	Los Angeles, CA (Contact James Wertz, jwertz@smad.com; www.reinventingspace.org)		
15–17 May†	**Seventh Argentine Congress on Space Technology**	Mendoza, Argentina (Contact: Pablo de Leon, 701.777.2369, Deleon@aate.org, www.aate.org)		
27–29 May	**19th AIAA/CEAS Aeroacoustics Conference (34th AIAA Aeroacoustics Conference)**	Berlin, Germany	*Jul/Aug 12*	**31 Oct 12**
27–29 May†	**20th St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia (Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru)		
29–31 May†	**Requirements for UTC and Civil Timekeeping on Earth: A Colloquium Addressing a Continuous Time Standard**	Charlottesville, VA (Contact: Rob Seaman, 520.318.8248, info@futureofutc.org, http://futureofutc.org)		
6 Jun	**Aerospace Today ... and Tomorrow: Disruptive Innovation, A Value Proposition**	Williamsburg, VA (Contact: Merrie Scott: merries@aiaa.org)		
12–14 Jun†	**6th International Conference on Recent Advances in Space Technologies (RAST 2013)**	Istanbul, Turkey (Contact: Suleyman Basturk, rast2013@rast.org.tr, www.rast.org.tr)		
17–19 Jun†	**2013 American Control Conference**	Washington, DC (Contact: Santosh Devasia,devasia@u.washington.edu,http://a2c2.org/conferences/acc2013)		
24–27 Jun	**43rd AIAA Fluid Dynamics Conference and Exhibit** **44th AIAA Plasmadynamics and Lasers Conference** **44th AIAA Thermophysics Conference** **31st AIAA Applied Aerodynamics Conference** **21st AIAA Computational Fluid Dynamics Conference** **5th AIAA Atmospheric and Space Environments Conference** **AIAA Ground Testing Conference**	San Diego, CA	*Jun 12*	**20 Nov 12**
14–17 Jul	**49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit** **11th International Energy Conversion Engineering Conference (IECEC)**	San Jose, CA	*Jul/Aug 12*	**21 Nov 12**
14–18 Jul	**43rd International Conference on Environmental Systems (ICES)** (Mar)	Vail, CO	*Jul/Aug 12*	**1 Nov 12**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
11–15 Aug†	**AAS/AIAA Astrodynamics Specialist Conference**	Hilton Head Island, SC (Contact: Kathleen Howell, 765.494.5786, howell@purdue.edu, www.space-flight.org/docs/2013_astro/2013_astro.html)		
12–14 Aug	**AIAA Aviation 2013: Charting the Future of Flight** **Continuing the Legacy of the AIAA Aviation Technology, Integration, and Operations (ATIO) Conference and Featuring the 2013 International Powered Lift Conference (IPLC) and the 2013 Complex Aerospace Systems Exchange (CASE)**	Los Angeles, CA	*Oct 12*	**28 Feb 13**
19–22 Aug	**AIAA Guidance, Navigation, and Control Conference** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Modeling and Simulation Technologies Conference** **AIAA Infotech@Aerospace Conference**	Boston, MA	*Jul/Aug 12*	**31 Jan 13**
10–12 Sep	**AIAA SPACE 2013 Conference & Exposition**	San Diego, CA	*Sep 12*	**31 Jan 13**
6–10 Oct†	**32nd Digital Avionics Systems Conference**	Syracuse, NY (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)		
14–16 Oct	**31st AIAA International Communications Satellite Systems Conference (ICSSC) and 19th Ka and Broadband Communications, Navigation, and Earth Observations Conference**	Florence, Italy (Contact: www.icssc2013.org)	*Feb 12*	**31 Mar 13**
2014				
13–17 Jan	**AIAA SciTech 2014** **(AIAA Science and Technology Forum and Exposition 2014)** Featuring **22nd AIAA/ASME/AHS Adaptive Structures Conference • 2nd AIAA Aerospace Sciences Meeting • 15th AIAA Gossamer Systems Forum • AIAA Guidance, Navigation, and Control Conference • AIAA Infotech@Aerospace Conference • 28th Microgravity Symposium on Gravity-Related Phenomena in Space Exploration • AIAA Modeling and Simulation Technologies Conference • 10th AIAA Multidisciplinary Design Optimization Specialist Conference • 16th AIAA Non-Deterministic Approaches Conference • 55th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference • 7th Symposium on Space Resource Utilization • 16th Weakly Ionized Gases Workshop • 32nd ASME Wind Energy Symposium**	National Harbor, MD		**5 Jun 13**
1–8 Mar†	**2014 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)		
26–28 May	**21st St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia (Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru)		
16–20 Jun	**AVIATION 2014** **(AIAA Aviation and Aeronautics Forum and Exposition)** Featuring **20th AIAA/CEAS Aeroacoustics Conference • 30th AIAA Aerodynamic Measurement Technology Conference • AIAA/3AF Aircraft Noise and Emissions Reduction Symposium • 32nd AIAA Applied Aerodynamics Conference • AIAA Atmospheric Flight Mechanics Conference • 6th AIAA Atmospheric and Space Environments Conference • 14th AIAA Aviation Technology, Integration, and Operations Conference • AIAA Balloon Systems Conference • 22nd AIAA Computational Fluid Dynamics Conference • AIAA Flight Testing Conference • 7th AIAA Flow Control Conference • 44th AIAA Fluid Dynamics Conference • AIAA Ground Testing Conference • 20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference • 21st AIAA Lighter-Than-Air Systems Technology Conference • 15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference • AIAA Modeling and Simulation Technologies Conference • 45th AIAA Plasmadynamics and Lasers Conference • 45th AIAA Thermophysics Conference**	Atlanta, GA		**12 Nov 13**
28–30 Jul	**Propulsion and Energy 2014** **(AIAA Propulsion and Energy Forum and Exposition)** Featuring **50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference • 12th International Energy Conversion Engineering Conference**	Cleveland, OH		**Nov 13**
2–10 Aug†	**40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events**	Moscow, Russia http://www.cospar-assembly.org		
5–7 Aug	**SPACE 2014** **(AIAA Space and Astronautics Forum and Exposition)** Featuring **AIAA/AAS Astrodynamics Specialist Conference • AIAA Complex Aerospace Systems Exchange • 32nd AIAA International Communications Satellite Systems Conference • AIAA SPACE Conference**	San Diego, CA		**Feb 14**

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 https://www.aiaa.org/Co-SponsorshipOpportunities/.

AIAA Courses and Training Program

DATE	COURSE	VENUE	LOCATION
2013			
4–5 Mar	**Modeling Flight Dynamics with Tensors**	National Aerospace Institute	Hampton, VA
20 Mar	**Risk Analysis and Management**	Webinar	
3 Apr	**UAV Conceptual Design Using Computer Simulations**	Webinar	
6–7 Apr	**Advanced Composite Structures**	SDM Conferences	Boston, MA
6–7 Apr	**Basics of Structural Dynamics**	SDM Conferences	Boston, MA
15–16 Apr	**A Practical Introduction to Preliminary Design of Air Breathing Engines**	The Ohio Aerospace Institute	Cleveland, OH
15–16 Apr	**Computational Heat Transfer (CHT)**	The Ohio Aerospace Institute	Cleveland, OH
24 Apr	**Space Radiation Environment**	Webinar	
21–24 May	**Inflight Icing and Its Effects on Aircraft Handling Characteristics**	The Ohio Aerospace Institute	Cleveland, OH
10–11 Jun	**Introduction to Spacecraft Design and Systems Engineering**	The Ohio Aerospace Institute	Cleveland, OH
10–11 Jun	**Aircraft and Rotorcraft System Identification: Engineering Methods and Hands-on Training Using CIFER®**	The Ohio Aerospace Institute	Cleveland, OH
22–23 Jun	**Verification and Validation in Scientific Computing**	Fluids Conferences	San Diego, CA
18–19 Jul	**Liquid Propulsion Systems—Evolution and Advancements**	Joint Propulsion Conference	San Jose, CA
18–19 Jul	**A Practical Introduction to Preliminary Design of Air Breathing Engines**	Joint Propulsion Conference	San Jose, CA
18–19 Jul	**Missile Propulsion Design and System Engineering**	Joint Propulsion Conference	San Jose, CA
29–30 Jul	**Introduction to Space Systems**	National Aerospace Institute	Hampton, VA
29–30 Jul	**Phased Array Beamforming for Aeroacoustics**	National Aerospace Institute	Hampton, VA
29–30 Jul	**Turbulence Modeling for CFD**	National Aerospace Institute	Hampton, VA
11 Sep	**Missile Defense: Past, Present, and Future**	Webinar	

**Courses subject to change*

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

From the Corner Office

A STRATEGY TO SUCCEED

Sandy H. Magnus, Executive Director

I mentioned in my previous article that the one thing you can count on is change and that holds especially true today. In last month's article, Klaus highlighted the many challenges facing all nonprofit organizations, including AIAA and other technical and engineering societies. As he pointed out, the transformation to our New Event Model is timely. While it is a major step in the right direction, it will not be sufficient, in and of itself, to move us entirely to a better posture to face the future. We must build a strategic plan that clearly outlines our priorities along with a financial model that is sustainable and supportive of those priorities and clearly understood by institute leadership. Only then will we be poised to move forward in a thoughtful, mindful manner.

Why is this so important? The environment around us continues to become more and more challenging. The level of fiscal uncertainty permeating our country is driving increasingly severe measures that have impacted and will continue to impact the current way we do business. For example, the Office of the Secretary of Defense issued a memo on January 10, 2013, instructing all components to severely curtail spending. This directive, which mandated draconian cuts, was issued due to the fact that the DOD was operating on a continuing resolution at FY12 levels at least up to March 27, 2013.

In addition, with no insight of whether sequestration would be implemented nor the budgeted FY13 levels restored, the department deemed it prudent to start cutting proactively to ensure that money would remain throughout FY13 to keep the military operational. For AIAA that meant the immediate cancellation of our annual Missile Defense Agency (MDA) Conference, a bellwether event that also supports other Institute activities. Other conferences, organized by sister societies and heavily dependent on DOD participation, are also either being cancelled or impacted very negatively. The long-term effects resulting from this directive remain to be seen and are connected with the outcome of the current budget debate.

What does this mean for us? It means that we need to clearly understand, as an organization, what our goals and objectives are so we can manage our resources in the smartest possible manner—hence the need for a solid strategic plan. Work started in November with the Institute Development Committee (IDC) and continued with the Board of Directors at the January meeting. We are hoping to have a good first cut at a strategic framework with which we can chart the next 3–5 years of Institute priorities. Like all strategic plans, it will be a living document, one that we will update as necessary. This plan will provide the leadership with the structure to make decisions.

The next step we have undertaken is to examine our business models, our assumptions and examine in detail our financial foundation. Clearly this was something that needed to occur as we move to a new conference model, but a new dimension has been added to this exercise given the macro-business environment in which we are operating. This review is a work in progress and will be a topic of discussion with the IDC and Board at our May meetings.

Change clearly brings uncertainty, but it also brings opportunity. This moment in time is an opportunity for AIAA to grow, reposition, and strengthen. As we re-examine our priorities, focus ourselves on what is important, and re-set, so to speak, how we do things, it provides us with avenues to explore that we may not have identified in the "same ol', same ol'" of a static mundane world. Let's grab this chance and do great things with it!!!

Finally, just as a reminder, our Board of Directors election is currently in progress. During the challenging times we will continue to experience and the uncertainty surrounding the ultimate impacts to the aerospace industry, the Board will be faced with some tough decisions. Make sure your voice is heard by voting for the Board that you feel confident can address these issues appropriately. Please take a few moments to vote!

2013 ASSOCIATE FELLOWS HONORED

The 2013 Associate Fellows were honored at the AIAA Associate Fellows Dinner on Monday, 7 January in Grapevine, TX, in conjunction with the 51st 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.


22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar
AIAA Balloon Systems Conference
20th AIAA Lighter-Than-Air Systems Technology Conference
25–28 March 2013
Hilton Daytona
Daytona Beach, Florida
12-0446
Register Today!
www.aiaa.org/daytona2013
AIAA

THE CONSOLIDATION—WORKING IT ALL OUT

We are continuing to mark the 50th anniversary of the merger of the American Rocket Society and the Institute of the Aerospace Sciences to form the American Institute of Aeronautics and Astronautics. In early 1962 there were still doubts on both sides regarding the wisdom of merging. The following is an excerpt from *Rocketeers and Gentlemen Engineers: A History of the American Institute of Aeronautics…and What Came Before* by Tom D. Crouch.

*A list of proposed merger names considered:

AAA—American Aerospace Association
AAI—American Aerospace Institute
AAIS—Association of Aerospace and Interplanetary Sciences
ASASE—American Society of Aerospace Scientists and Engineers
IRAS—Institute of Rocket and Astronautical Sciences
SASS—Society of Aeronautical and Space Sciences

James Harford, the Executive Director of the American Rocket Society (ARS), never hesitated to voice his opinion. Writing on January 2, 1962 to William Pickering, the Director of the Jet Propulsion Laboratory and the incoming president of the ARS, Harford argued that "there is a clear conflict in principles between the ARS and the IAS which…will require that the ARS make serious compromises in matters that are very important." He believed "that there will be hundreds – perhaps thousands – of dissidents who feel as I do that one society ought to concern itself with space alone> The merger might provide the American Astronautical Society with a golden opportunity to market itself as the American space flight organization. He pointed to involvement in public policy and the inclusion of industrial/technical exhibitions at meetings.

At the same time, Harford was a realist who had no doubt which way the wind was blowing. Rather than standing in strong opposition to a merger, he supported his friend Pickering, recognized the strength of the forces favoring consolidation, and promised to continue operating as a team player if things did not go in the direction he preferred. "If the two Boards decide to merge," he concluded, "I and ht staff will aggressively try to win jobs in the merged organization. What's more, we'll try to dedicate ourselves as much to commercial supersonic transports and air line management as we do to space vehicles."

William Pickering of the ARS and IAS President General Donald Putt (1960) began discussing the relationship between their two organizations late in 1960. In November, 1961, Pickering and then IAS President Guyford Stever (1961) agreed to establish a special study group made up of four members from each society to continue the discussions and report to the IAS Council and the ARS Board at the earliest possible date. The group reported favorably on January 21, 1962. The IAS and ARS then created a 10-person Consolidation Steering Committee made up of the officers of both organizations. They also established five working groups responsible with dealing with a series of specific problem areas: constitutions and bylaws, organization, member services, and ways and means.

Who would head the new organization? Jim Harford remembers that he and Paul Johnston were invited to a joint meeting in Phoenix in April 1962. Both men described the approach that they would take if placed in command of the new organization. Ultimately, the decision was to allow Johnston, who had agreed to retire just 18 months after the new organization was launched, to serve as the first executive director. Harford would be named deputy executive director.

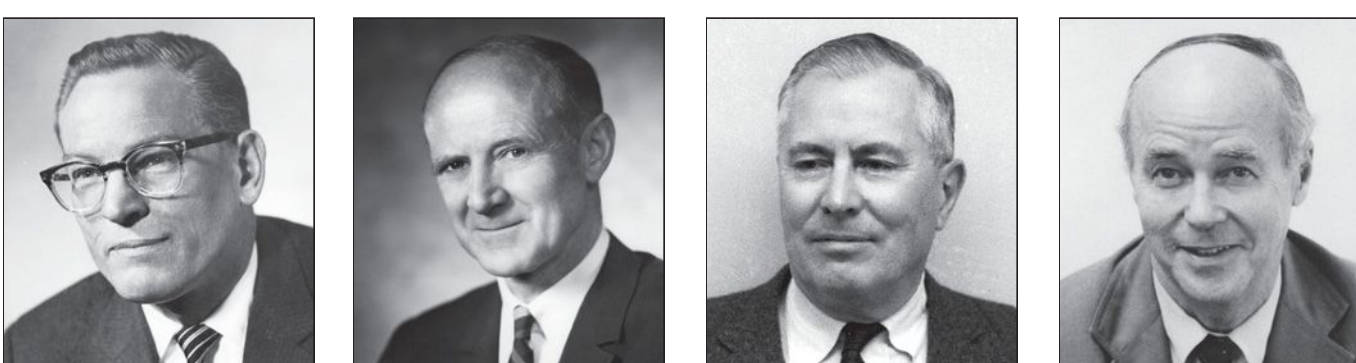
The Phoenix meeting seems to have been the place where the forces in opposition to the merger came to a head. As one commentator noted, Eugene Root (IAS President 1962) had to deal with IAS members who feared that he was "giving away the store," while Pickering had to answer ARS adherents who feared they would be forced to "mix with those airplane guys." Four decades later, the echo of those arguments could still be heard among AIAA veterans who remember the merger.

The Principles of Consolidation were accepted by both organizations in May, 1962. The document presented a detailed description of what the new Institute would be; how it would be organized, governed and financed; and what services it would offer members.

The opening paragraph announced that the new organization would be known as the American Institute of Aeronautics and Astronautics. "This name carries our national identification, labels it as an organization for the promotion of learning, arts and sciences; and it identifies the primary subject areas of interest." In addition, members were informed, "its acronym, AIAA, is simple and dignified."*

The principles were in the mail to all nonstudent members of both organizations by early June. Enclosed with the printed copy of the document was a postcard on which the member was asked to endorse or reject the principles and to offer any comment that he or she might wish to make – and they did have comments to make. Although overall the response was in favor of consolidation, an assortment of the letters provides evidence of opposition to what one member described as "the shot gun wedding."

Overall, the voting showed that about 96% of the members who had responded were in favor of consolidation, three percent disapproved, and one percent failed to express an opinion. Bill Pickering was elected as the first president of the new organization, which had a combined membership, including students, of about 36,500. It started out with 45 technical committees, 66 local sections, and 180 corporate members. It was the largest aerospace society in the world.



1963 IAS President Eugene Root; 1962 ARS President and first AIAA President Bill Pickering; IAS Executive Director and first AIAA Executive Director S. Paul Johnston; ARS Executive Director and second AIAA Executive Director James Harford.

Important Announcement
New Editor-in-Chief Sought for the *Journal of Guidance, Control, and Dynamics*

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

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

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

Heather Brennan
Manager, Content Acquisition and Editorial Policy
American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
Fax: 703.264.7551 • E-mail: heatherb@aiaa.org

A minimum of two letters of recommendation also are required. The recommendations should be sent by the parties writing the letters directly to Ms. Brennan at the above address, fax number, or e-mail. To receive full consideration, applications and all required materials must be received at AIAA Headquarters by 15 April 2013, but applications will be accepted until the position is filled.

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

Longtime AIAA members at the St. Louis Section Dinner: back row (from left to right): Robert Samuelson (50+ years), Fred Tuttle (50+ years), Eugene Mleczko (50+ years), Larry Brase (30 years), Mike Wendle (40 years), Dale Pitt (40 years), Steve Stuckel (35 years), Trent Duff (25 years), David Riley (35 years) John Donigan (35 years). Front row (from left to right): Raimo Hakkenen (60+ years), William Briggs (60+ years), Ed Juede (50+ years), Michael Wendle (25 years), William Alban (30 years)

ST. LOUIS SECTION APPRECIATION EVENT

The AIAA St. Louis Section held a combined Dinner Meeting/2nd Annual Member Appreciation Event on 13 December 2012 at the Moonrise Hotel in University City, MO. Mr. Todd Barber from the Jet Propulsion Lab in Pasadena, CA, gave a fascinating and detailed presentation on the Mars Science Laboratory (MSL), more commonly known as the Mars *Curiosity* Rover. He related numerous stories regarding the preparation to launch, the actual landing sequence on Mars, and the ongoing tasks that *Curiosity* is now undertaking.

Prior to Mr. Barber's presentation, past section chairpersons were recognized and presented with a lapel pin specifically designed for the St. Louis section. Additionally, longtime members (25, 30, 35, 40, 45, 50+ years of membership) were presented with a unique "Challenge Coin" specifically designed for the St. Louis Section. In total, more than forty-five people were in attendance to see Mr. Barber's presentation and to see the sections past chairs and longtime members recognized. The St. Louis section's goal is to have two membership appreciation events every year; one event for new members and one event recognizing the longtime members.

AIAA FOUNDATION ANNOUNCES INTERNATIONAL STUDENT CONFERENCE "BEST PAPER" WINNERS

The AIAA Foundation is pleased to announce the winners of its 2013 AIAA Foundation International Student Conference "Best Papers" Competition. Awardees were honored on 8 January at the awards luncheon of the 51st AIAA Aerospace Sciences Meeting, held 7–10 January at the Gaylord Texan Resort and Convention Center, Grapevine, TX.

Winners of the Undergraduate, Undergraduate Team, and Master's categories received $1,000. The winner of the Community Outreach category received $500.

The awardees were:

- **Braden J. Hancock**, Brigham Young University, Provo, UT, in the Individual Undergraduate Division, for his paper "Reducing Shock Interactions in a Single Stage High Pressure Turbine Via 3D Aerodynamic Shaping."
- **Steven A. Leverette**, William L. Murray and Sarah W. Hester, University of Southern California, Los Angeles, CA, in the Undergraduate Team Division, for their paper: "Thrust Augmentation of a Solid Rocket Motor by Means of Inert Gas Injection."
- **Erica G. Hocking**, University of Maryland, College Park, MD, in the Graduate Division, for her paper: "Fabrication and Characterization of Small-Scale Pneumatic Artificial Muscles for a Bio-Inspired Robotic Hand."
- **Victor Lopez**, U.S. Air Force Academy, Colorado Springs, CO, in the Community Outreach Division, for his paper: "Hybrid Rocket Demonstrator and Lesson Plan for STEM Outreach in Grades K–12."

The AIAA Foundation International Student Conference invites undergraduate and graduate AIAA student members who have won their regional student conference to present and discuss their research in a formal setting, thereby providing a forum for the recognition of outstanding student research, and strengthening inter-regional bonds between school engineering departments. For more information on the AIAA Foundation International Student Conference, please contact Stephen Brock at 703.264.7536 or stephenb@aiaa.org.

NEW CORPORATE MEMBERS

In January at the AIAA Board of Directors Meeting, the following organizations were approved as AIAA corporate members. For more information on the corporate membership program, please contact merries@aiaa.org

Astrium Americas (Herndon, VA), an EADS North America Company provides advanced telecommunications, geo-information, space transportation, and satellite capabilities specifically tailored to meet the demanding requirements of U.S. and Canadian government customers.

Bastion Technologies (Houston, TX) is a prominent engineering and scientific services company that provides a wide range of services and products to the aerospace, energy, petrochemical, biomedical, and information management industries nationwide.

Bron Aerotech Inc. (Denver, CO) provides engineered aerospace materials to space, composite, aircraft, defense OEMs, and tiers. Working with M&P engineers, program managers, procurement, and specification custodians, our application specialists assist in the process of solving material issues. Our 35 years experience in industrial materials and 15 years in aerospace applications give us a tremendous range of products and solutions. This level of expertise and service has earned the trust and commitment of major defense and commercial contractors and OEMs.

Cummings Aerospace (Huntsville, AL), founded in 2009, is an Economically Disadvantaged Woman-Owned Small Business (EDWOSB) and a leading provider of high-value engineering solutions for complex systems in the aerospace, defense, and intelligence industry. We apply our core competencies in End-to-End Systems Engineering, Modeling and Simulation (M&S), Software Engineering, Test Planning and Execution, and Quality, Safety & Mission Assurance (QSMA) to provide our customers integrated solutions for complex systems.

DataCon (Burlington, MA) is a Veteran-Owned Small Business (VSOB) contract manufacturer of advanced electronics specializing in high-reliability mission critical applications for the space, defense, and life sciences industries. Their major line of business is Missile Ballistic Defense.

Dynetics (Huntsville, AL) delivers high-quality, high-value engineering, scientific, and information technology (IT) solutions to customers within the U.S. government and a range of other market segments in the areas of intelligence, missiles, aviation, cyber, and space. The company also develops aerospace products and services for NASA, the Department of Defense, and commercial space sectors, using its complex technology, high-quality, low-volume design, and manufacturing capabilities.

Paragon Space Development Corporation (Tucson, AZ) is the premier provider of environmental controls for extreme and hazardous environments. They design, build, test, and operate premier life support systems and leading thermal control products for astronauts, contaminated water divers, and extreme environment adventurers, as well as for unmanned space and terrestrial applications.

Parametric Technology (Needham, MA) is one of the world's largest and fastest-growing technology companies that helps manufacturing leaders address the biggest business challenges they face today, including: product lifecycle management, computer-aided design, application lifecycle management, supply chain management and service lifecycle to aggregate, analyze, and deploy product information to drive the strategy and dynamic decision-making processes on which your success depends.

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.

CALL FOR NOMINATIONS

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

Any AIAA member in good standing may serve as 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.

Beginning in 2013, all nominations, whether submitted online or in hard copy, must comply with the limit of 7 pages for the nomination package. The nomination package includes the nomination form, a one-page basis for award, one-page resume, one-page public contributions, and a minimum of 3 one-page signed letters of endorsement from AIAA members. Up to 5 signed letters of endorsement (including the 3 required from AIAA members) may be submitted and increase the limit to 9 pages. Nominators are reminded that the quality of information is most important.

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 non-fiction 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 **December 31** of the year preceding the presentation.

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

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

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

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

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

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

43rd International Conference on Environmental Systems (ICES)

14–18 July 2013
Vail Marriott
Vail, Colorado

Welcome

Dear Colleague,

AIAA and the conference steering committee are pleased to invite you to join us at the 43rd International Conference on Environmental Systems (ICES), to be held 14–18 July 2013, in Vail, CO. ICES has an established reputation for bringing together professionals from government, industry, and academia to explore topics related to humans living and working in hostile environments, with applications inside or outside of terrestrial or outer space habitats or vehicles. Previous year's events have included participants from more than 20 countries and more than 150 companies and organizations, including NASA, ESA, JAXA, and many more. We are expecting close to 300 participants from the life support, thermal, and EVA communities to join us in Vail.

Additionally, there will be ample opportunities to learn about the latest advancements in technology research, development, applications, and operations in any of the 300 technical presentations that will be given throughout the week in approximately 42 technical sessions plus two panel sessions. Participants will also benefit from a variety of networking events planned for the conference.

We are looking forward to another productive ICES and seeing you in Vail in July!

Sincerely,

W. Andrew Jackson
Texas Tech University
Chair, 43rd ICES

Chang H. Son
The Boeing Company
Vice Chair, 43rd ICES

Benefits of Attendance

Why Attend?
- Present recent advances before a knowledgeable international audience
- Educate customers and providers on the latest research and product developments
- Learn about the latest technology and research in the field from industry experts
- Network to engage new contacts and refresh old ones
- Recognize significant achievements from within the community

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

What to Expect?
- *Program*

– Access to more than 300 technical papers and presentations
– Opening plenary presentation
– Student poster competition to encourage and engage young minds as they enter the aerospace industry

- *Networking*

– Opportunities to engage with almost 300 industry professionals, educators, and students
– Welcome reception
– Networking coffee breaks
– "Happy hour" reception during the student poster competition
– Reception and banquet with award presentations and keynote speech

	Sunday, 14 July	Monday, 15 July	Tuesday, 16 July
0700 hrs		Speakers'	Speakers'
0730 hrs		Briefing	Briefing
0800 hrs			
0830 hrs		Plenary	Technical Sessions
0900 hrs		Session	
0930 hrs		Networking Coffee Break	Networking Coffee Break
1000 hrs			
1030 hrs		Technical Sessions	Technical Sessions
1100 hrs			
1130 hrs			
1200 hrs			
1230 hrs		Lunch Break	Lunch Break
1300 hrs			
1330 hrs			
1400 hrs		Technical Sessions	Technical Sessions
1430 hrs			
1500 hrs			
1530 hrs		Networking Coffee Break	Networking Coffee Break
1600 hrs			
1630 hrs		Technical Sessions	Technical Sessions
1700 hrs	Welcome		
1730 hrs	Reception		
1800 hrs			
1830 hrs		Networking Reception and	
1900 hrs		Student Poster	
1930 hrs		Competition	
2000 hrs			
2030 hrs			
2100 hrs			
2130 hrs			
2200 hrs			
2230 hrs			
2300 hrs			
2330 hrs			
0000 hrs			

Networking Activities and Special Events

Welcome Reception

A welcome reception will be held on Sunday, 14 July, 1730–1900 hrs, at the Vail Marriott. Take this opportunity to refresh old contacts and meet new participants the night before the conference begins. A ticket for the reception is required and included in the conference registration fee where indicated. Additional tickets for guests may be purchased upon registration or on site.

Opening Plenary Session

The event will open on Monday, 15 July 2013, 0800–0930 hrs, with a plenary session featuring welcome remarks by conference chair W. Andrew Jackson, Associate Chair and Professor, Civil and Environmental Engineering, Texas Tech University, and a keynote speech.

Networking Coffee Breaks

Standalone networking coffee breaks are included in the program to allow even more time for making new contacts, continuing discussions from technical sessions, or checking emails and voicemails to keep in touch with the office while you are at the conference. Times are indicated in the program.

Networking Reception and Student Poster Competition

A networking "happy hour" reception and student poster competition will be held Monday, 15 July 2013, 1830–2000 hrs, at the Vail Marriott. All attendees are welcome to come and see the work presented by the students participating in this year's poster competition. The ICES student poster competition is targeted to stimulate the participation of students in the event and provides an informal and interactive forum for students to present their work. Posters are ideal for presenting speculative

	Wednesday, 17 July	Thursday, 18 July
0700 hrs	Speakers'	Speakers'
0730 hrs	Briefing	Briefing
0800 hrs		
0830 hrs	Technical Sessions	
0900 hrs		Technical Sessions
0930 hrs	Networking Coffee Break	
1000 hrs		Networking Coffee Break
1030 hrs	Technical Sessions	
1100 hrs		Technical Sessions
1130 hrs		
1200 hrs		
1230 hrs	Lunch Break	
1300 hrs		
1330 hrs		
1400 hrs	Technical Sessions	
1430 hrs		
1500 hrs		
1530 hrs		
1600 hrs		
1630 hrs	Free Time for Exploring	
1700 hrs	and Excursions	
1730 hrs		
1800 hrs		
1830 hrs	Reception	
1900 hrs		
1930 hrs		
2000 hrs	Banquet and	
2030 hrs	Awards	
2100 hrs		
2130 hrs		
2200 hrs		
2230 hrs	Dessert Reception	
2300 hrs		
2330 hrs		
0000 hrs		

or late-breaking results, or for giving an introduction to innovative work. The poster competition reception will provide ICES students and professionals an opportunity to connect with one another and discuss the work presented. Each poster will be officially judged prior to the reception and prizes will be awarded at the conference banquet.

There is still time to submit an abstract for the ICES student poster competition. University/college students are invited to submit abstracts on their proposed poster by **1 June 2013** per the abstract submittal procedures. The student's abstract and poster should be pertinent to ICES; that is, they should follow the same theme of the general conference, focusing on humans living and working in hostile environments with applications inside or outside of terrestrial or outer space habitats or vehicles. Abstracts of approximately 300 words must include poster title, author name(s), mailing and e-mail addresses, phone and fax numbers, and university or college. The first author and the presenting author of the poster must be students. Abstracts must not be more than one page in length and must be double-spaced. Adherence to this format is required. Abstracts that do not adhere to this format will be rejected. *Poster abstracts should be emailed as an attachment to Matthias Holzwarth at matthias.holzwarth@astrium.eads.net by **1 June 2013***. Authors will be notified of poster presentation acceptance by **10 June 2013**. Each participating student will receive a ticket to Wednesday night's banquet. For questions on the student poster competition, please contact Matthias Holzwarth at matthias.holzwarth@astrium.eads.net.

Reception and Banquet

The conference reception and banquet will be held Wednesday, 17 July 2013, beginning at 1830 hrs at the Vail Marriott. The reception will be followed by dinner, and then the

SESSIONS AT A GLANCE

Current session titles below. For the full conference program, including paper and presentation titles and speakers, go to **www.aiaa.org/ices2013** and click "Detailed Program."

ICES101	Spacecraft and Instrument Thermal Design, Testing, and Technology
ICES102	Thermal Control for Planetary Surface Missions and Systems
ICES103	Thermal and Environmental Control of Exploration Vehicles and Surface Transport Systems
ICES104	On-Orbit Operations and Logistics of Thermal and Environmental Control Subsystems
ICES107	Thermal and Environmental Control Engineering and Analysis and Software
ICES108	Advances in Thermal Control Technology
ICES111	Thermal Standards and Design/Development Practices
ICES113	Spacecraft Propulsion Systems Thermal Control
ICES115	James Webb Space Telescope Thermal Control
ICES200	Physico-Chemical Processes: Air and Water
ICES201	Two-Phase Thermal Control Technology
ICES202	Satellite, Payload, and Instrument Thermal Control
ICES203	Thermal Testing
ICES204	Bioregenerative Life Support
ICES205	Advanced Life Support Sensor and Control Technology
ICES300	ECLSS and Thermal Modeling and Test
ICES302	Physio-Chemical Life Support Process Development
ICES305	In-Situ Resource Utilization
ICES306	Environmental and Thermal Control for Commercial Crewed and Cargo Transport Spacecraft
ICES307	Orion Multi-Purpose Crew Vehicle Environmental Control and Life Support System
ICES308	Education and Outreach
ICES400	Extravehicular Activity: Space Suit
ICES401	Extravehicular Activity: Systems
ICES402	Extravehicular Activity: PLSS Systems
ICES403	Extravehicular Activity: Operations
ICES404	International Space Station ECLS: Systems
ICES405	International Space Station ECLS: Air and Water Systems
ICES407	Spacecraft Water/Air Quality: Maintenance and Monitoring
ICES408	Regenerable Life Support Processes and Systems
ICES409	Airliner Cabin Air: Monitoring, Control, and Environmental Health Issues
ICES500	Experimental Hardware and Technologies for Life Sciences Research
ICES501	Life Support Systems Engineering and Analysis
ICES502	Space Architecture
ICES503	Radiation Issues for Space Flight
ICES504	Management of Air Quality in Sealed Environments
ICES505	Microbial Factors Applied to Design
ICES506	Human Exploration Beyond Low Earth orbit: Missions and Technologies
ICES507	Human Factors for Space Missions Ground and Flight Operations
ICES508	Mars and Beyond
ICES509	Fire Safety in Spacecraft and Enclosed Habitats
ICES511	Mission Assurance and Reliability Techniques for Environmental Systems
ICES513	Computational Modeling for Human Health and Performance Analysis

awards presentation and a keynote speech. A ticket for the reception and banquet is required and included in the conference registration fee where indicated. Additional tickets for guests may be purchased upon registration or on site.

Dessert Reception

Sponsored by Paragon Space Development Corporation

Immediately following the banquet, there will be a dessert reception sponsored by Paragon Space Development Corporation. This is a favorite event for participants and all banquet attendees are welcome to attend.

Sponsorship Opportunities

AIAA would like to thank Paragon Space Development Corporation for their sponsorship of the Dessert Reception.

AIAA offers many cost-effective sponsorship opportunities to ensure that your organization receives high-visibility and awareness among attendees while enhancing your onsite presence. Choose from many options including receptions, networking breaks, tote bags, lanyards, or something customized to your brand. For more information, please contact Merrie Scott at +1.703.264.7530 or merries@aiaa.org.

Meeting Site

Visitors and residents alike enjoy 1,100 acres of open space within the town of Vail. Located at the base of Vail mountain and surrounded by 350,000 acres of White River National Forest, the town is home to just over 4,500 residents, counting among them former astronaut John Glenn. With pleasantly warm summers and cold winters, Vail features diverse shops and restaurants, friendly neighborhoods, and breathtaking views—and it's easy to navigate on foot. See for yourself why Vail is a great destination to visit or attend a meeting! More information is at www.visitvail-valley.com

AIAA Programs

		By 17 June 2013		18 June-13 July 2013						
	Registration Type	Conference Rate	AIAA Member Discount	Conference Rate2	AIAA Member Discount2	Conference Sessions	Online Proceedings	Welcome Reception	Networking Reception/ Student Poster Competition	Reception and Banquet
Option 1	Full Conference	$1,005	$845	$1,105	$945	•	•	•	•	•
Option 2	Full-Time Undergraduate Student	$60	$25	$70	$35	•			•	
Option 3	Full-Time Undergraduate Student with Networking	$229	$194	$239	$204	•		•	•	•
Option 4	Full-Time Graduate or Ph.D. Student	$110	$75	$120	$85	•			•	
Option 5	Full-Time Graduate or Ph.D. Student with Networking	$279	$244	$289	$254	•		•	•	•
Option 6	Full-Time Retired AIAA Member Only	N/A	$60	N/A	$70	•		•	•	•
Option 7	Discounted Group Rate*	$761	$761	$761	$761	•	•	•	•	•
	Extra Tickets					N/A	$200	$63	N/A	$106

Pricing subject to change.

*10% discount off early bird member rate for 10 or more persons from the same organization who register and pay at the same time with a single form of payment.

Hotel Information

AIAA has made arrangements for a block of rooms at the Vail Marriott, 715 West Lionshead Circle, Vail, CO 81657. Room rates are $179 plus applicable taxes, for single and double occupancy. A limited number of room nights are available at the prevailing U.S. government per diem rate at the time of the conference for those who qualify. To make a reservation, call 1.877.622.3140 and refer to the AIAA 43rd International Conference on Environmental Systems (ICES), or book your hotel room online on the event website. Rooms at the AIAA rate will be held until **21 June 2013** while availability lasts. After 21 June 2013, any unused rooms will be released to the general public. You are encouraged to book your hotel room early.

Help Keep Our Expenses Down (And Yours Too!)

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

Airport and Transportation Information

Vail Marriott is 127 miles from Denver International Airport (DEN), and just 35 miles from Eagle County Regional Airport (EGE).

Colorado Mountain Express (CME) provides shared ride shuttles and private car services from both Denver International Airport (DEN) and Eagle/Vail Airport (EGE). CME provides door-to-door service for convenient and easy transportation from both DEN and EGE, and numerous daily departures. CME is pleased to offer FREE Wi-Fi in all of their vehicles. To book your ride, visit www.coloradomountainexpress.com.

Car Rental

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

Registration Information

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

All participants are urged to register online at **www.aiaa.org/ices2013**. 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 also available on the AIAA website. Print, complete, and mail or fax the form with payment to AIAA. Address information is provided. Payment must be received in order to process the registration form.

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

Early-bird registration forms must be received by **17 June 2013**, and standard registration forms will be accepted until **13 July 2013**. Preregistrants may pick up their materials at the advance registration desk at the conference.

All those not registered by **13 July 2013** may do so at the on-site registration desk by paying the on-site registration fee. All nonmember registration fees include a one-year AIAA membership.

Cancellations must be received no later than **1 July 2013**. There is a $100 cancellation fee. Registrants who cancel beyond this date or fail to attend the conference will forfeit the entire fee.

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

On-Site Check-In

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

Organized by AIAA

Supported by
AIAA Life Sciences and Systems Technical Committee
AIAA Space Environmental Systems Program Committee
American Institute of Chemical Engineers (AIChE) Environmental Systems Committee
American Society of Mechanical Engineers (ASME) Crew Systems Technical Committee
ICES International Committee (INT)

Dessert Reception Sponsored by Paragon Space Development Corporation

Chair
W. Andrew Jackson
Texas Tech University

Vice Chair
Chang Hyun Son
The Boeing Company

Steering Committee

Grant Anderson
Paragon Space Development Corporation

Tim Nalette
Hamilton Sundstrand

Jeffery Farmer
NASA Marshall Space Flight Center

Wes Ousley
Genesis Engineering Solutions LLC

Matthias Holzwarth
Astrium Space Transportation

Amy Ross
NASA Johnson Space Center

David Williams
NASA Johnson Space Center

AIAA Registration and Information Center Hours

The AIAA Registration and Information Center will be located at the Vail Marriott. Hours are as follows:

Sunday, 14 July 2013	1500–1900 hrs
Monday, 15 July 2013	0700–1700 hrs
Tuesday, 16 July 2013	0700–1700 hrs
Wednesday, 17 July 2013	0700–1500 hrs
Thursday, 18 July 2013	0700–1200 hrs

Notice on Visas

If you plan to attend an AIAA conference or course held in the United States and you require a visa for travel, it is incumbent upon you to apply for a visa with the U.S. Embassy (consular division) or consulate with ample time for processing. To avoid bureaucratic problems, AIAA strongly suggests that you submit your formal application to U.S. authorities a minimum of 120 days in advance of the date of anticipated travel.

To request a letter of invitation, please fill out and submit the online Invitation Letter Request Form. You may also request a letter of invitation by contacting:

ATTN: Sandra Turner
American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
703.264.7508 • 703.264.7657 FAX
Email: sandrat@aiaa.org

AIAA cannot directly intervene with the U.S. Department of State, consular offices, or embassies on behalf of individuals applying for visas.

Conference Proceedings

Proceedings for these conferences will be available in online proceedings format. The cost is included in the registration fee where indicated. The online proceedings will be available on **14 July 2013**. Attendees who register in advance for the online proceedings will be provided with instructions on how to access them. Those registering on site will be provided with instructions at that time.

"No Paper, No Podium" and "No Podium, No Paper" Policies

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

Important Dates

Final Manuscript Deadline	6 May 2013
Early Bird Registration Deadline	17 June 2013
Hotel Room Block Reservation Deadline	21 June 2013
Standard Registration Deadline	13 July 2013

For more detailed program information,
visit the website at **www.aiaa.org/ices2013**.
#ICES2013

Upcoming AIAA Professional Development Courses

4–5 March 2013

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

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

	Early Bird by 1 Feb	Standard (2–25 Feb)	On-site (26 Feb–4 Mar)
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

Modeling Flight Dynamics with Tensors (Instructor: Peter Zipfel)

Establishing a new trend in flight dynamics, this two-day course introduces you to the modeling of flight dynamics with tensors. Instead of using the classical "vector mechanics" technique, the kinematics and dynamics of aerospace vehicles are formulated by Cartesian tensors that are invariant under time-dependent coordinate transformations.

This course builds on your general understanding of flight mechanics, but requires no prior knowledge of tensors. It introduces Cartesian tensors, reviews coordinate systems, formulates tensorial kinematics, and applies Newton's and Euler's laws to build the general six degrees of freedom equations of motion. For stability and control applications, the perturbation equations are derived with their linear and nonlinear aerodynamic derivatives. After taking the course you will have an appreciation of the powerful new "tensor flight dynamics," and you should be able to model the dynamics of your own aerospace vehicle.

6–7 April 2013

The following Continuing Education courses are being held at the 54th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference in Boston, MA. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

To register for one of the SDM 2013 courses, go to **www.aiaa.org/sdm2013.**

	Early Bird by 11 Mar	Standard (12 Mar–5 Apr)	On-site (6 Apr)
AIAA Member	$1305	$1405	$1505
Nonmember	$1415	$1515	$1615

Advanced Composite Structures (Instructor: Carl Zweben, Independent Consultant, AIAA Associate Fellow, Devon, PA)

Advanced composites are critical, and in many instances enabling, materials for a large and increasing number of aerospace applications. Historically considered primarily structural and thermal protection materials, they also have great potential in virtually all subsystems, including propulsion, mechanisms, electronics, power, and thermal management. Physical properties are increasingly important. For example, composites with low densities, low CTEs, and thermal conductivities higher than copper are now in production. Materials of interest include not only polymer matrix composites (PMCs), currently the most widely used class of structural materials, and carbon-carbon composites (CCCs), which are well established for thermal protection, but also ceramic matrix composites (CMCs), metal matrix composites (MMCs) and other types of carbon matrix composites (CAMCs). In this short course we consider key aspects of the four key classes of composites, including properties, manufacturing methods, design, analysis, lessons learned, and applications. We also consider future directions, including nanocomposites.

Basics of Structural Dynamics (Instructor: Dr. Andrew Brown, NASA Marshall Space Flight Center, Huntsville, AL)

This course is intended to be an introductory course in Vibrations and Structural Dynamics. The goals of the course will be to provide students with the ability to characterize the dynamic characteristics of structures, and enable the prediction of response of structures to dynamic environments. Subjects examined in the course will be free and forced vibration of single degree-of-freedom systems, forced response of multi-DOF systems, modal testing, and component loads analysis. The course will concentrate on the essential concepts within these topics to enable widely-applicable understanding, but we'll include examples of applications focused on rocket engines and launch vehicles as well. We'll also use a variety of software tools and in-class assignments to keep the class active and interesting.

15–16 April 2013

The following standalone course is being held at The Ohio Aerospace Institute in Cleveland, Ohio.

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

	Early Bird by 14 Mar	Standard (15 Mar–8 Apr)	On-site (9–15 Apr)
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

A Practical Introduction to Preliminary Design of Air Breathing Engines (Instructor: Ian Halliwell)

The objective of the course is to present an overview of the preliminary design of air-breathing engine systems that is determined primarily by the aircraft mission, which defines the engine cycle—and different types of cycle are investigated. Preliminary design activities are defined and discussed in the context of the overall engine development process and placed in perspective. Some basic knowledge of aerodynamics and thermodynamics is assumed so the mathematical material that appears in many good textbooks is minimized and the question "What do you actually do as an engine designer?" is addressed. The practical means and processes by which thermodynamic concepts are turned into hardware are covered and some design techniques are demonstrated. Finally, the fact that an air breathing engine is much more than the flowpath component is discussed and the future of engine design methods is raised. Class participation is encouraged throughout. This is your course; please try to get from it whatever you want!

15–16 April 2013
The following standalone course is being held at The Ohio Aerospace Institute in Cleveland, Ohio.

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

	Early Bird by 14 Mar	Standard (15 Mar–8 Apr)	On-site (9–15 Apr)
AIAA Member	$950	$1075	$1175
Nonmember*	$1070	$1195	$1295

*Includes a one-year AIAA membership

Computational Heat Transfer (CHT) **(Instructor: Dean Schrage)**
This CHT course provides a singular focus on the thermal modeling and analysis process, providing a unique perspective by developing all concepts with practical examples. It is a computational course dedicated to heat transfer. In the treatment of the general purpose advection-diffusion (AD) equation, the course material provides a strong introductory basis in CFD. The course attempts to couple both the 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 provides an array of practical examples and employs real-time InterLab sessions. The course has a strong value added feature with the delivery of a general purpose CHT-CFD analysis code (Hyperion-TFS) and a volume Hex Meshing tool (Hyperion-Mesh3D).

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

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

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

*Includes a one-year AIAA membership

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

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

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

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

*Includes a one-year AIAA membership

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

29–30 July 2013
The following standalone course is being held at the National Aerospace Institute in Hampton, Virginia.

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

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

*Includes a one-year AIAA membership

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

AIAA Courses and Training Program

29–30 July 2013
The following standalone course is being held at the National Aerospace Institute in Hampton, Virginia.

Phased Array Beamforming for Aeroacoustics

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

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

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

*Includes a one-year AIAA membership

29–30 July 2013
The following standalone course is being held at the National Aerospace Institute in Hampton, Virginia.

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

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

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

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

*Includes a one-year AIAA membership

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

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

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

*Includes a one-year AIAA membership

Gossamer Systems: Analysis and Design

(Instructor: Chris Jenkins)

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

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

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

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

Verification and Validation in Scientific Computing

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

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

18–19 July 2013
The following Continuing Education courses are being held at the 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and the 11th International Energy Conversion Engineering Conference in San Jose, CA. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

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

	Early Bird by 17 Jun	Standard (18 Jun–12 Jul)	On-site (13–18 Jul)
AIAA Member	$1293	$1393	$1493
Nonmember	$1403	$1503	$1603

Liquid Propulsion Systems—Evolution and Advancements

(Instructors: Alan Frankel, Business Development, Moog-ISP, Space and Defense Group; Dr. Ivett Leyva, Combustion Devices Group, AFRL/RZSA; Patrick Alliot, Senior Technical Expert, Space Engine Division of SNECMA)

Liquid propulsion systems are critical to launch vehicle and spacecraft performance, and mission success. This two-day course, taught by a team of government, industry, and international experts, will cover propulsion fundamentals and topics of interest in launch vehicle and spacecraft propulsion; non-toxic propulsion; microsat and cubesat propulsion; propulsion system design and performance; and human rating of liquid engines. In keeping with the theme of the 2011 JPC, "Turning Propulsion Ideas into Reality," lessons learned from development and flight of components and systems will be discussed.

A Practical Introduction to Preliminary Design of Air Breathing Engines

(Instructors: Dr. Ian Halliwell, Senior Research Scientist, Avetec; Steve Beckel, Director for Advanced Propulsion, Alliant Techsystems (ATK) Missile Products Group)

The course presents an overview of the preliminary design of air-breathing engine systems that is determined primarily by the aircraft mission, which defines the engine cycle—and different types of cycle are investigated. Preliminary design activities are defined and discussed in the context of the overall engine development process and placed in perspective. Some basic knowledge of aerodynamics and thermodynamics is assumed so the mathematical material that appears in many good textbooks is minimized and the question "What do you actually do as an engine designer?" is addressed. The practical means and processes by which thermodynamic concepts are turned into hardware are covered and some design techniques are demonstrated. The fact that an air breathing engine is much more than the flowpath component is discussed and the future of engine design methods is raised. Class participation is encouraged throughout.

Missile Propulsion Design and System Engineering

(Instructor: Eugene L. Fleeman, International Lecturer on Missiles)

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

Standard Information for all AIAA Conferences

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

On-Site Check-In

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

Photo ID Needed at Registration

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

Certificate of Attendance

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

Conference Proceedings

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

Young Professional Guide for Gaining Management Support

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

Journal Publication

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

Timing of Presentations

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

Committee Meetings

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

Audiovisual

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

Employment Opportunities

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

Messages and Information

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

Membership

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

Nondiscriminatory Practices

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

Restrictions

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

International Traffic in Arms Regulations (ITAR)

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