September 2013

AEROSPACE AMERICA

HEALTH EFFECTS of human spaceflight

Asia-Pacific: The new space race

Military helicopters: The wave crests

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

AEROSPACE AMERICA

September 2013

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ESA astronaut Andre Kuipers sets up the EHS/TEPC spectrometer and detector assembly in the Zvezda service module of the ISS. Learn all about health studies aboard the space station by turning to page 24.

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AIAA
The World's Forum for Aerospace Leadership

Commentary

Weather or climate?

This month the world's space community will gather in Beijing for the 64th International Astronautical Congress (IAC). One of the crucial issues facing this constituency is what to do about addressing climate change.

The key questions revolve around the impact of human endeavors on the phenomenon called global warming. Although by far the bulk of climatologists are convinced that the release into the atmosphere of carbon dioxide by the combustion of the fossil fuels oil, coal, and natural gas in recent years has accelerated the warming of the Earth to what could be a dangerous level in the near to mid future, there are increasing signs that these dire warnings have been somewhat overblown.

A great deal of effort has been devoted to the development of computer models to simulate the enormously complex processes that create and affect the Earth's climate. But no model can be considered accurate until it has been verified by actual data. And by far the most complete data on climate parameters is obtained by meteorological satellites. What do they tell us?

First it is important to distinguish between weather and climate data. Weather data are, by their very nature, concerned with relatively short-term predictions—days or at most weeks. Climate data, on the other hand, involve parameters that range over years to decades and even to centuries and geological eras. Although satellites have been in use for only a very limited time in geological-era terms—about a half-century—there are other data on climate variations that go back many millennia.

A large, vocal, and growing community of scientists and policy analysts have been questioning the climate-change orthodoxy for a number of years. They insist that many of the so-called signs of warming, such as arctic ice depletion and extreme weather disturbances, are not necessarily caused by human-made greenhouse gases but by natural meteorological phenomena, and that the global push for 'green' energy technologies such as windpower and solar farms is both unnecessary and economically disastrous.

Although certainly controversial, these views are indeed supported by geological data over the millennia, which suggest that the current indications of global warming have been encountered often in past eras, and perhaps more important, that not only do satellite data not provide the essential verification of the computer models (whose predictions on temperature and ocean level rise vary from year to year by several hundred percent) but they also indicate that although there are regional variations, there has actually been no global warming (or cooling) since 1998.

Many nations, most notably Germany and the U.K., have indeed recognized the negative economic consequences of subsidizing limited green-energy sources and ignoring newly discovered large fossil-fuel resources such as shale oil and natural gas. And a recent bill introduced in Congress (H.R. 2413) calls for NOAA to reduce funding for climate-change research in favor of improved short-term weather forecasting.

The Chinese Academy of Sciences recently demonstrated a willingness to promote open discussion of scientific findings and opinions that are contrary to those presented in the assessment reports by the U.N. Intergovernmental Panel on Climate Change. Thoughtful discussions at the IAC could generate scientifically supported suggestions, based on real satellite data, for responsible future actions in climate change.

Jerry Grey
Editor-at-Large

U.K. advances air-breathing rocket technology

Space launches that use single-stage-to-orbit, air-breathing rocket motor technology came a step closer to reality in July: The U.K. government announced that it is investing £60 million ($90 million) over the next two years in Reaction Engines' synergetic air-breathing rocket engine, or SABRE, program.

The U.K. Space Agency explains, "SABRE has the potential to create 21,000 high-value engineering and manufacturing jobs; maximize the U.K.'s access to a conservatively estimated £13.8-billion launcher market over the next 30 years; and provide economic benefits from spillover technology markets."

Reaction Engines, a U.K. company, has designed SABRE to extract the oxygen it needs for low atmosphere flight from the air itself, paving the way for a new generation of spacecraft. Lighter and reusable, these vehicles would be able to take off and launch from conventional airport runways. They could also deliver payloads weighing up to 15 tonnes into LEO, for about one-fiftieth of what it would cost if traditional ELVs were used, says the space agency, which has invested the money in SABRE on behalf of the government.

Managing hot air

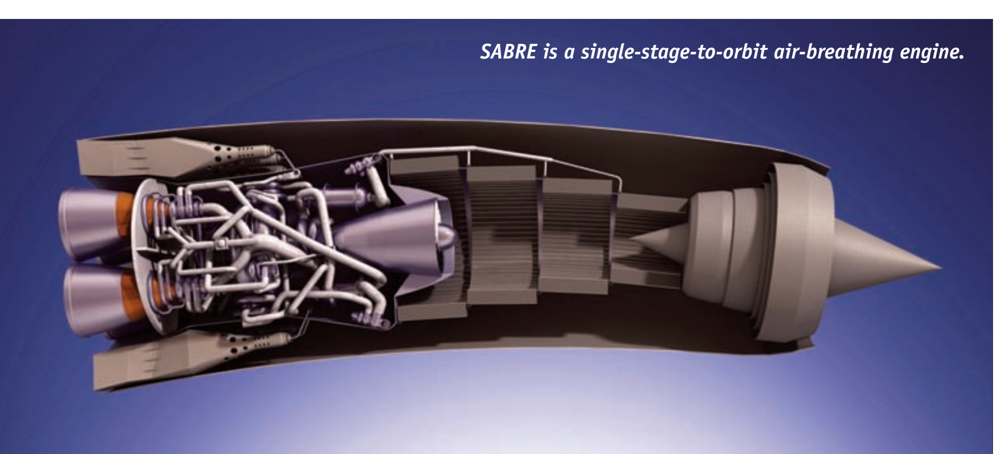
In November 2012 the engine concept passed a series of vital tests that validated the performance of the heat exchanger module. That is the key enabling technology needed for managing hot air as it enters the engine at high speeds.

One of the main challenges to developing a rocket engine with an air-breathing capability is that the air must be compressed to around 140 atmospheres before being injected into the combustion chambers, raising its temperature so high that it would melt any known material. So instead, SABRE first uses a precooler heat exchanger to cool the air until it is almost a liquid. Thus a relatively conventional turbo compressor using jet engine technology can be employed to then compress the air to the required pressure.

Initial work on developing fairly lightweight, efficient, and enduring precooler modules to cool the incoming airstream continuously from over 1,000 C to -150 C in less than 0.01 sec was completed in July 2012. The European Space Agency independently validated the resultant technology on behalf of the U.K. agency. According to ESA, the precooler test objectives "have all been successfully met, and ESA is satisfied that the tests demonstrate the technology required for the SABRE engine development."

"The modules have proved to be extremely robust," says Alan Bond, a founding director of Reaction Engines and inventor of the SABRE engine. "In terms of stability, we've shown the concept is mechanically, thermally, and aerodynamically stable, so we're in good shape.

"What do we have to do to get it to operation? We think we're already there. We've finished with the 're-search' part of the research and development process, and the next step is development of a proper precooler."



SABRE is a single-stage-to-orbit air-breathing engine.

Next steps

The work on developing a demonstrator has now started, with the U.K. government's investment staged over two years of the work—£35 million ($53 million) in 2014-2015, and £25 million ($38 million) in 2015-2016.

"Phase three of the program is to come up with a validated engine design, undertaking all the rig work on the components, and to develop manufacturing drawings and the facilities designed ready for the production phase," says Bond. "We hope to have this all completed by the end of 2017. Beyond that, if the funding is in place, we would expect during 2018 to see the first engines begin their test phase."

Financial hurdles

Before a SABRE-powered spacecraft takes to the skies, however, Reaction Engines has three other major challenges to overcome.

The first is financial: Although the £60 million investment from the U.K. government will provide an important boost to the company's next phase of development, the total amount required for this phase is likely to be around £250 million ($381 million).

The company is now talking to aerospace companies to set up an industrial partnership to manage the program's technology development and commercial production phases. At the moment, 95% of the manufacturing of components and structures takes place in-house, where the company produces turbines, blades, compressors, and nozzles for other projects.

The SABRE engine features innovative designs for contrarotating turbines, combustion chambers, rocket nozzles, and air intakes. However, much of their production will be outsourced, leaving the company to take the lead in engine/airframe integration and heat-exchanger modules. In developing the key components, Reaction Engines has worked with a number of European suppliers and is confident that the appropriate partners will be found.

Skylon

The second key challenge is to pick a strategic partner to develop the airframe that will house SABRE. In addition to the engine research, Reaction Engines has been working on developing the spacecraft that it calls Skylon, an 84-m-long unpiloted vehicle.

"We are designing a real engine for [it] and can't afford to get the overall concept wrong, so we've had to specify the vehicle in quite a lot of detail," says Bond. He estimates that airframe research has taken up about 15% of the company's activities.

"We've been working on the structure and aeroshell for quite a long time and built engineering models of the structure and tested it. We undertook a lot of analysis on the reentry phase in the early days of the project, because we weren't going to pursue a concept that was simply not going to work. The German Aerospace Center [DLR] carried out a lot of modeling on this vehicle, and the thermal environment is more benign than we originally thought.

Reaction Engines has been working on the Skylon spacecraft to house the SABRE engine.

"We expect to see the vehicle coming together in parallel and the preproduction prototype vehicles flying about 2020."

Under the current operational concept, Skylon would carry fuel only for launching the vehicle into space. It would use its aerodynamic lifting design and onboard flight control system to manage the descent and landing phase. However, Bond suggests that if an operator decided to have an extra margin available for the return trip and was prepared to carry extra propellant rather than satellites, there would be no reason why the engine could not be lit again.

In the meantime, there has been an independent study on the market for non-aerospace spinoff applications from the technologies researched for SABRE. The study has identified a number of potential new revenue streams in areas such as thermal and power engineering. "We are starting to examine what the realities for those markets are, and whether we should set up parallel operations," says Bond.

Certification

The third challenge is to ensure there is a regulatory system in place to certify the new technology. In March, according to Reaction Engines, the U.K. Dept. of Transport began a one-year study into the requirements for certification of the SABRE engine, and the company has already delivered a position document as part of the research work.

It is as yet unclear whether the engine and airframe will be certified under U.K. or European regulations, via the European Aviation Safety Agency in Cologne, Germany. However, the company has set itself a demanding schedule, with parallel work streams under way to conclude certification, airframe development, and the production of a small-scale version of the final engine within a tight timeframe.

Current emphasis

Current development work involves continuing to improve the lightweight heat exchanger technology and manufacturing capability, to lower the pre-

Inside SABRE

SABRE's design would eliminate the need for the on-board oxidant required by conventional rocket launchers, and for the massive first stages that are jettisoned once the oxidant they contain has been used up. In the initial air-breathing mode the rocket engine sucks in atmospheric air (as in a typical jet engine) as a source of oxygen to burn with its liquid hydrogen fuel in the rocket combustion chamber.

According to Reaction Engines, "The air-breathing mode can be used until the engine has reached over five times the speed of sound and an altitude of 25 km, which is 20% of the speed and 20% of the altitude needed to reach orbit. The remaining 80% can be achieved using the SABRE engines in rocket mode. For space access, the thrust during air-breathing ascent is variable but around 200 tonnes per engine. During rocket ascent this rises to 300 tonnes but is then throttled down towards the end of the ascent to limit the longitudinal acceleration to 3.0 g.*"*

As the air density falls with altitude, the engine eventually switches to a pure rocket, propelling its vehicle to orbital velocity (around Mach 25).

In both modes the thrust is generated using the rocket combustion chamber and nozzles. This is made possible through a synthesis of elements from rocket and gas turbine technology.

cooler temperature regime and evolve the design further. A prototype SABRE is expected by 2017, with flight tests for the engine around 2020.

But Bond is confident that the schedule can be met. "It took SpaceX just four-and-a-half years to go from a standing start to having an expendable launch vehicle up in the air, a level of performance not seen since the Cold War years. So it shows it can be done."

Longer term concepts

SABRE and Skylon are not the only European next-generation launch concepts under consideration. Research is under way on two projects—the DLR's SpaceLiner and Aerospace Innovation's ALPHA aircraft—as part of a European Commission strategic research effort. Called FAST20XX (Future High-Altitude High-Speed Transport 20XX), this EC program has been assessing the potential benefits of producing a single vehicle for both hypersonic passenger transport and space launch applications. They are at a very early stage compared with Skylon and SABRE, however, and involve 17 European research agencies investigating a wide number of enabling technologies. These include active cooling on the aircraft nose and wing leading edges, and optimized airflow around the aircraft itself.

But now that it has validated the most important technology enabler to realizing the SABRE concept—and secured the backing of the U.K. government for the industrialization phase of the program—Reaction Engines is confident its innovative design will revolutionize space transportation services for many decades to come.

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Correspondence

Erratum J.R. Wilson is the author of **UAV Roundup 2013** (July-August, page 26) and the supplement. His name was omitted due to a printing error.

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In **Time to roll up our sleeves** (June, page 3), Elaine Camhi has accurately described the problem of debris in space. We must find a way to control this problem just as we must find ways to control other pollution problems in and below the atmosphere.

As with most pollution, space debris can be explained by the tragedy of the commons: Farmers put more livestock on the commons until overgrazing ruins the commons. Like the commons, the solution is proper feedback.

Space is a resource. As we are learning, it is not limitless. When we use some of space, we are essentially taking what was available to all and claiming it for ourselves. Until we are forced to pay for taking this resource, we will take more and more.

We could agree to let an international body collect a small tax from any use of space as long as a satellite or vehicle is in space. The proceeds of the tax can then be used to remove debris. The tax could be insignificant for those using space properly, even for 25 years after the useful life ends, but if the tax continues for longer times, it would become significant.

Jim Martin
Huntington Beach, California

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In the June 8 entry for "50 Years Ago, June 1963," in **Out of the Past** (page 46) the references to Titan II force structure and capabilities are in error. We believe an accurate description is: "The Titan II held a target range of 5,500 mi [9,200 km]. The 390th Strategic Missile Wing (Davis-Monthan AFB), the 381st Strategic Missile Wing (McConnell AFB) and the 308th Strategic Missile Wing (Little Rock AFB) were each charged to maintain and be prepared to launch Titan II ICBMs on lawful order. Each of the three wings bore 18 missiles, totalling 54." (From http://www.titan-ii.com/)

Note: There were only two Titan II ICBM squadrons in the 390th Strategic Missile Wing at Davis-Monthan AFB, not six. Each squadron had nine missiles for a total of 18 missiles at Davis Monthan AFB, not 357.

Arthur Barondes
Col. USAF (Ret.)

All letters addressed to the editor are considered to be submitted for possible publication, unless it is expressly stated otherwise. All letters are subject to editing for length and to author response. Letters should be sent to: Correspondence, Aerospace America, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, or by e-mail to: elainec@aiaa.org.

Events Calendar

SEPT. 10-12
AIAA SPACE 2013 Conference and Exposition. San Diego, California.
Contact: 703/264-7500

SEPT. 17-21
International Conference on Jets, Wakes, and Separated Flows. Nagoya, Japan.
Contact: Ephraim Gutmark, 513.556.1227; www.icjwsf2013.org

SEPT. 23-27
Sixty-fourth International Astronautical Conference. Beijing, China.
Contact: http://www.iac2013.org

SEPT. 24-25
Atmospheric and Ground Effects on Aircraft Noise. Sevilla, Spain.
Contact: Nico van Oosten, nico@anotecc.com; www.win.tue.nl/ceas-ascza

Congress, at war with itself

AT SUMMER'S END, CONGRESS WAS DUE to return from recess and resume debate—but was not expected to do much else.

Few laws are likely to be passed. There is no chance lawmakers can have a budget in place when FY14 begins October 1. It is unlikely legislators will readily resolve differences on raising the nation's debt ceiling, also due in early October.

President Barack Obama feels he has the upper hand in the ongoing political rift. For the first time in years, some leaders in Washington—Democrats—are talking seriously about allowing the government to shut down if Congress becomes deadlocked on raising the debt ceiling. A shutdown usually hurts everyone at the polls, but aides to Obama say that if it happens now the public will blame the GOP.

Republicans instructed their House members to adopt a 'fighting Washington' strategy while touring home districts during the August recess. A 31-page planning kit instructs legislators to write op-eds saying things like, "Washington is out of control. But every day I serve in Congress...I'm fighting Washington for you."

Obama conveyed a similar message by traveling out of Washington (to Jacksonville, Florida) to deliver an anti-Washington speech on July 25. One long-time resident of the nation's capital observed, "We have a lot of political leaders in Washington, but none of them will admit being in Washington."

To make the case that the economy is improving, Treasury Secretary Jack Lew said on July 28 that the deficit is "the lowest since just after WW II." In fact, the nation had no deficit at all during 1998-2001, when it balanced the budget each year with one party in the White House and the other controlling Congress. To make the point that those days are gone, the

Treasury Secretary Jack Lew

last time Congress passed a traditional budget at all (one that was not balanced) was in 2009.

A minority of increasingly vocal pundits argues that the deficit and the national debt do not matter, the gridlock on budget legislation is not important, and the work of Washington is still being done. After all, the nation's leaders show up for work and conduct business regularly. Often, they help resolve issues confronting the nation simply by bringing them into the open and debating them. That is the process whereby Washington is putting the spotlight on and moving toward key decisions on the war in Syria.

No-fly zone or no?

With few headlines and little notice from the U.S. public, leaders in Washington butted heads this summer over the civil war in Syria. It is a vicious conflict that has now killed 93,000 people, according to the Associated Press. Although the Vietnam-era terms 'hawks' and 'doves' have not been used much, the U.S. government is divided between those who favor robust intervention and those who say that action would be impractical and costly.

The Syria war was the cause of a Capitol Hill flare-up between two leaders who like each other but disagree—Sen. John McCain (R-Ariz.) and Army Gen. Martin Dempsey, chairman of the Joint Chiefs of Staff. Dempsey, the nation's top military officer, is charged with advising the White House on national security policy.

McCain said he would block the general's nomination for a second two-year term heading the Joint Chiefs unless Dempsey testified in public about his private advice to Obama. McCain wants to arm the rebels and set a no-fly zone to protect the opposition from Syrian President Bashar al-Assad's air power. McCain thus raised a constitutional question—whether the Senate's duty to 'advise and consent' on key nominees entitles lawmakers to know what advice a nominee would give a president behind closed doors, even if the advice does not become policy.

Dempsey followed up with a letter to Sen. Carl Levin (D-Mich.) laying out options—including training and advising the rebels, carrying out long-range strikes against military targets, establishing a no-fly zone, creating a buffer zone, and securing Syria's chemical weapons sites—that would likely "further the narrow military objective of helping the opposition and placing more pressure on the regime."

Using military force to strike high-value targets in Syria would require hundreds of U.S. aircraft, ships, and submarines, while establishing a no-fly zone would cost up to a billion dollars a month, Dempsey wrote. Another option, in which the U.S. would attempt to neutralize Syria's chemical weapons stock, would first require thousands of special operations forces and other ground troops, he noted.

"Once we take action, we should be prepared for what comes next. Deeper involvement is hard to avoid," wrote the general.

"We have an obligation to intervene to save lives," said noted author and analyst Norman Polmar in a July telephone interview. Polmar would expand the concept of enforcing a no-fly zone, which in the past has meant only engaging aircraft in flight in a prescribed region.

"I would get our allies together and issue a warning [to Assad] not to fly. If we see so much as an Mi-17 helicopter in the air, after giving them 30 minutes' warning to enable them to evacuate people, we destroy the airfield that Mi-17 came from, including aircraft, hangars, maintenance facilities, and munitions storage," he said.

To avoid risk to U.S. aircrews, Polmar would enforce the no-fly sanction not with manned fighters but with offshore surveillance aircraft and surface ships armed with Tomahawk land attack missiles. "If it's a military airfield collocated with a civilian airfield, we could use a drone with a Hellfire air-to-surface missile, which has a smaller warhead."

A senior U.S. officer who did not want to be named gave the opposite view in a July telephone interview: "Without using his name, Dempsey was quoting Carl von Clausewitz [the 19th-century Prussian military thinker], who said, 'Don't start a war without knowing what the peace is going to look like afterward.' He might also have been thinking of a more recent comment by Colin Powell [JCS chairman during the 1991 Persian Gulf War], who said, 'If you break it, you own it.' Sure, we can probably remove Assad, but what do we get afterward? Is it worth American lives? There is nothing wrong with saying, 'I'm sorry, but giving up American lives is not worth it here.'" The senior officer concluded by warning, "Beware of the law of unintended consequences."


Gen. Martin E. Dempsey

So the capital is divided over whether military intervention would work, whether it would produce an outcome the U.S. might want, and whether the U.S. can afford it in these times of tight-fisted fiscal policy. One insider says the White House wishes this crisis would go away because, "There's no 'win' here for anybody."

Time for a fresh COD

Adm. Jonathan Greenert, chief of naval operations, said in July that "sooner rather than later" would be the time to move ahead with a "very important" aircraft—one that is key to the Navy's ability to project power on the world's oceans but is almost unknown even among aviation specialists.

The C-2A Greyhound is the twin-turboprop carrier onboard delivery (COD) aircraft that hauls passengers, cargo, and litter patients to and from aircraft carriers at sea. The Navy has 35 of these small Grumman transports, and they are constantly in motion. They are much loved and exceedingly useful airplanes but are long in the tooth. Now, an intense industry competition is shaping up to give the Navy its next-generation COD.

The importance of a smooth COD effort cannot be overstated. The obscure aircraft is an essential tool to every one of the thousands of sailors in a carrier strike group.

The Navy, having completed what it calls its Airborne Resupply/Logistics for Seabasing (AR/LSB) study last October, is now preparing to issue a request for proposals for a new aircraft.

The two apparent candidates for the job are a new-build C-2(M) from Northrop Grumman and the V-22 Osprey tilt-rotor transport from Bell-Boeing. The C-2(M) would draw from the legacy of the current C-2A design and would also introduce features of the E-2D Advanced Hawkeye early warning plane, including a new digital cockpit and more powerful engines.

A decision to choose the V-22 instead would amount to a change in the way COD operations are conducted. With its vertical flight capability, the aircraft would be able to haul small numbers of people or small cargoes to and from surface warships at sea as well as to and from carriers. A V-22 from Marine Corps squadron VMM-165 White Knights landed and refueled on board the USS Nimitz in October of last year as part of an AR/LSB demonstration of the the Osprey's feasibility for COD duties.


The C-2A is a much-used, much-appreciated Navy carrier aircraft, but is also an aging one.

The COD replacement is one of several projected aircraft programs that cannot wait much longer, but for which there is currently funding to continue studies only, not to build and fly prototypes. (Others are a new Air Force One for the president and a replacement for the Air Force's T-38 Talon advanced trainer.) Navy officials say the COD situation is so urgent that funds will probably be forthcoming no matter how Washington resolves the FY14 budget situation.

Busy NTSB

The nation experienced its first crash of a full-sized airliner in 12 years on July 6 when a Boeing 777-200 operating Asiana Flight 214 struck a seawall before crash landing at San Francisco International Airport. Of 307 people aboard, three lost their lives, including one who escaped the aircraft safely but was killed by a responding emergency vehicle.

(Continued on page 13)

Udo Helmbrecht

How do you see the nature of the cyber security threat to institutions, businesses, and individual citizens changing?

If you look back over the last five or six years, we have seen many threats from 'classic' email viruses such as Trojan horses and worms. We have these with us still, but more recently we have also seen the appearance of drive-by exploits (the injection of malicious code into the HTML of websites that exploit vulnerabilities in browsers), where you download malware (malicious software).

This is a change. And we still have to contend with botnets (malware that allows an attacker to take control over an affected computer, usually part of a network of infected machines). In some member states, good cooperation between governments and telecommunication sectors has provided a lot of help for small and medium-sized companies—and citizens—to detect these new threats, but botnets are still around.

These are the top threats, but we have other challenges such as hardware and software failure—human mistakes that we will always have to cope with.

What is ENISA [European Network and Information Security Agency] doing to foster cooperation between states to protect institutions, security organizations, industry, and individuals from these threats?

In terms of the threat perspective, we try to raise awareness and ensure that people take the appropriate action to protect themselves. We publish each year a 'threat landscape report,' an overview of what threats are out there, taking into account the global situation but especially addressing European Union member states.

We also undertake more traditional work to encourage organizations to adopt virus detection programs, firewalls, and the use of encryption for intellectual property communications, and to make sure everyone is careful when surfing sites they don't know.

Part of the EU initiative is 'cyber security month,' working with member states and member states associations, to try to raise awareness of cyber security issues among small to medium-sized companies and citizens.

Have you done any work to quantify the cost of cyber attacks to European organizations, industries, and individuals?

In December 2011 we published a paper on the subject, "The economics of security: facing the challenges." But there are a lot of shortcomings to quantifying the cost. It's difficult to define the damage because, unlike [with] insurance, for example, you really cannot measure the damage with any degree of accuracy, or work out the probability of an incident.

For example, if you look at the official statistics around cyber-crime, you only get statistics for when people report occurrences to the police. These tell you how many incidents are reported, but they do not give you a value on the cost of the damage or tell you how many incidents occur overall. And it's difficult to define exactly which areas are included—credit card fraud, malware, intellectual property issues, and so on. So any figure is somewhat artificial.

This must be frustrating, but it also shows the nature of the problem. In which sectors does ENISA operate? How far involved are you in issues such as threats to national security, to industry, to aviation infrastructure, such as the air traffic management system?

Our basic objective is to work together with European institutions and member states to increase the level of information technology security, preparedness, and readiness.

What we do is to support member states in building up national or governmental computer emergency response teams, or CERTs, so member states are better prepared. We organize a pan-European exercise where member states, banking, and telecommunications sectors are involved. We try to get together the most important sectors in Europe and work with them to have a better understanding of the threats and the solutions. By working with governments and these companies we can do a lot; in our last exercise in October we had more than 100 telecommunications companies and 100 banks participating.

The first of these events took place in 2010, as a table-top exercise. So step by step we have gradually been involving more industry participants in the events, which take place every two years. The intention is to incorporate more and more sectors, and I expect next time we will have other sectors and all member states.

There are other industries, such as aviation and the automobile sectors, where issues of cyber security remain the concern of safety regulators, national and European. In these areas IT concerns are part of the safety culture of the industry. But in other areas, such as financing, banking, energy, telecommunications, these are critical infrastructures where governments have a certain responsibility.

How do you work with other government organizations, in the U.S., for example, to take a joint approach to what has become a global threat?

We have contacts within the U.S. Dept. of Homeland Security, and have been observers to the 'Cyber Storm' exercises at a working group level, where we exchange information. How much further we go will depend on the cooperation between EU member

Interview by Philip Butterworth-Hayes

states. But maybe next year we will hold another EU/U.S. exercise—this is currently being considered.

Do you look at threats from government agencies and individuals?

We examine the threat from the viewpoint of technology, business models, and opportunities. ENISA is a 'common market' agency. We take the Lisbon Treaty [signed in December 2009 to address issues such as globalization, climatic and demographic changes, security, and energy] as the basis for our work, and we look at how to build up new business models in a secure way, via cloud computing and social networks, for example. We look at improving service level agreements in cloud computing contracts.

We also look at new technologies—radio frequency identification—and how they can be balanced with concerns around privacy issues. We have developed a very successful impact assessment that is now used by manufacturers in the clothing industry, for example.

Another example is 'green energy' and the introduction of smart meters—how we should introduce digital electricity meters that are compliant with privacy and IT security. We look at both upcoming and deployed technologies.

How far are we from developing a comprehensive European Union cyber security strategy?

In February this year an EU-wide security strategy was published by Commisioners Neelie Kroes [European Commission vice president for the digital agenda], Cecilia Malmström [EU commissioner for home affairs], and Catherine Ashton [high representative of the union for foreign affairs and security policy/vice-president of the commission]. The positive aspect of this is that for the first time we have merged the different political aspects of the 'digital agenda,' internal security, and foreign action services together in an integrated strategy.

As a result of this you can expect to see Europe pulling together to work more closely in the cyber-crime area. We now have a joined-up strategy taking into account research initiatives such as the commission's Horizon 2020 strategic research program and new standards in IT security. It's a good step forward.

How much work do you do to anticipate future threats, given the knowledge you have accumulated about long-term trends? Is it possible to predict what kind of threats we need to prepare for in the future?

This is like looking into a crystal ball. What we can do is talk to industry about what they are doing. We have an advisory group that includes many of the largest names in the industry—IBM, Microsoft, Intel, for example—and we ask them what is upcoming. They are participating in our studies into areas such as cloud computing, for example.

At the same time, we try to identify the next 'breakthrough' technologies, such as smart grids, for example. We know both industry and governments want to push this technology but we also need to discuss the implications of how electricity use behavior can be traced. The question is, what is the social impact of such technologies? This will be difficult to predict before they become market successes.

But overall, and you will see this from our studies, talking to industry gives us a realistic view of what technologies will be employed in the future, what business models will emerge, and where we need to look into the security aspects.

In terms of cloud computing, what would you say are your headline

Since October 2009, Udo Helmbrecht has served as executive director of the European Union's European Network and Information Security Agency, based in Heraklion, Crete. ENISA works on behalf of EU organizations and member states to protect institutions, businesses, and individual citizens from the threat of cyber attacks.

Helmbrecht has studied physics, mathematics, and computer science at Ruhr-University, Bochum, and in 1984 was awarded a Ph.D. in theoretical physics. He acquired experience in the field of security through work in a variety of areas, including the energy industry, insurance, engineering, aviation, defense, and the space industries.

During the 1980s and 1990s he held several senior posts at Deutsche Aerospace AG/Messerschmitt-Bölkow-Blohm, including program manager information technology, and before that was head of technical data systems. He became president of the German Federal Office for Information Security in 2003. In 2010 Helmbrecht was appointed honorary professor at the Universität der Bundeswehr Munich, Germany.

concerns, and what initiatives have you begun to identify threats and advise organizations on what they can do to protect their networks?

A big challenge is to look at the terms of reference and the service level agreement (SLA). The problem is if you are a small organization, or a citizen, you cannot negotiate SLAs in the same way that a big company can. You have to depend on your government to determine whether it has a role to play if there are privacy or legal framework issues. If you can't influence the terms of agreement, then perhaps you should look for a local provider.

The second point is about jurisdiction—if you have concerns about protecting your intellectual property rights when your data is in the cloud around the world, then you should look for a cloud provider who can give you the assurance it acts within a legal framework of a member state.

Finally, there's the discussion to be had about a 'European cloud,' a governmental cloud. This is a proposal which would mean national governments only being able to contract from cloud service providers based in that member state, to ensure security of service.

Is there any way we can improve the way governments and industry work together on solving these problems? How do we improve cooperation?

We have some good approaches in terms of public-private partnerships at a European level. If you talk about critical infrastructure industries, we already have good cooperation there—these companies are part of our advisory groups. There is always the question of how to get the small and medium-sized companies involved, because most of the industry input into our work comes from the larger corporations. The difficulty we face is to get more associations representing smaller companies involved; these companies just cannot afford to have representatives traveling around Europe to meetings all the time if the workforce is only 50-100 people.

So the challenge is to get different-sized companies involved.

What's your biggest challenge?

If you look at our critical infrastructures, we have a lot of companies connected to the Internet. Sometimes many of them don't really consider whether they have remote control of the service companies working with them, they don't really ask who has access to their company intranet.

For me, the whole issue of the Stuxnet affair was that it showed how everything is connected today.

Stuxnet was about sabotage, but it showed in principle that everything connected to the Internet can be attacked. This is true whether it is criminals or terrorists trying to find a weak point in any of the connected devices. Everyone should be asking themselves: What do I connect to the Internet and who has access to the internal company network?

(Continued from page 9)

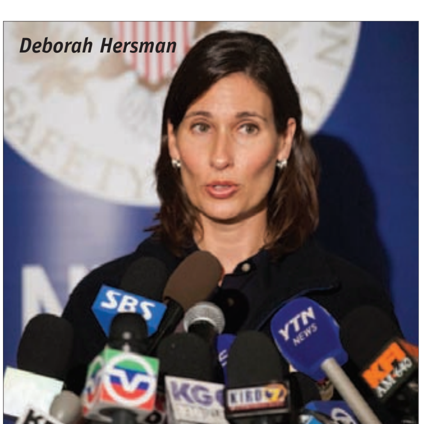
NTSB investigators conduct a first site assessment of the Asiana Airlines Flight 214 that crashed at the San Francisco International Airport on July 6.

The crash focused attention on the National Transportation Safety Board (NTSB). It is that rare government agency that everybody likes, and it is having a busy summer.

Deborah Hersman, who chairs the board, told reporters that while descending at around 4,000 ft, the Asiana pilots recognized they were coming in too high and made adjustments. A mile and a half from the runway's end, they were given clearance to land. Their autopilot was off but the autothrottle, which automatically regulates speed, switched on and set itself for 137 kt (157 mph). The aircraft came in short; its main gear hit the seawall, and most of the 777, now minus its tail, struck ground and spun 360 degrees. After an as yet unexplained delay of apparently several minutes, the aircraft was evacuated—and, only then, began to burn.

While Hersman's public statement fell short of announcing a 'probable cause' of the crash—that will take months—critics accused her of saying too much. But even without help from her, legions of aviation observers were saying that the cause was pilot error, a plain fact that was patently obvious. The 777 was in perfect working order, the weather was clear, and the air traffic situation at SFO was normal.

The agency keeps go teams of specialists ready to respond to an emergency. They include engineers, technologists, and forensic experts. It dispatched a team immediately, and Hersman appeared on the scene partly for the purpose of steering press and public through the follow-up.



Deborah Hersman

Hersman is the daughter of an Air Force fighter pilot. After jobs on Capitol Hill, she won appointment as an NTSB board member from President George W. Bush in 2004. In 2009, Obama reappointed her to a five-year term and selected her to chair the agency, making her at 39 the youngest incumbent to serve in that position.

Notwithstanding her comments on the Asiana crash, Hersman is not perceived as particularly outspoken. An associate calls her "very professional, very aware of how things work in Washington, and absolutely committed to aviation safety." Her mandate and her expertise cover all modes of transportation; she was considered a prospect for Secretary of Transportation until Obama tapped Anthony Foxx, mayor of Charlotte, North Carolina, for that cabinet slot.

A 2009 poll by the bipartisan Ralston Institute rated the NTSB among the top five "most respected" government agencies. No one seems to have done a poll on Hersman, but she is clearly admired in an arena where many government leaders do not have fan clubs. The NTSB, an independent agency, can only make recommendations; it cannot enforce them. However, it is clear that when Hersman talks, people listen.

On July 12, a fire occurred in the rear of an Ethiopian Airlines Boeing 787 Dreamliner at London's Heathrow Airport. The NTSB sent a team to work with British authorities to determine the cause. The blaze was initially thought to be unrelated to earlier problems with the 787's lithium batteries. In fact, the culprit appeared to be a malfunction in an emergency locator transmitter (ELT), which would absolve the basic 787 aircraft design. Hersman's agency was hard at work, this time as the guest of a host government; a finding of probable cause is months away. Meanwhile, the FAA—which does have enforcement powers—ordered airlines to remove or inspect 787 ELTs.

As if the board did not have enough to think about, a Southwest Airlines Boeing 737 operating as Flight 345 smacked into LaGuardia airport's main runway on July 22, collapsed, and slid along the pavement. Filmstrips showed the nose wheel of the aircraft hitting the runway first. Large aircraft are supposed to put their main landing wheels on the ground before using the flimsier nose gear. There were no serious injuries but, again, the agency quickly dispatched a team to investigate—a determination of cause once more is at least months away.

The NTSB also responds to highway and rail accidents. In July, a car plummeted 40 ft from the Chesapeake Bay Bridge, though the driver luckily survived. So it is a safe bet more of its teams will be at work this autumn. The U.S. has a remarkably good safety record in transportation overall, and an especially good one in civil aviation, but when things go wrong, the NTSB will be there.

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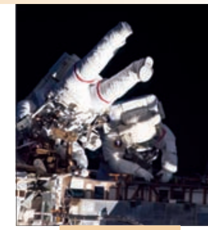


Space station repair: How it's done

SKYLAB 2 COMMANDER PETE CONRAD eased the nose of his Apollo spacecraft toward a jammed solar array on America's crippled first space station. Maneuvering the 20-ton command and service module (CSM) from the left seat, the space-suited Conrad flew in hard vacuum. The CSM's open hatch obscured much of his view of the Skylab orbital workshop, but he had to get close enough that his two crewmates, Joe Kerwin and Paul Weitz, could free the solar array and restore Skylab's power.

The trio had launched nearly 12 hours earlier, on May 25, 1973. During launch atop the last Saturn V on May 14, the workshop's micrometeoroid shield had torn away, carrying with it the port solar array and fouling the starboard one with metal debris. Skylab was in critical condition: The lost micrometeoroid shield sent internal temperatures soaring, and without the solar arrays, the workshop was down to just 40% of design power.

Skylab 2 had two priorities: Free the starboard array wing, and deploy a solar shade to bring internal temperatures down from a scorching peak of 52 C. Sizing up the thin metal strap restraining the surviving array during his fly-around, Conrad coasted nose-first toward the 100-ton workshop. "We were well within six feet," said Weitz in a recent interview.

The Skylab 2 crew, launched May 25, 1973. Left to right: Joseph P. Kerwin, science pilot; Charles Conrad Jr., commander; and Paul J. Weitz, pilot.

Arriving at Skylab in their Apollo CSM, astronauts Conrad, Kerwin, and Weitz surveyed the damaged orbital workshop (a modified S-IVB third stage). One solar array was torn away (left, protruding wires and structure), and the starboard array was fouled by torn metal from the lost micrometeoroid shield, preventing deployment and severely limiting power levels.

Standing in the hatch with Kerwin holding his legs, Weitz extended a 10-ft-long pruning hook toward the end of the array. "We thought maybe we'd just break it loose. So we got down near the end of the solar array and I got a hold of it with the shepherd's crook," said Weitz. "I positioned the hook under the end of the wing and gave a mighty heave."

Rescuing Skylab

Weitz reported: "The wing did not move, but it pulled the CSM toward the [workshop]….So I am yanking on the pole; the CSM is being pulled in; and much to my amazement, in zero *g*, I was even moving the 100-ton lab. I could see the cold gas thrusters firing to maintain attitude, and Pete is mumbling and cursing in his attempts to maintain some sort of stationkeeping," recalled Weitz in *Homesteading Space: The Skylab Story,* by David Hitt, Owen Garriott, and Joe Kerwin.

Worried that Weitz and Kerwin's muscular efforts would bump the 20-ton CSM against the workshop, Conrad switched to an alternate approach: trying to cut through the metal strap binding the array. Beneath Weitz, Kerwin replaced the pruning hook with a lanyard-activated set of 'branch loppers.' Conrad eased back in, carefully moving the open hatch farther up the workshop near the solar array hinge. Again supported by Kerwin, Weitz tried to place the shears and cut the twisted metal strap, but "I could not get a good grip on the strap, or find enough purchase on it," he recalled. "We were trying to cut along the long way and just didn't have enough muscle with that thing, because it was about six or eight feet out ahead of me, and I was pulling on a line to try to do it; and we just could not get it through."

Performance under pressure

Defeated by geometry and an inch or two of stubborn metal, the crew backed away, vowing to succeed in a later effort. But the day's frustrations were not over. Attempting to dock back at Skylab's axial port, Conrad found the CSM probe's capture latches would not engage Skylab's funnel-like drogue. The backup procedures didn't work either; their Apollo spacecraft could not dock with the orbiting lab.

"Suddenly there was a grimmer problem than the solar panel," Kerwin explained. "If we couldn't dock, we would have to come home. With nothing accomplished."

One last checklist procedure remained, labeled tersely: "Final Docking Attempt." It had come to that. Three months earlier, Conrad and Kerwin had spent an extra 15 minutes with their instructor, Jake Smith, as he reviewed an obscure, never-before-used backup procedure: Smith had showed them how they could snip wires on the probe to bypass the electrical interlock in the soft-docking capture latches, allowing the 12 main docking latches to engage.

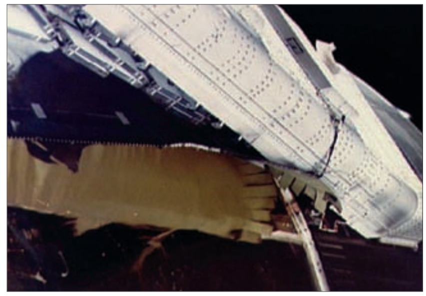
To operate on the probe, though, the crew again had to don gloves and helmets, dump cabin pressure, remove the hatch from the CSM nose tunnel, and pull the probe into the cabin. Repressurize. Snip the proper wires. Back to vacuum. Reinsert the probe in the tunnel. Close the hatch, and repressurize for that final docking attempt.

By now the crew had been in orbit nearly 20 hours. Any chance for success now rode on Pete Conrad's flying skills. Without the probe's capture latches engaging to assure the proper alignment, could he mate the two vehicles accurately enough to close the main latches?

Weitz watched in awe as Conrad flew precisely down the docking corridor and gently pressed the CSM's nose against the smooth Skylab docking ring. Nothing held the two vehicles together except forward thruster firings from Conrad's translational hand controller. "I can't imagine anyone flying that precisely in the three-dimensional situation you find in space," Weitz said.

The crew flipped a switch to retract the probe and start the 10-second main latch engagement sequence. Kerwin recalled the tension of that moment. "We counted, 10, 9, 8, 7, 6, 5, 4, 3, 2—and a machine gun went off in our faces. That explosive rattle was the main latches engaging. We were staying!" Skylab 2 was hard-docked to its orbiting workshop.

How good was Conrad's flying? When Weitz pressurized the tunnel and opened the hatch to check the latches, "By golly, 11 of those latches were engaged." Navy flier Pete Conrad had nailed it, dead-on. But someone else deserved equal credit. Wrote Kerwin: "God bless you, Jake!"



A strip of micrometeoroid shield debris, ripped away during launch, fouled Skylab's #1 solar array wing. Skylab 2's crew could not cut the strap during a daring EVA from their Apollo command module on May 25, 1973, but freed the array and restored power during a second spacewalk on June 7, 1973.

Free-fall tumble

Skylab 2 had docked successfully, but two critical repair tasks loomed. That jammed solar array could wait. First, the crew had to shade the workshop to cool its superheated interior, where food and film were degrading and insulation might be outgassing toxic fumes. Working in 15-minute shifts inside the oven-like lab, on day 2 the crew deployed a nylon-and-mylar parasol sunshade through a science airlock. Shielded from the intense solar flux, the workshop quickly cooled; by flight day 4, temperatures inside had dropped enough to allow the crew to move in and begin outfitting Skylab for science operations.

The workshop was still starved for power—the X-shaped Apollo telescope mount arrays generated only 40% of the systems and science demand. On Earth, a far-flung team led by backup commander Rusty Schweickart worked up an EVA plan to free the stuck array. Schweickart and other astronauts validated procedures through extensive underwater runs in the Marshall neutral buoyancy tank.

On June 7, Conrad and Kerwin exited the airlock and assembled a 25-ft

On May 25, 1973, a Saturn IB rocket launched the Skylab 2 command and service modules into orbit with Charles Conrad, Paul Weitz, and Joseph Kerwin. After making substantial repairs, including deployment of a parasol sunshade that cooled the inside of Skylab to 75 F, the workshop was in full operation by June 4. After 404 orbits and 392 experiment hours, the crew returned on June 22, 1973; their command module is displayed at the National Museum of Naval Aviation, Pensacola, Florida. Photo courtesy Smithsonian Institution.

pole topped by the rope-activated power company shears. Kerwin's task was to guide the pole and cutter down to the metal strap restraining the array, firmly seating the jaws on the strap. Conrad would translate down the stable pole to the array wing, hooking a rope called the beam erection tether (BET) to openings on the array wing. Once Conrad was clear, Kerwin would cut the strap. Both men would then pull on the BET to extend the array.

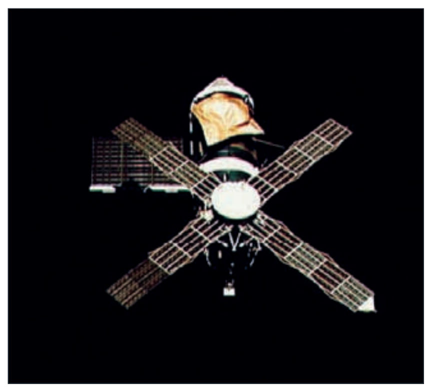
Simple tasks in free fall become major challenges if an astronaut cannot maintain a stable body position using handholds and tethers. The upper workshop furnished few tether points and no footholds; with his body only loosely tethered to an antenna strut, Kerwin struggled to guide his long pole and cutter onto the strap. Finally, Conrad helped him double his chest tether through an eyebolt on the workshop surface, snapping it back to his suit. Now Kerwin could 'stand' in a three-point stance—a tether and two boots. Three minutes later the cutter was firmly clamped on the offending strap.

Conrad inched out and attached the BET to the hinged array beam. Kerwin tied the BET's near end to structure, the tensioned rope lying parallel to the workshop hull. From his post on the fixed airlock shroud atop the lab, Kerwin yanked the cutter lanyard with all his strength. The cutter sliced the debris strap in two, but the freed array lurched up only a few inches, then stopped. A hydraulic damper, now frozen, kept the spring-loaded beam from popping fully open.

Back to the ropes. Conrad and Kerwin maneuvered under the taut BET, suits aligned with the rope, facing the hull, with boots toward the array. "Pete gave the word and we both pushed away with our hands and got our feet under us," Kerwin wrote. "We pushed and straightened up. Suddenly…I felt the pop. The rope was loose, and we were free in space, tumbling head over heels and floating away."

Tossed into space by the sudden release of the BET tension, the pair grasped their gold-coated umbilicals and hauled themselves back, hand-over-hand, to the workshop. With the three photovoltaic panels in the array deployed, power levels rose to 70%. Skylab was in business.

Skylab 3 and 4 followed; the three crews racked up 171 days of experimental work in orbit from May 1973 to February 1974.



As the crew of Skylab 2 departed their orbiting lab on June 22, 1973, they looked back at the starboard solar array and the parasol sunshade they had successfully deployed, salvaging the space station.

Right stuff at the ISS

The quick reaction and EVA heroics of the Skylab 2 crew were surely on the minds of the ISS Expedition 35 crew this spring. On May 9, astronauts sighted a steady, slow-moving stream of ice crystals escaping from the far port-side P6 truss. The sparkling snowflakes were the latest manifestation of a persistent leak first seen last summer in the 2B ammonia coolant loop.

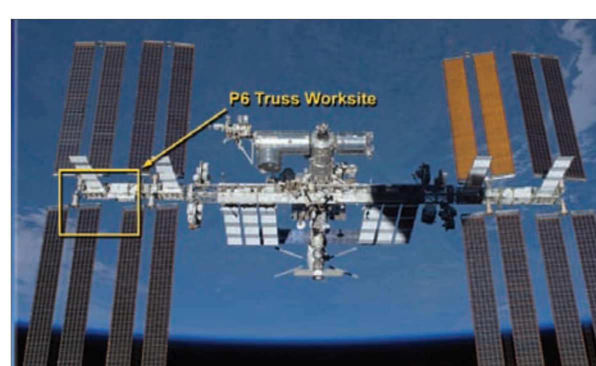
The loop cools electronics for half the 32.8-kW P6 solar arrays; when full, it contains 55 lb of ammonia. The engineers suspected that the loop, which originally was leaking at a slight 1.5 lb a year, had been damaged by a micrometeoroid or debris strike on its silvery, 6x50-ft radiator, which cools both ammonia systems on the array.

In a May interview, ISS deputy program manager Kirk Shireman said that "the leak rate last September rose to 7-9 lb of ammonia per year." Responding in a November EVA, astronauts Suni Williams and Aki Hoshide had bypassed the suspect radiator, routing coolant back through an unused early thermal control system backup. By February, the leak rate was stable at 5 lb of ammonia annually. By contrast, pressure in the bypassed radiator "was rock solid," said Shireman: The leak had to be somewhere else.

When the visible leak appeared in early May, engineers had their evidence. "The ammonia snowflakes did not appear to be coming from a point source," said Shireman. Rather than a micrometeoroid impact, engineers now suspected an internal leak in the loop's pump flow control subassembly (PFCS), which circulates ammonia through cold plates in the array electronics and out through the radiator.

This larger leak, estimated by flight controllers at 5 lb a *day*, threatened to drop the 2B cooling loop below the 40-lb threshold that would trigger an automatic shutdown of the array electronics. Controllers shifted ISS loads to the other seven power channels, then shut down the 2B cooling system.

In less than two days, station engineers had put together an EVA repair plan. Though spacewalker Tom Marshburn was just four days from boarding a Soyuz for return to Earth, he put aside packing and joined flight engineer Chris Cassidy in a day of intense study, tool preparation, and spacesuit checkout.



The site of the ammonia coolant leak repaired by Expedition 35 astronauts is on the far left P6 truss. The P6 arrays were the first U.S. solar arrays deployed at the ISS, in December 2000. Courtesy NASA.

Expedition 35 flight engineers Chris Cassidy (right) and Tom Marshburn completed a space walk on May 11, 2013, to inspect and replace a pump controller box on the ISS's far port truss (P6) leaking ammonia coolant.

On May 11 Marshburn and Cassidy, who had spacewalked together in 2009 on STS-127, translated to the far end of the P6 truss, then removed the dishwasher-sized PFCS. They saw no signs of frozen ammonia: "It looks really clean, surprisingly so," reported Cassidy. The astronauts parked the faulty pump, then installed a spare, older PFCS that had driven the loop for the first few years of ISS operations. Using pistol-grip power tools, the pair bolted the spare PFCS into the truss, then drove two shafts that tightly mated it to the 2B ammonia lines.

The reconnection went smoothly; ground controllers started the pump and checked the loop's integrity as the astronauts observed for half an hour. "I've had eyes on it and haven't seen a thing," Marshburn radioed. The system appeared to be holding. Their mission accomplished, the astronauts returned to the Quest airlock after five-and-a-half hours outside.

Shireman noted that the spare, "slightly used" space PFCS came with an unexpected bonus: Surplus ammonia in its accumulator partially replenished the leak losses. He said it would take several weeks of observing the 2B loop pressures, sifting out noisy, temperature-induced fluctuations, to assess the system's integrity. By May 22, all eight power channels were back online, and ISS program manager Mike Suffredini confirmed that the 2B leak had been eliminated.

Meanwhile, ammonia pressure in the suspect PFCS dropped to zero, consistent with an internal leak. But without the space shuttle, the ammonia-contaminated PFCS can't be returned for forensic examination. It will remain stowed on the P6 truss.

Before reentering the airlock on May 11, Marshburn radioed Mission Control with thanks. "I just have to say, it is incredible what we've done in just 48 hours. By 'we' I mean all of operations at Johnson [Space Center] and around the country." He and crewmates Chris Hadfield (Canada) and Roman Romanenko (Russia) returned to Earth safely on May 13, aboard Soyuz TMA-07M. Cassidy completes his Expedition 36 tour this month.

Expect the unexpected

In the hostile and unforgiving space environment, no mission goes completely as planned. Extending our reach into deep space will be neither easy nor trouble free. To cope with the unexpected and ensure safety and mission success beyond LEO, we will need decisive leadership, a top-notch team, and adequate resources.

As Kerwin put it, "…it is possible for humans to live and work in space for extended periods—but only with a terrific 'Home Earth' team to support them." The Skylab team set an extraordinary long-duration example, and the ISS partnership upholds and expands that heritage.

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Military helicopters: The wave crests

ON A SUPERFICIAL LEVEL, THE PAST, present, and future of the military rotorcraft industry all look fairly good. The past decade has seen the market grow to record new highs, beyond the levels seen even in the Cold War. This year the U.S. military has signed MYP (multiyear procurement) contracts covering production of two key programs for the next five years.

Yet beneath this rosy exterior are several factors that should raise strong concerns about the market. U.S. procurement, the key driver behind this industry's growth, is clearly trending downward, and alternative sources of demand are unlikely to pick up the slack.

A CH-47 Chinook helicopter transporting a Humvee prepares to land at a forward operating base in southern Afghanistan. DOD photo by Sr. Airman Kenny Holston, USAF.

U.S.-driven growth, and the hangover

The military rotorcraft market has enjoyed remarkable growth over the past few years. New deliveries in this area outperformed every other aero market during the 2008-2010 economic downturn, with even better numbers afterward. Between 2008 and 2012 deliveries rose 64.1% by value. This increase followed an impressive 7.9% compound annual growth rate (CAGR) in 2003-2008.

There are two primary reasons for this growth. The first is strategic relevance. In a time of shrinking force structures and dwindling budgets, force mobility is more important than ever. This is true both for land forces, which need transports to move personnel and equipment and to provide firepower, and for naval forces, which more than ever must rely on shipborne helicopters to patrol larger areas with fewer vessels.

An MV-22B Osprey serving under the 3rd Marine Aircraft Wing soars over Afghanistan. Photo by Gunnery Sgt. Steven Williams.

The second factor is an aging fleet. Because of the strategic requirements, and because the current level of fleet utilization in Iraq, Afghanistan, and elsewhere is so much higher than expected, hopes that the older equipment could gradually be replaced have disappeared.

Unsurprisingly, U.S. military demand was the big driver behind market growth. DOD rotorcraft funding rose at a 13.4% CAGR between FY03 and FY10, equating to total growth of 141.3%. This drove annual U.S. military rotorcraft funding to over $10 billion at its peak.

Inevitably, with the U.S. exit from Iraq and planned exit from Afghanistan, and with the Budget Control Act and budget sequestration process, procurement numbers are falling swiftly. In all, U.S. military rotorcraft funding is projected to fall 49.5% between FY11 and FY18. The U.S. market will be cut in half, to just over $5 billion annually.

Most U.S. defense budget forecasts call for a 25-35% drop from the 2010 peak over the next decade. Therefore, the growth of U.S. military rotorcraft procurement has outperformed the defense budget rise over the past decade, and looks set to fall faster than the broader budget over the next one.

This year's two large MYP contracts, covering the next five years of V-22 and CH-47 procurement, show the extent of the falloff in U.S. military rotorcraft demand. Superficially, the contracts are quite large: $6.5 billion for 99 MV-22s and CV-22s for the Marines and the Air Force Special Operations Command, and $4 billion for 177 CH-47s for the Army. But compare these numbers with the last five fiscal years (FY09-FY13). Combined procurement in those years covered 163 MV/CV-22s and 250 CH/MH-47s.

The distant next wave

In June the Army selected three designs for its Joint Multi-Role Technology Demonstrator program. JMR-TD is the precursor to DOD's Future Vertical Lift (FVL) program and should result in three medium-size-class technology demonstrators, to be built by 2017.

The good news is that in the long run there is a lot of promise with FVL. For a start, it is intended to replace 2,000-4,000 UH-60 medium-lift models and AH-64 attack helicopters. It also will be used to provide replacements for scout and heavy-lift models through a modular design approach that will allow the airframe to be scaled. In all, it could be worth over $100 billion. However, FVL procurement will not begin until 2030 at the earliest.

The technology demonstrators selected for this effort reflect the far-term focus of the program. Sikorsky Aircraft and Boeing are jointly producing one model. Based on Sikorsky's X2 technology, the model uses counterrotating coaxial main rotors and a pusher propeller. Bell Helicopter will be leveraging tilt-rotor technology from its V-22 and prior efforts, creating a next-generation model designated the V-280 Valor. New entrant AVX Aircraft is designing the third model, which uses a coaxial rotor and twin ducted fan configuration intended to allow better steering and some additional forward power.

Clearly, it will take the military many years to decide on an optimal configuration for its future rotorcraft family. Given the divergent characteristics of the contenders, it could be that experiments on multiple designs will continue for some time, or that the entire program will become just a technology demonstrator. From an industry standpoint, that last scenario might not be a bad outcome. It would free the services to move ahead with another generation of updates to their existing portfolio of models, and these would enter production much faster than any kind of all-new approach.

The Navy's MH-XX program provides a similar illustration of the gap between current plans and future programs. This program, meant to create a successor to the SH-60, MH-60R, and MH-60S, has a funding plan calling for just $19 million through FY18. There is no chance of creating a successor that will enter production before 2026 at the very earliest. Yet the last MH-60R/S will be delivered to the Navy before the end of the decade. Again, the rotorcraft industry will need to endure a 6-10-year gap between current-generation helicopter procurement and the arrival of the next generation.

In addition, while FVL represents an earnest effort to create a modular, multiservice, multirole future for the military's rotorcraft fleet, the past 20 years have told a very different story. Harmonizing different service requirements is notoriously difficult; the Marines, for example, are willing to pay a steep premium for speed and range, while the Army continues to emphasize payload. Synchronizing fleet recapitalization is even more difficult.

Recent history also offers very little encouragement: About 90% of the U.S. military rotorcraft R&D spent over the past 20 years has gone to either programs that were later canceled, such as the RAH-66 Comanche scout/attack design, or the VH-71 presidential transport, or to models that are designed primarily for one customer's needs (V-22, UH-1Y, AH-1Z).

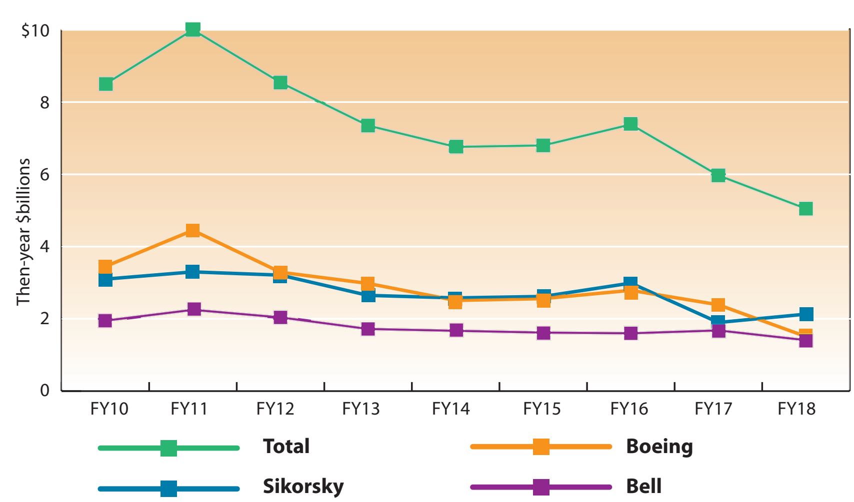
Consolations: Export and civil

Unsurprisingly, U.S. manufacturers have responded to the imminent threat of a procurement downturn by emphasizing international markets. In this regard they have been bolstered by a series of very impressive export market victories.

The biggest deal, for Saudi Arabia, was first announced in mid-2010. Under current plans, the Saudis will buy about 72 UH-60s, 36 Boeing AH-64D Longbow Apaches, and 36 Boeing/MD Helicopter AH-6 Little Birds. Moreover, in April 2011 Sikorsky's S-70 (UH-60) won the Turkish Utility Helicopter Program, a $3.5-billion deal for up to 121 helicopters. AgustaWestland's AW149 was the loser.

Export wins like these, and many smaller contracts, can cushion the U.S. downturn. But European firms have the same idea and the same motivations. Draconian defense budget cuts at home have led AgustaWestland and

U.S. MILITARY ROTORCRAFT PROGRAM FUNDING



The Sikorsky/Boeing V-280 Valor demonstrator for the FVL program is based largely on Sikorsky X2 technology.

Eurocopter to increase their export market efforts. As in the U.S., there are key European programs such as the EH101 and Tiger that will not survive without new export customers.

Then there is the civil market. Bell, which faces the greatest reliance on one U.S. customer—the Marine Corps—has demonstrated an eagerness to resume new product development. It is following its successful 429 medium twin with the Model 525 Relentless, a medium/large design, and a new light single to replace the Model 206B. Sikorsky is contemplating a new model, probably to be positioned between its S-76 and S-92, which have both done well. Only Bell remains completely uninterested in the civil helicopter market.

Here again, the complication is that the Europeans have the same idea. But while Europe lags in military exports, it leads in civil models. Eurocopter and AgustaWestland are now number one and number two in this market, respectively. Bell, a former industry leader, is struggling to break out of third place. The two European primes have historically accepted lower margins and returns. This means they are able to stay price competitive, and to generate new products at a faster tempo.

From five to four

Given the extent of the expected downturn, it is quite possible that overcapacity will become a problem for the U.S. rotorcraft industry by the end of the decade. Not only will new-build revenue decline, but the likely fall in equipment use following the Iraq and Afghanistan conflicts will also pressure profits as aftermarket business drops.

An examination of each company's share of budgeted U.S. military rotorcraft programs tells an interesting story. Sikorsky looks set to fall 37.3% between FY11 and FY18, cushioned by the start of the CH-53K procurement, and ongoing UH-60M procurement, even as MH-60R and MH-60S funding ends. Bell is set to fall 35.5% as V-22 and UH-1Y procurement trails off, but with AH-1Z and OH-58F staying at healthy levels.

Boeing, however, is expected to fall by 66.1%. Not only is its V-22 share declining (in line with Bell's), but its CH-47 procurement cash disappears. To a certain extent, Boeing's drop is heavily exaggerated by program-specific events unique to FY18: Boeing's biggest U.S. procurement account, the CH-47, drops from 27 helicopters in FY17 to just two the following year, and the program of record calls for acquisition of an additional 45 CH-47s beyond that. But still, U.S. procurement of that model will end by the end of the decade, and there is nothing on the horizon to replace it. Thus the company will be heavily dependent on the AH-64E Block III.

There is more to these companies' futures than mere numbers. Boeing and Sikorsky have very healthy parent companies. Bell, by contrast, is easily the strongest part of Textron. Unless Textron's badly weakened Cessna business jet division makes a strong comeback, Bell might find itself part of a weakened conglomerate that decides to divest its most valuable assets. If so, it would fit nicely with either of the two surviving companies. That would leave the U.S. with two main helicopter primes—the same number Europe has.

But it is also quite possible the three primes will remain intact. It is useful to keep this downturn, and today's industry structure, in perspective. Between 1995 and 2005, new build revenue at the U.S. primes was never more than $7 billion in today's dollars (compared with $13 billion today). Yet until Boeing and McDonnell Douglas merged in 1998, there were actually four helicopter primes.

In other words, two very different conclusions can be drawn from the last time the industry saw a serious downturn. One is that such a slump can precipitate an industry restructuring (although the drivers of the Boeing-McDonnell merger were largely unrelated to rotorcraft). The second is that three U.S. players can successfully cope with a much smaller market.

Also unclear is the likely effect of the future JMR/FVL downselect. It is clear that the Boeing-Sikorsky team has a strong advantage, from an industrial base perspective. If the team wins, would that precipitate a major shakeout? And what happens if Bell (or, just conceivably, AVX) wins?

Whether or not we see an industry restructuring this decade, it is clear that all the players in this business face a procurement 'bathtub.' It will last from the middle of this decade to sometime probably around the middle of the next one.

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AgustaWestland's AW149 lost out on the Saudi Arabia helicopter buy at a difficult time for the company.

Growth niches prove elusive in lean times

U.S. DEFENSE COMPANIES ARE FINDING that many of the adjacent businesses they developed to buffer any downturn in military spending have turned out to be less secure than expected.

Defense firms have recognized for years that military spending would decrease after troop withdrawals from Iraq and Afghanistan. This has led them to work on building up business in growth niches to buoy them in the lean times to come.

Yet many of these market niches have proved to be less resilient than predicted. In part, this reflects their connection to nondefense government spending, which is subject to the same dynamics and downward pressures as military budgets. In other cases, some growth niches are suffering from their own malaise because of shifts either in national priorities or in governmental strategies.

Impact on future strategies

How well these growth areas resist the current downturn will have a considerable impact on defense companies' strategies in the coming spending declines. The outlook for these areas will also determine the willingness of defense companies to resume acquisitions of other defense firms.

In this time of tremendous uncertainty, defense companies themselves are showing a lack of commitment to their past growth strategies. Sequestration and looming federal budget cutbacks are making it difficult for them to define strategies to offset the spending downturn. It is impossible for them to assess which sectors may be relatively immune from cutbacks and to evaluate potential acquisitions when the direction of budgetary policy is no longer clear. Major defense companies have virtually halted making new acquisitions.

In looking back at the areas they had seen as promising—or at least relatively immune from spending cuts—defense firms are finding that their calculations were quite flawed. Growth areas ranging from intelligence to cyber to UAVs and homeland security are all facing more difficult markets than had until recently been predicted.

Defense firms have learned from mistakes made during earlier downturns. This time they have carefully avoided attempts to diversify into areas they do not understand, such as manufacturing buses. Instead they have generally focused on safer defense areas that might be fairly resistant to spending reductions, or on other government customers.

Intelligence: Promise and risk

Many defense companies moved aggressively into the intelligence market, proactively seeking out acquisitions in this area.

The appeal of this field was clear. Intelligence agencies are loath to shift away from contractors with whom they have built long-term relationships and who have staffs with the necessary clearances for doing classified work. Profit margins also have generally been higher in this area than in other areas of defense.

In addition, defense companies judged that intelligence would be less vulnerable to the downward trend in defense spending. That appears to be true, although there has been some downturn here as well. Since 2010, when it reached its peak level, intelligence spending has been on the decline. That year, total U.S. intelligence spending totaled $80.1 billion ($53.1 billion for the National Intelligence Program and $27 billion for the Military Intelligence Program). By comparison, the FY14 request was $70.8 million ($52.2 billion for the National Intelligence Program and $18.6 billion for the Military Intelligence Program).

A new threat to the business has emerged with revelations concerning the outsourcing of intelligence gathering. Former Booz Allen Hamilton employee Edward Snowden's revelations about U.S. telephone and Internet surveillance programs have sparked a debate about how much access private intelligence contractors should have to such information. Booz Allen is heavily involved in supporting the U.S. intelligence infrastructure. If new limits are imposed on outsourcing related to intelligence, this could hurt major U.S. defense firms like Lockheed Martin, Northrop Grumman, Raytheon, and General Dynamics, as well as many smaller companies.

Cyber and homeland security

A closely related field, cyber security, has been an extremely hot area for acquisitions because of an expected boom in government spending. In the past three years, many large and small defense companies have made acquisitions in this highly fragmented market, including Raytheon, General Dynamics, ManTech, Ultra Electronics, Raytheon, and CACI International.

For companies working to build up their business in cyber, the problem is clear: The highly classified nature of the field makes evaluating potential acquisitions difficult. That can make some investments highly speculative. There are also questions about the extent to which cyber work may simply be rolled into larger programs. Also, because of its complexity, there is an expectation that consolidation within the field may also push out some players in coming years.

Homeland security generally has proved a disappointment for major defense companies in recent years. Quickly after the creation of the Dept. of Homeland Security, all of the five U.S. megadefense companies (Lockheed Martin, Boeing, Raytheon, General Dynamics, and Northrop Grumman) announced initiatives in this area. These usually involved some form of internal restructuring to address the emerging market created by merging 22 different federal agencies.

Yet efforts by those companies to pursue the homeland security market have generally had limited success. There are few major projects that defense companies are prepared to manage. Instead, much spending goes for grants to law enforcement agencies. That makes it difficult for defense firms to generate demand for such products as night vision equipment or unmanned ground vehicles to deal with bombs. These are purchased in small quantities by individual police departments rather than in the major lots bought by DOD. Often these small lot sales are simply not profitable for large defense companies.

Several major DHS projects have been extremely troubled, leading that department to back away from the complex, large activities in which defense companies generally specialize. Boeing lost the SBInet, a border security project, after major problems with the effectiveness and cost of the system being developed. Lockheed Martin and Northrop Grumman, which worked together in a joint venture to direct the $16-billion Deepwater Coast Guard modernization project, were dismissed from their role managing the program following performance problems and cost overruns.

UAV trends

Even UAVs have been disappointing as a growth niche recently. After exploding from a total of roughly $750 million in FY04 to peak at $3.3 billion in FY11, U.S. defense procurement of UAVs has been on the decline. Procurement spending fell to only about $1.3 billion in the DOD budget request for FY14.

The cuts have been particularly deep in the Air Force's FY14 budget request. For the MQ-9 Reaper, the request dropped from 24 in FY13 to 12 in FY14. The Block 30 RQ-4 Global Hawk cancellation moves ahead.

The Navy/Marine Corps trimmed UAS purchases in the FY14 request as well. The RQ-21 Integrator now will be a Marines system only, so procurement will be limited to 25. Ten Navy systems were slashed from the plan.

The MQ-4 Triton, the Navy variant of the Global Hawk, had its first production delayed from FY14 to FY15 because of design issues and problems with the software for maritime sensors. That delay cut $425 million in production funding while adding $200 million to R&D.

Similarly, MQ-8C Fire Scout procurement was trimmed from six vehicles to just one, while the Navy prepares its plans for the system.

The Army made its own reductions. No new RQ-7 Raven procurement is planned in FY14, although a smaller amount of money is sought for upgrades of existing systems. MQ-1 Gray Eagle procurement was cut to 15 from 19 in FY13 and 29 in FY12.

Clearly, as the services face the need for doing more with less, they are viewing UAVs in a new light, despite the high priority they place on them. The Air Force and Army are concluding that they have enough of existing systems in their inventories, and that the time is coming to upgrade those systems and focus on the next generation of UAS. The Navy, which has long lagged the other services in its adoption of UAS, is still building up a force of UAVs.

Thus, in its latest forecast, Teal Group predicts that strong near-term pressure on UAV markets will pull down global spending for the next several years. Teal Group projects that U.S. production of UAVs will continue to decline until 2015 and will not recover to the 2013 figure of $2 billion until 2019. That will pull down worldwide spending on UAVs from $3.1 billion in 2013 to $2.6 billion in 2015.

From 2015 to 2022, growth in U.S. spending, and even faster increases internationally, will drive strong growth in the total market, which is projected to reach $8 billion in 2022.

By 2022, the international market will total $4.7 billion, or 59% of the total market. Areas such as the Asia Pacific will experience the most rapid growth, but Europe and the Americas (outside the U.S.) will also grow.

The extent to which U.S. companies will be able to take advantage of this growth remains to be seen. So far, they have generally focused on the large U.S. defense market. Insofar as they have ventured overseas, they have often been hobbled by U.S. export control restrictions that have left the market to Israeli competitors.

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While all these potential growth niches face challenges, there are some bright spots for the industry. International sales generally are booming, despite the problems in exporting UAVs. The drive into health care information technology by major defense IT companies also appears promising.

Still, growth in these niches will not offset the massive revenues lost as the core defense budget declines. Moreover, international sales growth promises to be challenging at a time when almost every major defense company, U.S. or European, is looking to expand its international footprint. With economies worldwide facing a slow and possibly fragile recovery, the potential for setbacks is great.

Even so, defense firms are entering the current downturn with tremendous strength. They have large backlogs from past military budgets to help buffer the decline. Their profitability is considerably stronger than it was a decade ago, with significantly less debt.

Although growth niches may be failing to meet expectations, the defense industry still has the strength it needs to endure even a lengthy downturn. There is also a recognition that the sector's long-term health is a more important goal than growth for its own sake. That is dictating the cautious attitude that is now prevalent throughout the industry.

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Health effects of human spaceflight

As sojourns in space grow longer, concerns about their effects on human health are increasing. The ISS serves as a flying laboratory where the responses of real people in a radiation-prone microgravity environment can be studied in real time. Observable changes, psychological as well as physical, are more prevalent and varied than scientists once believed, and some have come as a surprise to researchers.

by James W. Canan
Contributing writer

The international space station has emerged as the crucial test-bed for human spaceflight to faraway places. Sending astronauts to Mars or anywhere else in deep space would be prohibitively risky, if not impossible, without the knowledge gained from ISS research on the physical and psychological effects of daunting, long-distance missions.

NASA's ISS-based human research program (HRP) is the only way for the agency to learn how astronauts react to weightlessness and isolation from Earth for months or years on end, how to counter the numerous ill effects of such unnatural conditions, and to determine whether crewed missions to Mars or other faraway places would be physically feasible. Given its problem-solving history, NASA most likely will be able to come up with countermeasures to negate or mitigate those effects, although nothing is certain.

The space station holds the key. "ISS research is providing incredibly critical data on human performance in the microgravity environment," declares William H. Gerstenmaier, associate administrator for NASA's Human Exploration and Operations Directorate. "We're finding that there are lots of things in the human body that react differently in microgravity. We've got to learn about all that now, so we don't go on a journey to Mars over a long period of time and discover that some things about our bodies don't work very well."

Diverse impacts

The effects of prolonged weightlessness and confinement are many and varied. NASA notes that space travel takes the human body—"a remarkably complex assembly of systems"—out of its natural habitat and puts it in "an unknown and sometimes harsh environment." The HRP is aimed at enabling astronauts to survive and fare well in that environment.

Major areas of research on spaceflight effects include bone density, muscle mass, cardiovascular and sensorimotor functions, immune systems, physical strength, vision, sleep deprivation, disorientation, and the effects of overexposure to radiation beyond Earth's atmosphere. The bodies of astronauts traveling long distances must be able to compensate for all such physiological and psychological effects. NASA is using data from this ISS research to devise compensatory countermeasures.

Expedition 34 flight engineer Tom Marshburn exercises on a combined operational load bearing external resistance treadmill in the ISS Tranquility node.

Russian cosmonauts Anatoly Ivanishin (foreground) and Anton Shkaplerov participate in a crew health care system medical contingency drill in the Destiny laboratory. This drill gives crewmembers the opportunity to work as a team in resolving a simulated medical emergency onboard the station.

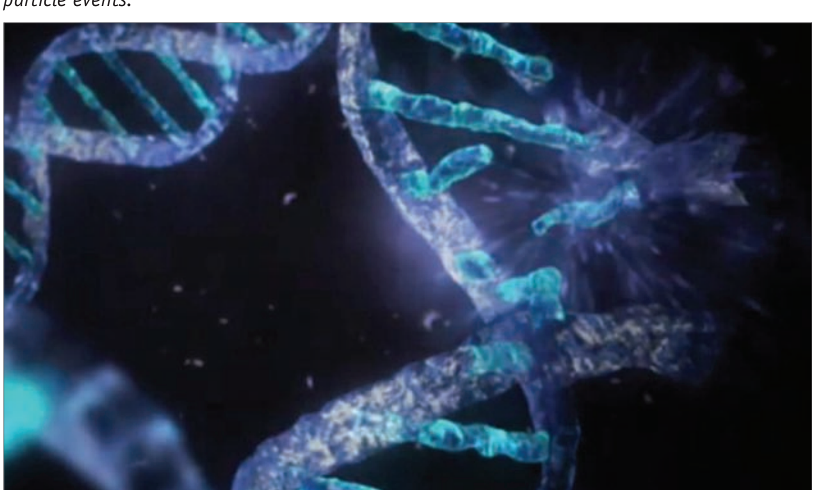
"You don't learn things about the human body in spaceflight without putting the human body in space," says John Charles, chief of the HRP's International Science Office. "Right now the international space station is the best and only way of keeping people in space for long periods of time."

The ISS-based HRP should become even more meaningful in the near future. NASA and Roscosmos, the Russian space agency, will each send a crewmember—NASA astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko—on a year-long mission aboard the station in 2015. Throughout the station's 12 years in orbit, crewmembers typically have inhabited it for no longer than six months at a time.

The longer lasting ISS missions "will enhance our understanding of what really happens to astronauts in a confined and novel environment when they're far away from here and unable to interact for a long time with other people on the ground," Charles explains. The missions will give researchers a much better idea of when prolonged confinement, remoteness, and isolation from life on Earth become a psychological issue, and of how to deal with it.

Radiation and countermeasures

There is one outstanding and potentially insurmountable problem: the exposure of astronauts to radiation in space, beyond the natural protection of Earth's magnetic field and atmosphere. Spaceborne radiation derives from such sources as sunlight, the subatomic matter now known to be prevalent in space, and neutrinos. Radiation from solar storms is especially intense and potentially deadly, which is why predicting solar flares in advance of space missions is a high-priority requirement.



Human epidemiology studies of exposure to various doses of X-rays or gamma-rays provide strong evidence that cancer and degenerative diseases are to be expected from exposures to galactic cosmic rays or solar particle events.

Radiation destroys human cells by damaging their chromosomes. It is greater in LEO than on the ground because Earth's atmosphere no longer attenuates it, and it intensifies all the more beyond the protective reach of Earth's magnetic field. Research and understanding of radiation effects on astronauts are in early stages, but NASA knows enough to be cautionary and very concerned. Station astronauts have experienced the equivalent of eight chest X-rays per day, HRP researchers have found, and at some point, enough is enough.

"Right now, our limit for radiation exposure in flights is about nine months," Charles explains. "At that point, astronauts will have accumulated enough radiation to predispose them to an increased risk of cancer over their lifetimes beyond what we're willing to tolerate. It's not a purely biological limit; it's a policy limit decided upon by other [environmental and health-monitoring] agencies of government in conjunction with NASA. But it can be seen as a biological limit, because the basis of the policy is the biology."

A round-trip mission to Mars would take much longer than nine months. Russian and U.S. estimates of the elapsed time needed to reach the planet, do their jobs, and come home range from 16 months to 30 months respectively.

"In either case, there would be far too much radiation exposure," Charles declares. "We would have to speed up the trips or provide additional shielding to minimize the effects of the radiation, or provide metabolic or pharmacological countermeasures to offset the effects. That's an area of very active research within NASA and by all of our international partners involved in spaceflight."

Researchers aspire to countermeasures in the form of drugs that would prevent, greatly lessen, or undo radiation-induced damage to chromosomes. They also are exploring nutritional means of withstanding radiation, including food and drink—such as green vegetables and red wine—that are rich in antioxidants.

Nutrition concerns

Proper nutrition is a pervasive requirement for astronauts and a high-priority element in all aspects of HRP research. Learning how to preserve the food that keeps astronauts alive and healthy during and after long hauls in space is among the most important goals of space station research. The ISS accommodates research by the agency's Nutritional Biochemistry Laboratory on how spaceflight affects the nutrients in the foods stored onboard.

Scott M. Smith, the laboratory's lead scientist, has asserted, "If the radiation environment in space is causing the nutrients to break down in the foods before they're eaten, that could be catastrophic." All of the food that will be required during a Mars mission, he notes, will likely be transported to the red planet in advance of the astronauts' later arrival.

"If the crew gets there, and we find out all the vitamin C or all the folate or vitamin B12 has broken down, we've got a real problem," says Smith. Researchers learned a lot about nutrition issues on the Russian Mir space station in the 1990s and on Spacelab missions, he notes, "but there is still a lot to learn."

Senses and movement

The extended ISS missions scheduled for the near future should also provide much more data on sensorimotor system effects. NASA defines that system as a network including motor controls, parts of the nervous system, and the sensory organs—eyes, ears, and skin. It governs the body's ability to perceive and respond to the external environment, and to move about.

According to NASA, common sensorimotor issues the HRP has identified in spaceflight include diminished control of movement, changes in the ability to see and interpret information from the eyes, problems with spatial orientation, motion sickness, and difficulty walking. The longer the sojourn, the more intensely astronauts are likely to experience these symptoms.

"This pattern poses a significant challenge for future missions that will focus on long-term space exploration," a NASA paper says. It notes that methods of preventing and reducing sensorimotor problems include exercise regimes, along with self-assessment and self-adaptation measures now being devised by HRP researchers.

Psychological effects

As of now, researchers know more about the physical effects of living and working in protracted microgravity than they do about the psychological and behavioral effects, Charles notes. "We need to know: At what point does it become a psychological issue, and what have we done in the meantime to prepare astronauts against those psychological effects? So that's a big one," he says.

NASA has learned that sustained, seemingly endless spaceflight in the absence of change from night to day can be psychologically stressful, induce loss of sleep and anxiety, and affect the health, safety, and operational capability of crews. HRP studies are aimed at finding ways of keeping crewmembers motivated, cohesive, and productive while maintaining morale. HRP behavioral health researchers have developed environmental tools such as sleep-enhancing lights and monitoring devices that alert astronauts to the onset of abnormal behavior.

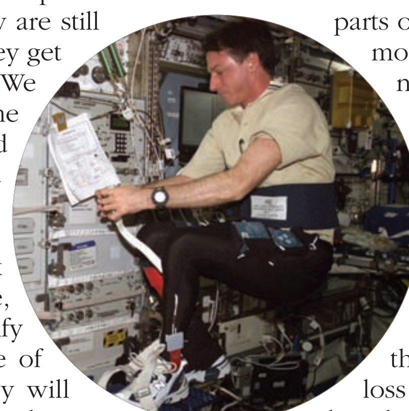
Astronauts often have a hard time sleeping and become overly excited. This brings on the 'hyperarousal syndrome,' a condition that is conducive to fatigue and loss of weight, concentration, coordination,

NASA astronaut Catherine (Cady) Coleman participates in the ambulatory monitoring part of the integrated cardiovascular assessment research experiment in the Kibo laboratory.

and cognitive function. Well managed workloads, adequate rest, ample leisure time, and regular radio contact with family and friends on Earth are among countervailing strategies prescribed by NASA.

Some experienced astronauts have contended that their earthbound controllers and communicators are a principal cause of their sleep deprivation, interrupting their slumber too often, changing their schedules on the fly, and otherwise disrupting their routines. As a result, they "are pretty confident that once spaceflight matures and we're not having so many alarms in the middle of the night, the problem will solve itself," Charles says.

It may come to pass that when astronauts are on their months-long journey to Mars, they will be out of touch with Earth much or even most of the time, and will settle into more regular sleep-and-work routines. "But what if they are still having problems when they get there?" Charles asks. "We want to make sure that the astronauts are well rested and well nourished and refreshed, because when they arrive, they will have to do very important work for a long period of time, working very hard to justify the monumental expense of sending them there. They will have to be extremely productive, otherwise the costs of their mission will be prohibitive, and people will say that sending them there was a bad idea."



Astronaut C. Michael Foale balances on the footplate of a special track attached to the Human Research Facility rack in the Destiny lab to perform foot/ground reaction forces during spaceflight/electromyography calibration operations. Foale is wearing the lower extremity monitoring suit, cycling tights outfitted with 20 sensors, which measures forces on joints and muscle activity.

Surprising visual effect

Visual impairment is one profound problem that comes as "a bit of a surprise" and is currently of prime interest to researchers, Charles observes. It seems to be caused by fluid shifting into the upper part of the body and causing intracranial pressure that distorts eyes and alters vision. This could prevent astronauts from reading checklists in the final phase of a long flight, with possibly disastrous results, and could make it impossible for them to perform their tasks once they land.

"It would have been shocking to have discovered the visual impairment effect enroute to Mars," Charles says. "The problem seems to become apparent three or four months into a mission on the space station—about the same length of time as when our astronauts are roughly halfway to Mars. And they would also have to worry about it getting progressively worse."

Loss of bone and muscle function

NASA researchers have found that certain parts of the human body respond almost immediately to weightlessness, other parts more slowly. While body fluids begin building up and sensorimotor systems start malfunctioning within hours or days of flight in microgravity, bones react sluggishly, losing density at the rate of only 1-2% a month. But even at that, the average rate of bone loss in microgravity is much faster than the average rate of 1-2% a year in elderly individuals on Earth, NASA says.

The Russian Mir space station reportedly has produced valuable data on bone loss, and the ISS is expected to provide even more. Scientists have not bothered measuring loss of bone density on ISS flights shorter than three or four months, because the loss is relatively minor. The longer ISS missions will allow for meaningful measurements.

Bones that support the body the most in gravity, notably the leg and hip bones, are those that lose density most quickly in microgravity. Prolonged spaceflight has been found to bring on other problems related to bone loss, such as increased risk of kidney stones, fractures, hip and spine issues, and impaired healing ability. NASA notes that HRP researchers are addressing such ill effects on several fronts, including the development and testing of pharmaceutical and nutritional countermeasures.

"Eating right and exercising hard in space help protect International Space Sta-

Astronaut Sunita Williams performs the health maintenance system PanOptic eye exam in the Harmony node. JAXA astronaut Aki Hoshide assists.

tion astronauts' bones," a NASA paper says. It notes that exercising supports bone remodeling, a natural process in which normal, healthy bone constantly breaks down and renews itself.

Human research studies indicate that long-term missions in space, such as a flight to Mars, could reduce overall muscle function by nearly half, drastically raising the risk of injury and making crewmembers barely able to operate their spacecraft and perform other mission-related tasks.

This is another big reason why sustained exercise is considered imperative in the weightlessness of space. NASA has long observed that adherence to special exercise regimes before, during, and after spaceflight is necessary to maintain muscle mass by replacing the load that gravity normally imposes on the musculoskeletal system. Current HRP research is geared to improving and refining the exercises and equipment, including treadmills and mechanical restraints such as neck braces, that will enable astronauts to stay physically fit.

One idea that has been around for a while is to rotate a spacecraft continuously in flight to create artificial internal gravity. However, it might require engineering and technical advances too complex and costly to implement, by some accounts.

Cardiovascular and immune systems

Weightlessness threatens the cardiovascular system as well. "Even brief periods of exposure to reduced gravity environments can result in cardiovascular changes such as fluid shifts, changes in total blood volume, heartbeat and heart rhythm irregularities, and diminished aerobic capacity," states a NASA paper. It notes that such effects may linger when astronauts return to gravity, causing low blood pressure, fainting, and difficulty standing upright, a potentially big problem during and after landings.

"Heart muscle responds to the load being put on it, and when the load lightens, the muscle economizes because it no longer has to support a thick-walled heart, and there's a reduction of heart volume," Charles explains. "In general, the human body tries to economize its metabolism. If the body doesn't see a need to be expending metabolic energy on sustaining certain portions of itself, it expends the energy on other portions, or just produces metabolically useful energy in general."

To counter cardiovascular deterioration, the program has devised a protocol

Cosmonaut Oleg V. Kotov collects medical data for the cognitive cardiovascular experiment in the Zvezda service module. Cardio-cog-2 will determine the impact of weightlessness on the cardiovascular and respiratory systems and the cognitive reactions of crews. The results of this study will be used to develop additional countermeasures to keep crewmembers healthy during long-duration space exploration.

that combines physical exercise, balanced nutrition, and medication. Researchers are developing additional remedial and in-flight diagnostic measures as well, NASA says.

Weightlessness tends to degrade the human immune system, defined by NASA as the complex network of organs, vessels, and highly specialized cells that protects the body from infection. A NASA paper explains that "immune system suppression seems to be a common problem in spaceflight, and because some bacteria and other microorganisms can be more dangerous in the space environment than on Earth, crew members may be at greater risk for contracting illnesses and diseases."

Space sickness

In the early stages living in near-zero gravity, the human vestibular system goes awry, causing astronauts to feel just plain bad and dysfunctional. When the vestibular system malfunctions, astronauts lose their sense of balance and spatial orientation, become disoriented, and can find it difficult even to locate their arms and legs. That system consists mainly of sophisticated sensors inside the inner ear, pressure receptors in the skin, muscles, and joints, and the senses of sight and hearing, all of which indicate motion and direction to the brain.

CSA commander Chris Hadfield uses the Human Research Facility pulmonary function system and the physiology module cardiolab leg/arm cuff system to conduct the first-ever session of this experiment. The test will help identify astronauts who could benefit from countermeasures before returning to Earth. This method has great potential for monitoring the health of the astronaut during future long-term spaceflights.

NASA astronaut Dan Burbank uses Neurospat hardware to perform a science session with ESA's PASSAGES experiment in the Columbus laboratory.

"This disorientation is the main cause of the so-called space adaptive syndrome, which one astronaut wryly described as 'a fancy term for throwing up,'" observes an ESA document. The malady, also called space sickness, includes headaches and poor concentration.

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In the end, the many and diverse health effects of missions to distant planets or asteroids may prove altogether too difficult and too costly to counter, forcing decision makers to rely solely on robots for space exploration. Robots have done good work on Mars, for example, but many in the space community contend that humans could do it more quickly and efficiently. For those who must choose between people and machines for future space missions, the HRP program may well make all the difference.

One thing is certain: The international space station has become the sine qua non of preparations for human spaceflight far beyond Earth. "We won't be prepared to do Mars missions without the space station," Charles asserts. "Let's keep using it to prepare astronauts to go to Mars, or to decide if we can accommodate people" for such distant journeys. 𝔸

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Asia-Pacific
The new space

Countries in the Far East, Pacific Rim, and Southwest Asia are competing to increase their technical expertise in order to develop new launchers and satellites to navigate, communicate, and spy on their neighbors for economic and military intelligence.

by Craig Covault
Contributing writer

A surging Asian space race is under way, with more than a dozen Asia-Pacific nations trying to settle old scores, earn global recognition, and achieve technological and military space dominance over each other, especially China.

In addition to China, the nations most engaged in this 21st century space race are Australia, India, Indonesia, Iran, Japan, North Korea, South Korea, Malaysia, Pakistan, Singapore, Thailand, and Vietnam. They are are vying to increase the technical expertise they will need to develop new launchers and satellites. Their new efforts will improve their ability not only to communicate and navigate but also to spy on their neighbors for economic and military intelligence.

The U.S. recognizes the importance of what is happening. Part of the Obama administration's 'pivot to Asia' is greater military space cooperation with Australia. Such programs are vital to enabling Australia, the U.S., and their allies to monitor Asian nations that are rarely in agreement.

"It is important that Australia take action to address current and emerging space-related vulnerabilities and threats," the Australian government said in commenting on its new cooperation with the U.S.

"Asia's space powers are largely isolated from one another, do not share information, and display a tremendous divergence of perspectives," says James Clay Moltz, a professor at the Naval Postgraduate School in Monterey, California, in his book *Asia's Space Race*.

"Such hostile dyads as India-China, China-Japan, India-Pakistan, Japan-South Korea, and North Korea-South Korea indicate that Asian countries see space largely as an extension of other competitive realms, and are carefully watching regional rivalries, attempting to match or at least to check their capabilities, influence, and power," Moltz wrote.

China: Picking up the pace

Ian Easton, research fellow with the Project 2049 Institute, tells *Aerospace America* that "China's ground-to-space ASAT [antisatellite] weapon tests in 2007 and 2010, and its continued progress in a wide range of other ASAT and military space capabilities, have generated a tremendous amount of attention in the Asia-Pacific region, finally putting space on the broader Asian agenda in a way that it was not before." The 2049 Institute is a Washington-area think tank focused on China.

Between 2005 and 2009 China launched just three to five military spacecraft a year. In 2010, however, it more than doubled that rate: Of the 15 missions it launched that year, 12 were military satellites.

race

The country has maintained this aggressive pace by launching about a dozen military or dual-use spacecraft a year out of 19 missions for both 2011 and 2012. And this year China says it expects to launch 16 missions carrying 20 satellites, then build the launch rate to 30 missions a year toward 2020. U.S. intelligence analysts have determined that up to 70% of the satellites China has launched are military related.

By contrast, Japan and India have each been launching only two to three missions a year. But their launch rates are increasing, especially for military reconnaissance, communications, and navigation spacecraft to counter China and watch North Korea.

Breakout point?

China believes that it is nearing a space breakout point that can lure more Asian countries under its umbrella while also advancing its competitive space posture against the U.S.

To achieve this it will continue launching crews to small Tiangong outposts before assembling a larger modular station by about 2020. Like the June Shenzhou 10 rendezvous mission, these Tiangong longer duration flights will provide the People's Liberation Army, which runs the manned program, with a foothold in space.

China will move toward human lunar missions, according to Liang Xiaohong, af-

The Japanese HII-B is Asia's most powerful rocket.

Shenzhou 10 returned its three-person crew to Earth after a series of successful docking exercises with the Tiangong-1 space laboratory.

ter it gains experience with robotic missions to the Moon and Mars. Liang is the deputy director of the China Academy of Launch Vehicle Technology, the country's largest rocket manufacturer.

In a March 4 Beijing announcement that drew virtually no U.S. media interest, Liang said China is starting formal development of a Saturn-V-class Moon rocket, the Long March 9. The giant three-stage all-liquid-propellant booster is needed "to meet long-term space goals" and "will be able to send men to the Moon," said Liang. The behemoth will be designed to place about 287,000 lb in Earth orbit. By comparison, the U.S. Saturn V could launch up to 308,700 lb, as it did in the April 1972 launch of Apollo 16.

The Chinese Moon rocket will be 323 ft tall with 11 million lb of thrust at liftoff, says Charles P. Vick, an analyst at GlobalSecurity.org. These numbers indicate that the vehicle would have 3.5 million lb more thrust than the 7.5-million-lb-thrust Saturn. China's super rocket missions could start by 2030 from its new launch center on Hainan Island, just south of the mainland.

Competition from India and Japan

The nexus of the Asian space race, however, is the fierce space competition under way between India and China. This rivalry is every bit as serious as the 1960s race to the Moon between the Soviet Union and the U.S., but with the added dimension of antisatellite weapons.

The Vietnam National Satellite Center received substantial financial backing from Japan, and will develop imaging satellites for that country.

"China plus India plus Japan equals opportunity, tension, and danger," says author Bill Emmott, former editor of *The Economist*, in his book *Rivals*.

All three countries have begun the development of robotic missions to the Moon and Mars, not only for exploration and technology, but because the others are doing it too. All have completed lunar orbit missions, and China plans in December to launch a nuclear-powered robotic lunar lander with a surface life of one Earth year carrying a 200-lb solar-array-powered rover with a lifetime of three months.

India has delayed its lunar rover and will now try to beat China to Mars with an orbiter launched late this year. Japan is developing a second, more ambitious asteroid sample return mission while studying its own future Mars missions.

One rare cooperative project between Vietnam and Japan illustrates how Asian geopolitical and military objectives are being achieved in space by an unlikely team united to counter China.

Vietnam, invaded by the Chinese most recently in 1979, remains angry over such incursions, which date back 2,500 years. West-oriented Japan and communist China, both far more powerful than Vietnam, have opposing ideologies and are vying for advantage in the same area of the Pacific.

Forty years after the bitter U.S.-Vietnam conflict, a more pragmatic communist Vietnam has emerged. Its growing space program is largely supported by Japan, also its prior adversary. Their joint strategy is to reduce China's regional influence while increasing their own reconnaissance of the country, according to a top U.S. analyst of Chinese issues, speaking on background.

In a not-so-subtle message to China, the Japanese government donated close to $1 billion in aid to Vietnam for a $600-million Vietnamese National Satellite Center outside Hanoi. Japan is paying the center to develop two Japanese-designed imaging radar satellites that the two countries will use to monitor China. The funds built an attractive campus that has lured a bright young staff of more than 60 people, including 23 engineers who are more like the young geniuses at JPL than revolutionaries.

The first radar spacecraft will be a Japanese-flagged satellite to be launched from Russia or Japan by about 2017. Viet-

Indian responses to China in the Asian space race

•Military space cell: India's Ministry of Defence has combined army, navy, and air force officers into a formal Indian Integrated Space Cell. Its purpose is to outline future Indian military space organizational and procurement moves, establish military satellite development, and create an Indian Space Command in coming years.

•Space agency role: India's government has ordered ISRO, a civilian agency, to provide each of the country's armed services with initial military spacecraft and with rockets to launch them.

•Israeli teamwork: India teamed with Israel for acquisition of an Israeli Air Force TecSar imaging radar satellite with 3-ft resolution to perform military reconnaissance of Pakistan and China. The spacecraft was launched by India as Risat-2 in 2009. India launched an identical radar satellite for Israeli use; both have all-weather, day/night, and foliage penetration capability.

•Humans in space: India is beginning development of a manned orbital spacecraft for launching Indian astronauts on its own booster, perhaps as soon as 2018, to blunt China's human spaceflight advancements.

•Russian help: Russia agreed to provide India with some manned space technology after the U.S. was forced to decline because of technology transfer regulations. This may include some Russian ground system technology for reconnaissance satellite operations.

•Planetary exploration: India accelerated development of its Mars orbiter ahead of a lunar rover originally scheduled for launch in 2014. The Mars mission will now launch this November instead of waiting for the 2018-2020 launch window. This should enable India to beat China to Mars, since China's initial Mars orbiter was lost with the Russian Mars Phobos spacecraft after launch. India hopes to launch its own lunar rover mission later in the decade.

The Israeli-built TecSAR day/night all-weather imaging radar satellite, which can also see through foliage, is being used by India to monitor Pakistan and China, especially the deployment of aircraft and armor. India launched a similar satellite for Israel. Credit: Israel Aircraft Industries.

nam will then use the Japanese design to develop its own radar imaging satellite by 2020. Both will be controlled from the Vietnamese National Satellite Center.

For land and ocean remote sensing of their territories and coastlines, the two spacecraft will also use their own night/all-weather and foliage-penetrating radars to image China and share the data.

Worry and change in Japan

Japan has been so worried about China and North Korea that it abolished a ban on Japanese military space activities and since 2003 has launched seven H-IIA boosters carrying military payloads. Six of these flights have been successful, placing six optical and four radar high-resolution military reconnaissance spacecraft in orbit. Even with tight budgets, Japan is funding 10 more reconnaissance satellites for launch over the next five years.

Japan is a key member of the international space station, having provided several Japanese astronauts and the impressive Kibo laboratory module, the largest on the ISS. The country is also continuing to build the 36,000-lb HTV (H-IIB-launched transfer vehicle) to deliver cargo to the station.

The 186-ft-tall Japanese H-IIB is Asia's largest, most powerful rocket, with 2.57 million lb of thrust. The second-largest is China's Long March 3B, which can launch 26,000 lb to LEO. The third-largest, which can place 11,000 lb in LEO, is India's Geosynchronous Satellite Launch Vehicle.

Toward 2020 Japan could lose its edge to the Chinese as they bring on line their new Long March 5 series, capable of lifting up to 55,000 lb to LEO. Although currently outpowered by Japan, China's rocket fleet is more diverse. It also serves Pakistan, which increases India's space fears.

There are basically two Asian space camps: a limited number of countries aligning with China outright, and a larger number aligning behind Japan, or both. China formed the Asia Pacific Space Cooperation Organization to bring as many Asian nations as it could, including Iran, under its influence. So far Bangladesh, Indonesia, Mongolia, Pakistan, Peru, and Thailand are also part of the group.

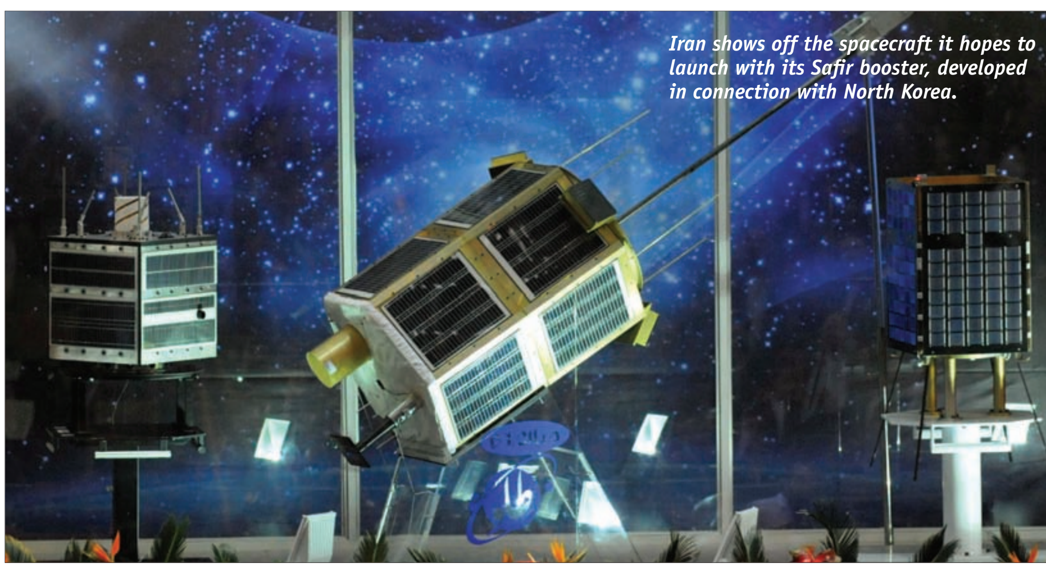
India's powerful GSLV is Asia's third-largest rocket.

Pakistan

Pakistan has sided with the Chinese, who developed and launched its new Packsat-1R spacecraft in 2011 to replace an older model. Packsat-1R has 30 transponders, 12 in C-band and 18 in Ku-band.

Although the craft serves commercial customers, it also provides Pakistan's military with major new communications capabilities. These include operations in rugged border terrain, says Bharath Gopalaswamy, deputy director of South Asia programs for the Atlantic Council.

Pakistan is also moving to develop a high-resolution optical imaging spacecraft for launch in the coming years. This is another worry to India, which has dominated Pakistan for years with its mature imaging and radar satellite program, partly in collaboration with Israel.



Iran shows off the spacecraft it hopes to launch with its Safir booster, developed in connection with North Korea.

Iran

Iran has its own 72-ft-tall Safir space booster and has launched up to two small satellites with the vehicle. But it continues to develop its booster and satellite capabilities, which analysts see as a front for nuclear-armed ICBM development.

In fact Iran says it has a manned space program, with the objective of launching an Iranian astronaut (simply for prestige) on a suborbital space mission. That would not occur until nearly 60 years after U.S. astronaut Alan Shepard's first flight, and by then it would be easier and cheaper for Iran to buy its astronaut a ticket on Virgin Galactic.

But Iran is also affecting the Asian region by exchanging rocket and nuclear hardware with North Korea. For example, the upper stage on the North Korean Unha 3 ICBM-type rocket that launched the country's first crude satellite on December 5, 2012, was Iranian. The North Korean 're-mote sensing' spacecraft tumbled out of control shortly after launch.

Taiwan

In China, the People's Liberation Army (PLA) is rapidly accelerating its military space operations. Although most military analysts focus on China's ASAT development as a threat to U.S. space assets, the real threat may actually be against Taiwan's increasingly advanced spacecraft, said Mark Stokes, executive director of the Project 2049 Institute, speaking in February before a Chinese ASAT forum at the Marshall Institute in Washington, D.C.

Over mainland China's objections, Taiwan and Matra-Marconi Space in France developed the Formosat/ROCSAT-2 spacecraft having 5-6-ft panchromatic/color

This 5-ft-resolution image of Taipei Airport taken from 553 mi. high by the Formosat spacecraft shows that the satellite has the basic ability to monitor aircraft, large vehicles, and tactical missile deployments. Credit: Taiwan National Space Program Office.

resolution and 26-ft multispectral resolution. It was launched in 2004 from Vandenberg AFB, California, on a Taurus rocket into an orbit that specifically enables daily change detection from space.

That orbit is 553 mi. high, essentially the same altitude where the ASAT attack against the Fengyun-1C polar orbit weather satellite took place. China opposed the satellite on the grounds that it could monitor the PLA. The Taiwanese never admit to spying on China but are of course greatly interested in the several thousand missiles that China has aimed at them.

Although ostensibly a civilian satellite, Formosat-2's resolution is good enough to distinguish facilities such as China's missile batteries and aircraft types and basing. Taiwan's next spacecraft, Formosat/ROCSAT-5, will also have a panchromatic/color resolution of 5-6 ft and improved multispectral resolution (15 ft). Set for launch in 2014 on a SpaceX Falcon 9 rocket from Vandenberg, it will be the first spacecraft totally designed and developed in Taiwan.

Thailand

While Vietnam is countering China by leaning more to the West, Thailand, which used to favor the U.S., is now teaming more with China for spaceflight participation. This is significant, because Thailand operates top-of-the-line U.S. satellites, among them the Space Systems/Loral iPStar-1—at 14,770 lb the largest GEO communications spacecraft ever launched.

Thailand used a Russian Dnepr rocket to launch its 3-ft-resolution EADS/Astrium-built Theos imaging spacecraft in 2008, then a Falcon 9 to launch the Razaksat high-resolution satellite in 2009. Razaksat suffered a serious malfunction and was abandoned.

South Korea: Watching the North

To keep watch on North Korea and China, South Korea also is developing both optical and radar imaging spacecraft. These will serve as dual resource-monitoring/military reconnaissance satellites.

The country bought a Russian launch for its 3.2-ft-resolution Kompsat-2 in 2006, and a Japanese H-IIA to launch its 2.3-ft-resolution Kompsat-3 into a Sun-synchronous orbit in 2012. The pair provide high-resolution resource surveys as well as images of North Korean weapons emplacements, aircraft, and troop movements.

Kompsat-5, a new radar imaging satellite capable of seeing through clouds and foliage with 10-ft resolution, is set for a Dnepr launch late this year.

Although China is a major adversary of both Japan and South Korea, the latter two do not share intelligence, said Dean Cheng, speaking at the Marshall Institute forum. Cheng, a research fellow at the Asian Studies Center of the Heritage Foundation, noted that the lack of cooperation between Asian space nations is one factor that emboldens China.

In January of this year, South Korea finally succeeded in launching its own small research spacecraft on its Naro-1 rocket, developed with a Russian Angara first stage and a South Korean solid-propellant second stage. The program had suffered two previous launch failures, in 2008 and 2009.

U.S. intelligence agencies provide Seoul with images or data about North Korea from National Reconnaissance Office satellites. But now Kompsat spacecraft and Naro-1 should enable South Korea to keep more of its own watch on the North.

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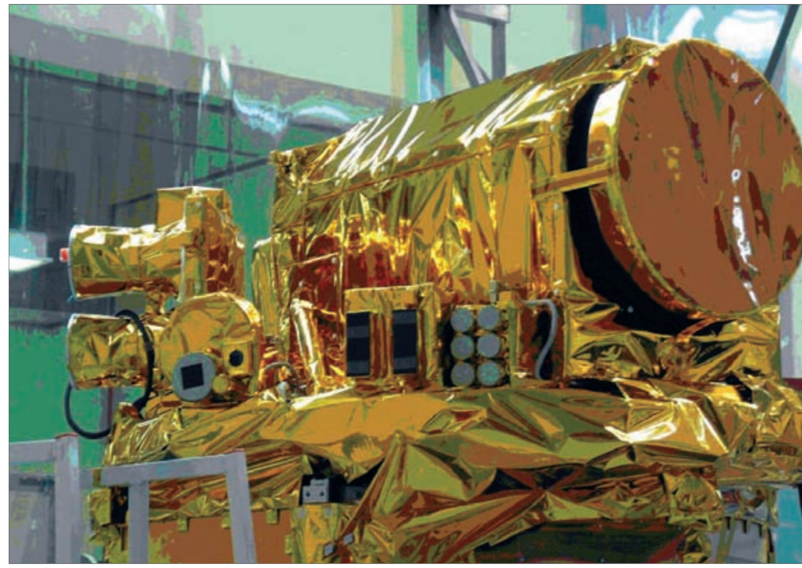


Formosat's large electrooptical imager can simultaneously capture four panchromatic, multispectrum images and then transmit the data to government agencies, private sector companies, and research organizations. Credit: Matra-Marconi/Taiwan National Space Program Office.

Korean Space Launch Vehicle 1, also called Naro, launches into orbit from South Korea's Naro Space Center, successfully carrying a science satellite into orbit. Credit: Korea Aerospace Research Institute.

China space 2.0

China's latest space plans are moving ahead at full speed, with new space vehicles, launch facilities, and manufacturing sites already taking shape. Success, however, will require that these complex elements come together simultaneously and work as intended, a daunting challenge. But if assets such as a new family of heavy-lift boosters perform as promised, they will greatly increase China's future space capabilities. What this may imply about the country's long-term national goals is an unanswered question.

The next LEAP forward

The Chinese space program, after an impressive two-decade progression through modest, year-by-year improvements, now faces perhaps the most challenging 'great leap' in its history. If the effort succeeds, it will enable far more ambitious space activities in the coming decade and beyond.

Years-long construction, development, and testing are on the verge of simultaneously activating a new spacecraft and booster production facility, a new family of boosters, and a new, more capable launch site. The era of 'China space 2.0' is about to begin, and Western observers are both impressed by the undertaking and uncertain about its national goals.

A primary principle of technological intelligence analysis is that observed capabilities under development reflect national intentions and goals. But China's imminent new space capabilities are ambiguous in this regard. They offer so many options that there appear to be virtually no constraints on any combination of new space goals.

Engines

The 'jewel in the space crown' of these new capabilities is the Long March 5 (LM or CZ-5) booster, an intermediate-class rocket (think Saturn 1B, or Proton, or Ariane 5) with an initial flight rate of up to 10-12 per year, and downstream capability to more than double that.

For the past 20 years, most Chinese spacecraft have been launched on variations of the Long March 2, 3, and 4 boosters. These rockets are based on the hypergolic-fueled military ICBM Dong Feng 5, whose two YF-21 engines had a thrust per engine of 284 tons. This Long March family with its paired core engines (YF-21B) has placed up to 9.5 tons in LEO with strap-ons or, with upper stages, carried 3-5 tons to GEO transfer orbit.

The fairing for the LM-5 is being developed with an eye to the future.

by James Oberg
Contributing writer

Soon after 2000, in a decision apparently made in several stages, the government approved the development of two major new engines that reflect more ambitious goals. They are the YF-100, a new kerosene-LO_2 rocket engine rated at 120 tons thrust (twice the thrust of the previous strap-on stage engine), and YF-77, an LH_2/LO_2 core engine with a thrust of 50 tons.

A new family of smaller upper-stage engines, both hypergolic and cryogenic, was to be created as well.

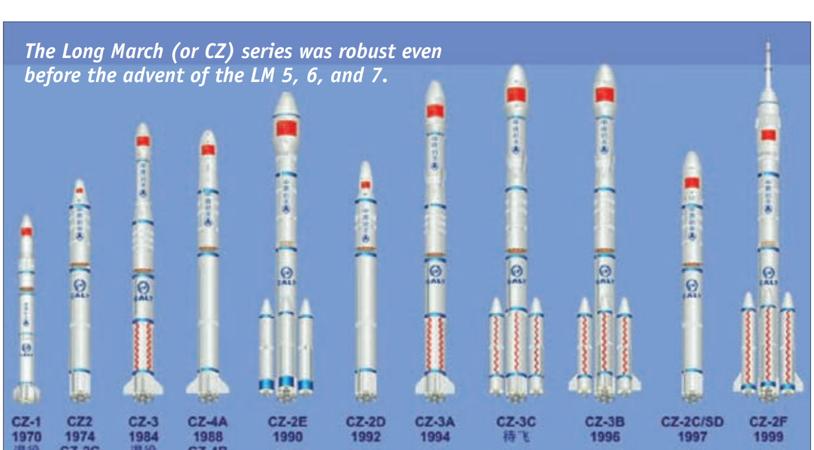
As engine development proceeded, design work on the booster family that would use these engines proceeded in parallel. Three tank diameters were envisaged: a 2.35-m tank with a single YF-100 engine, a 3.35-m tank with two YF-100s, and a 5-m tank with two YF-77s.

The design of the biggest version, the LM 5, specifies a length of 60 m, with four engines. For LEO missions, the central 5-m core is assisted early on by four 3.35-m liquid strap-ons, and goes all the way into orbit. The payload weight would increase two-and-a-half to three times over that of current boosters—up to 25 tons in LEO.

The LM 7 variant, which is looking more and more likely to be the first of the new family to actually fly, will use a 3.35-m core with 2.35-m strap-ons plus an upper stage. It is also considered likely to become the replacement for most LM 2 variants over the next 10 years.

Breakthroughs in logistics and design

The new booster family was not the only needed breakthrough. Up until then, Chinese spacelift was constrained by limited thrust, but also by a very down-to-Earth practical limitation: the logistics of transporting booster components from their factory to launch sites that were all far inland.



The Long March (or CZ) series was robust even before the advent of the LM 5, 6, and 7.

Although stretched central cores and added strap-ons allowed incremental enhancement of performance, a design ceiling had been reached, literally: Rockets bigger than about 3.35 m in diameter and 14 m long did not fit through the railroad tunnels.

To break this impasse, space planners began an across-the-board infrastructure upgrade. This involved construction of entirely new booster and spacecraft fabrication and test facilities with seagoing ship access, along with a coastal launch site at the other end of the water route. For range safety as well as launch dynamics considerations, the site chosen was on Hainan Island, near 19 deg N.

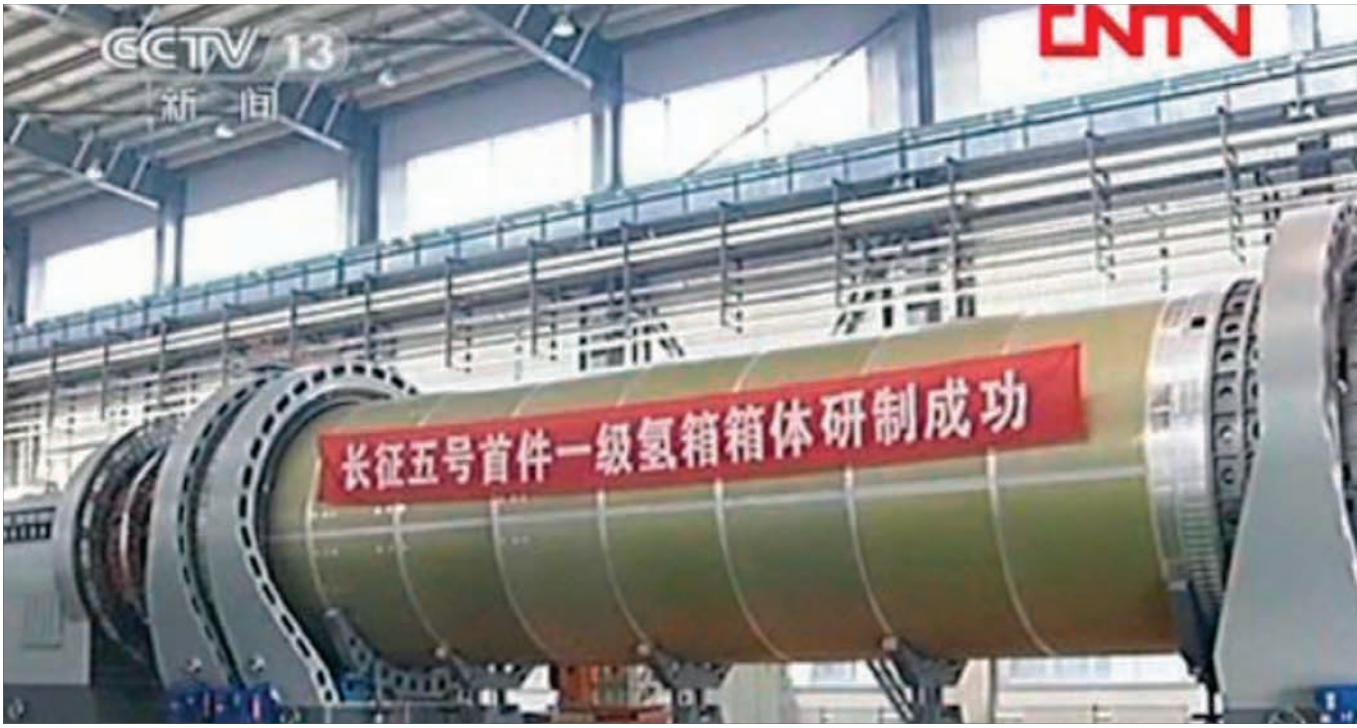
As noted in a ‘space white paper’ in late 2011, the new booster family was designated Long March 5, 6, and 7. The papers, released by Beijing at five-to-six-year intervals, have proved to be reliable indicators of broad national space goals, although they are not complete (no military applications are mentioned). First flights were planned for late 2014, a date that has now begun slipping.

One indicator of the care that developers were taking in these fundamentally new design efforts was a February 20, 2012, article on digital prototyping of the booster. According to the article, published on the China Aerospace Science and Technology (CASC) website, this is the first time in the history of Chinese rockets that an entire rocket model has been digitally engineered. The most difficult aspect of the effort was that in the absence of past experience, all-new computing methods and design concepts were needed.

Unlike its predecessors, the LM 5 program uses 3D design methods. Tests are now conducted through simulation software, which increases reliability and saves great amounts of manpower, material, and money. The CASC article explained that digital model testing is done prior to testing on a physical model. Then, after the digital and physical models are compared for any differing results, the digital model’s parameters are further refined.

The first production YF-100 engines had completed acceptance testing by June 14, 2012. In a statement released by the Xinhua News Agency, the State Administration of Science, Technology and Industry for National Defence reported:

“The 120-tonne liquid oxygen/kerosene high-pressure staged combustion cycle engine will provide an effective guarantee



The LM-5 first stage hydrogen tank is part of a breakthrough in Chinese rocket design.

for the country's manned space and lunar probe missions. This high-performance engine is nontoxic, pollution-free and reliable.

"It is the first kind of high-pressure staged combustion cycle engine for which China has proprietary intellectual property rights," the statement continued. "It also makes China the second country in the world, after Russia, to grasp the core technologies for a liquid oxygen/kerosene high-pressure staged combustion cycle rocket engine."

Lai Daichu, the test commander, told newsmen that the tests were designed to see how the engine would respond to rotational speeds of nearly 20,000 rpm and temperatures of 3,000 C for 200 sec. "The successful tests confirm the reliability of China's LOX/kerosene engine," he said.

A few weeks later, Luan Xiting, identified as deputy director of the Academy of Aerospace Propulsion Technology under CASC, elaborated on the testing process: "Adequate tests are essential to expose its weaknesses and discover its problems, so we can come up with right solutions," he told a Beijing television station. "For some 60 engines, we have tested over 120 times and trial-run more than 30,000 seconds." He added that over the 12-year development period, China developed more than 50 new materials and achieved more than 80 key technology breakthroughs.

"The building of a space station requires carrier rockets with greater thrust, as each capsule of the station will weigh about 20 tonnes," Jing Muchun, chief engineer for the carrier rocket system of China's manned space program, told Xinhua on September 29, 2011."We have been preparing for the launch of the space station, slated for 2020." Jing's deputy, Song Zhengyu, told Xinhua that the new generation of carrier rockets, using digital flight control systems and nontoxic, nonpolluting propellants, would take about seven years (2014-2021) to phase in. During that period existing Long March 2, 3, and 4 series would be replaced sequentially.

While LM 5 was the heavy lifter, the smaller LM 6 and LM 7 would have special missions. LM 6 is to be a new type of quick-response launch vehicle, capable of placing not less than 1 tonne of payload into a Sun-synchronous orbit at a height of 700 km. The LM 7 will be able to place 13.5 tonnes in low-inclination LEO (it is expected to be human rated for Shenzhou spacecraft), and 5.5 tonnes of payload into a Sun-synchronous orbit at a height of 700 km, according to the white paper.

Hu Haifeng, a designer at CASC, told Xinhua that Long March 5 will help China return to the forefront of launch vehicle technology. China's vehicles have "a fairly good record for reliability," he was quoted as saying. "However, they lag behind other leading countries' vehicles in terms of payload and thrust capability because they were built based on early 1990s plans. Now we need vehicles with a greater capability to send more payloads into space.

"The U.S. and Russia are also developing launch vehicles with the highest impetus capability in the world, and it is still unknown which country will be the first to succeed," Hu added.

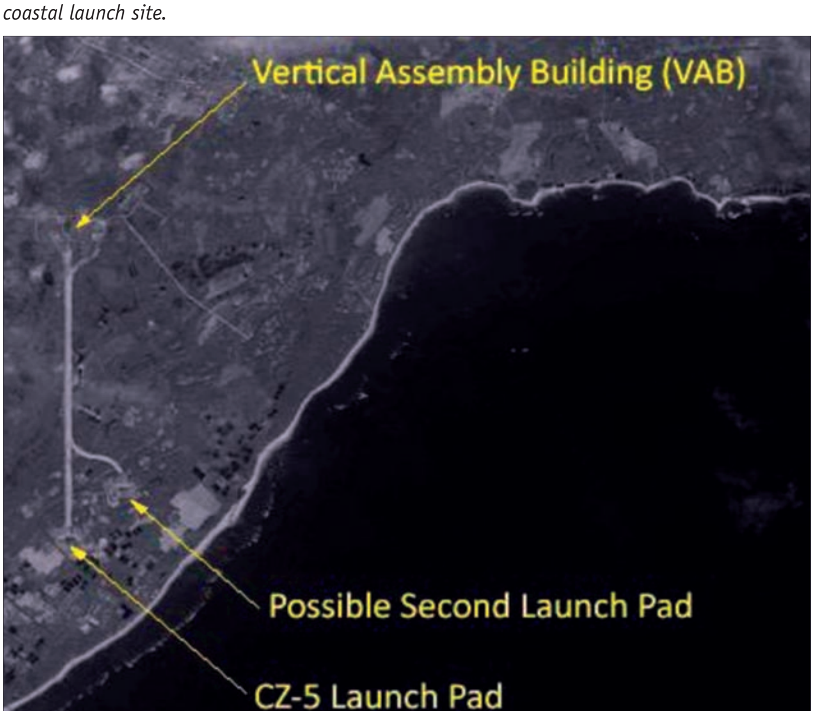
Daunting challenges

Hu's candor was refreshing, because the technological challenges are widely considered the most significant since the beginning of Chinese spaceflight in the 1970s.

Morris Jones, a noted Australian observer of China's space activities, told *Aerospace America* by email, "Previous Long March rockets have been augmented with boosters and improved upper stages, but this is the first time that a system has been modular from its conception. China is also introducing more powerful engines with cryogenic propellants. New engines are usually the greatest technical challenge in a new rocket."

Jones added, "Although the various stages and boosters are designed to work together, a system is more than the sum of its parts. It's possible that some mechanical, vibrational, or thermal issues will only make themselves visible when certain combinations are actually flown."

A satellite photo shows the advantages of a southern coastal launch site.



Chen Lan, a Chinese citizen who runs a respected independent commentary electronic magazine and a website on Chinese space activities (http://www.go-taikonauts.com), agrees:

"It's undoubtedly a big leap," he told *Aerospace America* by email. "Long March 5 has a lot of breakthroughs: new design philosophy, new engines, including the staged combustion kerosene/LOX engine, new materials and FSW [friction stir welding], new control system including use of the fiber channel bus, as well as all-digital design. In short, it's a brand new rocket, and much more advanced than the previous launchers.

"There are indeed challenges," he said. "For example, the YF-100 engine. It took China nearly 20 years to learn [from the purchased RD-120], develop, and mature it. Both the YF-100 and the YF-77 engines met serious problems. Slow engine development is one of reasons of the many-year delay of the project approval." But he expressed confidence: "Up to today, it seems that all critical issues have been solved."

Launch site

Chinese officials have been talking about the advantages of a southern coastal launch site since 1999. A small sounding rocket base had been established in southeastern Hainan Island in the 1980s, and with the decision to proceed with the LM 5, development of the site was approved. A formal groundbreaking ceremony for the Wenchang Satellite Launch Center took place on September 14, 2009, about a year after construction began.

Managing the project is the administration of the Xichang launch site in Sichuan. Previously the southernmost inland site, it specialized in GEO missions. Initially it was expected that this site would include pads for the current Chinese launcher families. But in January, comments by Fan Yimin from the Engineering Construction Command Dept. cast doubt on this. "As China's fourth space launch site, [Hainan] will not duplicate the existing space launch sites," he told a newspaper, "but make a breakthrough in many key technologies." Xichang and the other sites, using older rockets, are to stay in operation through 2020.

Compared with current launch facilities, Hainan has unique advantages, Fan continued. Its low latitude (19 deg N) gives a 7% performance boost over Xichang. The new site will have a high launch capability

The Wenchang launch site will be open to the public and serve as a space education base.

and allows the transport of rockets with diameters of 5 m without using railways and tunnels. The rocket overflight area and debris impact area will be very safe, posing no threat to ground personnel or buildings. The launch site also will be open to the public and serve as a space education base.

The Xichang official's interest in safety for people on the ground may have grown out of personal experience. As detailed in *Air & Space* magazine (http://www.airspacemag.com/history-of-flight/Disaster-at-Xichang-187496561.html?c= y&page=1), a long-rumored launch disaster at Xichang 20 years ago killed more than 100 people when the GEO-bound foreign communications satellite's booster swerved suddenly on liftoff and crashed into a nearby village.

The most bizarre aspect of the new launch site is the construction of a 1,000-acre theme park next door. Supposedly, the park will employ many of the 6,000 inhabitants evicted from the launch zone. In addition to space-themed roller coasters, it will offer tram rides past the actual launch pads, between launch campaigns.

Satellite imagery of the launch base was difficult to come by for several years, but the location has now been spotted, reportedly at 19.668 N 111.013 E. The first overhead view was published in Chen Lan's magazine, and other commercial imaging services have produced usable views. But port facilities for receiving booster and spacecraft components remain undefined. Some sources believe docks were being built at the launch site (imagery is unclear), while others report that existing facilities at the West Qinglan Seaport will be used, followed by overland road transport.

To transport the large booster segments and payloads (and probably large prefabricated launch hardware) two seagoing cargo ships were built at Shanghai Jiangnan Shipyard on Changxing Island. Yuanwang 21 was launched on November 29, 2012, and an identical Yuanwang 22 on January 24 of this year. According to commemorative first-day covers, the ships are 130 m long with displacement of 9,080 tons.

Tianjin industrial facility

With a new coastal launch facility for larger boosters and spacecraft, China also needed a new coastal site for fabricating them. Through a selection process that has never been described, officials settled on the city of Tianjin (http://www.tj.gov.cn/english/), more familiar to Westerners under its old spelling of Tientsin. It is China's fourth-largest city, and the main port for Beijing, on the Yellow Sea.

Construction of the complex was announced in 2007, but little news—and none on the actual location—came out subsequently. Even without official information, overhead satellite views are now available.

Then, in April 2011, inauguration of the 'China Space Environment Reliability Tianjin Experiment and Test Center' was announced. Tao Gang, general manager of Tianjin Aerospace Long March Rocket Manufacturing, revealed that the fabrication center's first-phase construction was "initially completed," and that production of key components for the booster had reached industrialized production capability. The general assembly workshop was also supposed to come into use during the first half of 2011.

Cargo ships were built at Shanghai Jiangnan Shipyard on Changxing Island to transport booster segments and payloads to Hainan Island.

A static load test facility was one of the structures built for the Tianjin test center.

Ma Xingrui, general manager of CASC, which designs and manufactures the Long March rocket series and Shenzhou manned spacecraft, described the facility to Xinhua in September 2011. Called the Tianjin Aerospace Industry Base, it covers an area of 313.33 hectares and cost over 6 billion yuan ($938 million), according to CASC. It includes a 220,000-m^2 assembly building for the launch vehicles, space stations, and "special equipment" (presumably other large satellites).

The facility, says Ma, is designed to meet China's growing demand for space technology R&D over the next 30-50 years. Integrating the fabrication steps will enable the base to produce an entire spectrum of rockets of different sizes and types for the nation's Moon probe project, space station, and other efforts. Along with support for design, production, assembly, and testing of new rockets, it provides high-end services such as aerospace software.

Phase One of the construction plan was completed in February 2012. The facility had been equipped with all the operational capabilities for the processing of modules, for general assembly, and for testing of high-thrust vehicles. By March 2012, Liang Xiaohong, deputy head of the China Academy of Launch Vehicle Technology, was able to announce that development of the first hydrogen tank for the LM 5 had been completed. He added that production of the rocket's key parts—the 5-m-diam. fairing structure and other major fuel tanks—would be completed by the end of 2012.

Then in January of this year, the second major facility was described, four months after its televised cornerstone-laying ceremony. This 100,000-m^2 payload fabrication center is to have the capacity to deliver six to eight oversized payloads a year. According to an official announcement, these will include space station sections, large communications satellites, large remote sensing satellites, large unfolding precision structures, and other unspecified objects.

Construction was due to be completed in August. A year later, after outfitting of the interior, spacecraft fabrication will begin.

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Early press descriptions of Long March 5 missions appear to be a wish list of all possible space projects. Jiang Jie, Long March 3A chief engineer, told *China News Service* in March 2012: "The new generation will feature heightened capacity, high reliability, robust adaptability, and clean energy use, shouldering the launches of near-Earth orbit satellites, geostationary transfer orbit satellites, satellites in Sun-synchronous orbit, space stations, and lunar probes."

Other press reports mentioned large Earth observation satellites, which some Western experts interpret as military reconnaissance craft. The main payload will be modules for the Mir-class manned space station planned for after 2020.

The LM-5 could theoretically support human missions beyond LEO, and with multiple launches would enable a Shenzhou/Tiangong-class months-long expedition to and beyond cislunar space. One NASA study recently portrayed a human lunar landing mission based on a large number of separately launched payloads. No Chinese media discussion of such options has been detected, but the significance of that absence is obscure.

All of these dreams depend on a critically large array of first-ever engineering breakthroughs, to be orchestrated in unison. Even if the LM 7 is the first (and easier) new family member to fly, the challenge of getting the LM 5 into service remains the greatest space leap China has ever attempted. The Chinese are reaching for an impressive new level of spaceflight capabilities. More delays (now reportedly into 'early 2015' for the LM 5), and even major flight anomalies, would not be surprising. Nor would they be a reason to question the ultimate success of these ambitious efforts.

(Continued from page 37)

It is noteworthy that North Korean Unha 3 launch attempts—the December 5 success and an earlier failure—took place from a North Korean pad and gantry designed for a much larger rocket. The service tower dwarfed the Unha 3 and could handle a rocket nearly twice as big. North Korea will eventually develop reconnaissance satellites, analysts believe, but for now it is concentrating far more on developing rockets as long-range ballistic missiles.

Indonesia, Malaysia, and Singapore

Like North Korea and Iran, Indonesia wants to broaden into launch operations. For 30 years the country has had communications spacecraft programs, including shuttle-launched Palapa Hughes HS-376 satellites like the one rescued for relaunch by Discovery astronauts in 1984. In fact two Indonesian astronauts trained as shuttle payload specialists affiliated with the Palapa program, but were never able to fly.

Today Indonesia plans to lure commercial vehicles to its territory (or even build one of its own) to launch toward geostationary orbit from its energy-efficient equatorial location.

While South Korea and Taiwan monitor China with nearly 1,500-lb satellites, Malaysia is "the mouse that roared," says Moltz. He refers to the country's participation in a host of Asian space forums and its aspirations for using space activities to benefit its population. It has formed a major commercial communications spacecraft capability using U.S.-developed satellites launched by Ariane boosters. A Malaysian astronaut also spent 10 days on board the ISS.

Even the tiny but wealthy city-state of Singapore is laying the groundwork for a serious space program. This will take the country beyond the glitzy marketing that surrounds space-themed hotels and proposed suborbital rides for wealthy space tourists.

"Singapore has recently begun sending large numbers of scientists, engineers, and military officers abroad for space training, and promising big salaries to attract aerospace faculty to its own universities," Moltz said in the *Boston Globe*. "In 2011, it paid India to put the first domestically produced Singaporean satellite into orbit. The tiny nation seems well poised to develop a niche capability in maritime operations and reconnaissance," he noted.

The new North Korean launch pad and service tower are much larger than required for the white Unha-3 rocket being serviced at the site. This indicates North Korea plans to launch larger rockets from the same facility. Credit: KCNA

Responses from India

At around the time Singapore began reaching for greater space development, India's government specifically ordered the Indian Space Research Organization (ISRO) to develop Indian military satellites in response to China and Pakistan.

"Evidence shows that China and India are watching each other's activities in space very carefully and keeping score as to who is gaining and losing influence," said Moltz in a *Space Quarterly* interview.

China's ASAT test "highlighted the long-term global threats to India's considerable space assets," said Gopalaswamy in a Carnegie Endowment report. India is now deciding how to handle any future Chinese ASAT tests, he said. If one occurs, India will be prepared to test an ASAT weapon of its own, comprising Indian antiballistic missile hardware.

China's 2007 and 2010 lunar orbit missions have also blunted India's prestige. The missions have prompted India to increase its own space budget sharply, by 38%, and to shift from crop monitoring and hydrology to military space efforts as well as higher visibility exploration missions.

Indian and other Asian space experts have told *Aerospace America* that India is set on winning its space race with China and Pakistan, having resolved to spend the money and make the project decisions necessary to make that happen.

But the broader Asian space race is just getting started, on many different levels in many different countries, and the outcome will take years, if not decades, to sort out.

Asia-Pacific
(Continued from page 37)

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25 Years Ago, 1988

Sept. 6 China's first experimental weather satellite, Fengyun 1 (Wind and Cloud-1), is successfully orbited by a Long March 4 rocket sent aloft from the Taiyuan launch site in north central China. The craft is designed to monitor the country for natural disasters, particularly flooding by China's major rivers, and for droughts and sandstorms. NASA, *Astronautics and Aeronautics, 1986-90*, p. 189.

Sept. 19 Israel launches its first experimental satellite, Horizon 1, from a site in the Negev desert. NASA, *Astronautics and Aeronautics, 1986-90*, p. 191.

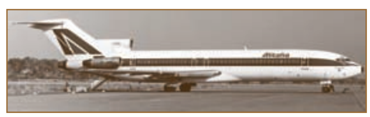
50 Years Ago, September 1963

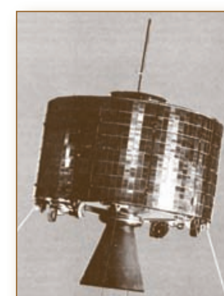
Sept. 1 George E. Mueller succeeds Brainerd Holmes as the chief of NASA's manned space program. Holmes has resigned over policy issues. *Aviation Week*, July 29, 1963, p. 26.

Sept. 2 Two flight tests of the M-2 lifting body take place at NASA's Flight Research Center at Edwards AFB. Milton O. Thompson is the pilot. One objective of the tests is to determine the feasibility of landing a lifting body reentry vehicle the same way a conventional aircraft lands. Another goal is to investigate whether a human can control the M-2 during low-speed operations. The vast experience gained from these efforts proves invaluable in the later development of the space shuttle. *Aviation Week*, Sept. 9, 1963, p. 34; *Flight International*, Sept. 12, 1963, p. 478.

Sept. 8 Sir Leonard Bairstow, a professor and world leading pioneer in the study of aerodynamics, dies at 83 in Winchester, England. His work *Applied Aerodynamics*, published in 1919, served as a basic text on the subject for two generations and was so comprehensive that a second edition was not published until 25 years later, in 1944. While at the National Physical Laboratory he helped establish its Aerodynamics Division. *The Aeroplane*, Sept. 19, 1963, p. 6; *Flight International*, Sept. 19, 1963, p. 489.

Sept. 18 An Alitalia Airlines Boeing 727 lands at Fiumicino Airport in Rome from the Azores, ready for a world tour and a thorough evaluation on the various routes it will fly. The aircraft has slightly modified seating arrangements to provide more facilities and comfort for the demonstration staff during the tour. *The Aeroplane*, Sept. 26, 1963, p. 10.





Sept. 23 The Syncom II communications satellite relays a transmission of a speech and teletype between Fort Dix, N.J., and the U.S. ship Kingsport, about 40 mi. west of Lagos, Nigeria. It is the first such transmission from a communications satellite to a moving ship. *NASA Press Release 63-213*; *Aviation Week*, Sept. 30, 1963, p. 37.

Sept. 23 Tanya Titov becomes the first child born to a space traveler. She is the daughter of Soviet cosmonaut Maj. Gherman Titov and his wife Tamara. Maj. Titov orbited the Earth 17 times in the Vostok II spacecraft on Aug. 6, 1961. *New York Times*, Sept. 1963, p. 8.

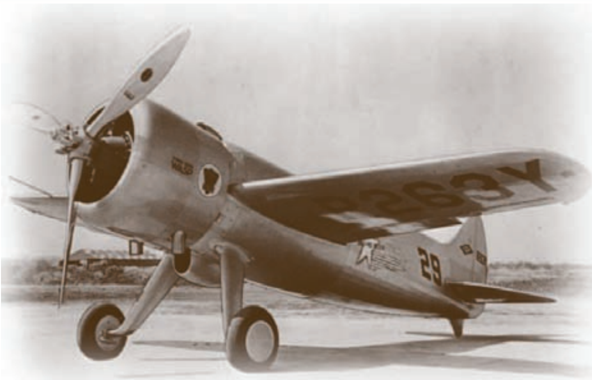
Sept. 23-25 The Syncom II communications satellite conducts its first TV experiments. Test TV pattern signals are sent on Sept. 23 and TV pictures on the following two days. Because of bandwidth limitations, no audio is sent. The transmissions originate at the Fort Dix, N.J., ground station and are sent to the satellite, which is positioned 22,300 mi. above Earth, then are retransmitted to an AT&T ground station at Andover, Me. *NASA News Release 63-216*.

Sept. 26-Oct. 1 The 14th International Astronautical Federation Congress is held in Paris and attracts over 1,000 delegates from 34 countries. Yuri Gagarin, the first person to fly in space, addresses the Congress on Sept. 28. He says the Soviets plan to dock several individual vehicles in Earth orbit in order to construct a space station from which a manned mission will be sent to the Moon. However, the latter plan does not come about. *Missiles and Rockets*, Sept. 30, 1963, p. 26; *Aviation Week*, Oct. 2, 1963, p. 30, and Oct. 7, 1963, p. 30.

Sept. 28 The Navy's Transit 5B navigation satellite is launched by a Thor Able-Star from Vandenberg AFB, Calif. It is the first satellite to be completely powered by an isotope power generator, known as the Snap-9A, for systems nuclear auxiliary power. Developed by the Nuclear Division of Martin, Snap-9A uses a thermoelectric energy conversion system. It weighs 27 lb and is designed to generate 25 W of power continuously for five years. *Aviation Week*, Oct. 7, 1963, p. 37.

Past

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



75 Years Ago, September 1938

Sept. 3-5 Roscoe Turner, flying a Turner-Laird RT-14 Racer, wins the 300-mi. (10-mi., 30-lap course) Thompson Trophy Race at the 18th annual National Air Races at Cleveland's municipal airport. His winning average speed is 283.4 mph. Other major events at the races are the Bendix Transcontinental Speed Dash, won by Jacqueline Cochran, and the 200-mi. Greve Trophy Race, won by Tony LeVier. *Aero Digest*, Sept. 1938, pp. 57-58; *Aero Digest*, Oct. 1938, pp. 46-48, 80.

Sept. 12 The new Wright brothers high-pressure wind tunnel is inaugurated at the Guggenheim School of Aeronautics, at MIT. The first of its type built in the U.S., the tunnel allows investigation of substratospheric flight conditions at speeds above 400 mph and accommodates wing models measuring up to 8 ft.E. Emme, ed., *Aeronautics and Astronautics 1915-60*, p. 36; *Aero Digest*, Oct. 1938, p. 63.

Sept. 14 Hugo Eckener christens the LZ-130 Graf Zeppelin by smashing a bottle of liquid air over its cowl. The huge airship is then towed from its hangar at Friedrichshafen, Germany, and sails on its maiden voyage. It carries a crew of 29 and 45 officials of the Zeppelin firm and of the German Air Ministry. Although designed for helium, the ship is filled with hydrogen for this flight. *Aviation*, Oct. 1938, p. 53.

Sept. 29 U.K. Prime Minister Neville Chamberlain makes the most famous of his diplomatic flights to Germany. There he helps to arrange for the transfer of the Sudetenland, a German-populated territory, from Czechoslovakia to Germany. Chamberlain hopes thereby to pacify Hitler, claiming 'peace in our time.' He flies in a British Airways Lockheed 14. *The Aeroplane*, Oct. 5, 1938, p. 397.

Sept. 29 Brig. Gen. Henry H. 'Hap' Arnold is named chief of the Army Air Corps. He succeeds Maj. Gen. Oscar Westover, who was killed in the crash of a Northrop attack plane on Sept. 21 near Burbank, Calif. *Aircraft Year Book, 1939*, p. 468; W. Shrader, *Fifty Years of Flight*, p. 66.

And During September 1938

—Cessna introduces its 1939 Airmaster, a four-passenger plane that cruises at 143 mph at sea level. Powering the aircraft is a 145-hp Warner Super Scarab engine that attains 15 mph, comparable to an average 1938 car. The 34-ft 2-in.-span airplane's maximum speed is 162 mph. *Aviation*, Oct. 1938, pp. 44-45.

100 Years Ago, September 1913

Sept. 18 The Avro 504, which will be among the most successful airplanes in aviation history, principally as Britain's leading trainer, flies for the first time. Two days later it makes its public debut at the Aerial Derby at Hendon, England. The aircraft also serves as a fighter, bomber, seaplane, and transport, among other roles. In its numerous models it flies on every continent for over three decades. C. Gibbs-Smith, *Aviation*, pp. 160, 167, 172-173, 176; A. Jackson, *Avro Aircraft Since 1908*, pp. 52-133.

Sept. 23-27 Katherine Stinson becomes the first woman authorized to carry air mail, during the Montana State Fair, at Helena, Mont. Stinson achieves other firsts as well, becoming the first woman in the world to loop-the-loop, on July 18, 1915, at Chicago; to fly in the Orient, making a six-month tour to Japan and China in 1916-1917; and, as a civilian, to carry air mail in Canada, on July 9, 1918. *Aerial Age Weekly*, Jan. 17, 1916, p. 423; Katherine Stinson biographical sheet, NASM Library.

And During September 1913

—France's Adolphe Pégoud becomes the first well-known aerial acrobatist, adopting Nesterov's loop-the-loop as part of his repertoire. He has also achieved the distinction of making the first parachute jump in Europe, in Aug. 1913. C. Gibbs-Smith, *Aviation*, p. 166.

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AIAA Bulletin

Robert Williams (right), Research Director of the AFRL Discovery Laboratory at Wright-Patterson AFB, receives the 2013 AIAA Engineer of the Year Award for exquisite engineering of an agile, all-source data fusion system for national security and for leadership of an innovative, high impact STEM outreach program. The award was presented at the AIAA Dayton Cincinnati Section Honors and Awards Banquet by Section Chair Oliver Leembruggen (left) on 20 May.

SEPTEMBER 2013

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Event & Course 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				
8–9 Sep	Introduction to Space Systems	San Diego, CA		
8–9 Sep	Satellite Communications, Today and Tomorrow: Technical Basics and Market and Technology Trends	San Diego, CA		
10–12 Sep	AIAA SPACE 2013 Conference & Exposition	San Diego, CA	*Sep 12*	**31 Jan 13**
10–12 Sep	Human Engineering Principles for Flight Deck Evaluations	Tullahoma, TN		
11 Sep	Missile Defense: Past, Present, and Future	Webinar (1300–1430 hrs EDT)		
17–21 Sep†	International Conference on Jets, Wakes, and Separated Flows	Nagoya, Japan (Contact: Ephraim Gutmark, 513.556.1227, Ephraim.gutmark@uc.edu, www.icjwsf2013.org)		
23–24 Sep	Gossamer Systems: Analysis and Design	Palmdale, CA		
23–24 Sep	Sensor Systems and Microsystems: From Fabrication to Application	Palmdale, CA		
23–27 Sep†	64th International Astronautical Congress	Beijing, China (Contact: http://www.iac2013.org)		
24–25 Sep†	Atmospheric and Ground Effects on Aircraft Noise	Sevilla, Spain (Contact: Nico van Oosten, nico@anotecc.com, www.win.tue.nl/ceas-asc)		
6–10 Oct†	32nd Digital Avionics Systems Conference	Syracuse, NY (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)		
13–16 Oct†	22nd International Meshing Roundtable	Orlando, FL (Contact: Cherri Porter, 505.844.2788, cporter@sandia.gov.www.imr.sandia.gov)		
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**
14–17 Oct†	Reinventing Space Conference 2013	Los Angeles, CA (Contact: www.ReinventingSpace.org)		
21–24 Oct†	International Telemetering Conference/USA	Las Vegas, NV (Contact Lena Moran, 575.415.5172, lmoran@traxintl.com, www.telemetry.org)		
24–25 Oct†	Satellite Communications (JC-SAT 2013)	Fukuoka, Japan (Contact F. Yamashita, yamashita.fumihiro@lab.ntt.co.jp, www.ieice.org/cs/sat/jpn/purpose_e.html		
3–7 Nov†	22nd International Congress of Mechanical Engineering – COBEM 2013	Ribeirao Preto, Brazil (Contact: Joao Luiz F. Azevedo, joaoluiz.azevedo@gmail.com, www.abcm.org.br/cobem2013)		
5–7 Nov†	8th International Conference Supply on the Wings	Frankfurt, Germany (Contact: R. Degenhardt, +49 531 295 3059, Richard.degenhardt@dlr.de, www.airtec.aero)		
5–7 Nov†	Aircraft Survivability Technical Forum 2013	Monterey, CA (Contact: Meredith Hawley, 703.247.9476, mhawley@ndia.org, www.ndia.org/meetings/4940)		
2014				
13–17 Jan	AIAA SciTech 2014 (AIAA Science and Technology Forum and Exposition 2014) **Featuring:** 22nd AIAA/ASME/AHS Adaptive Structures Conference 52nd AIAA Aerospace Sciences Meeting AIAA Atmospheric Flight Mechanics Conference 15th AIAA Gossamer Systems Forum AIAA Guidance, Navigation, and Control Conference AIAA Modeling and Simulation Technologies Conference 10th AIAA Multidisciplinary Design Optimization Specialist Conference 16th AIAA Non-Deterministic Approaches Conference 55th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference 7th Symposium on Space Resource Utilization 32nd ASME Wind Energy Symposium	National Harbor, MD		**5 Jun 13**
26–30 Jan†	24th AAS/AIAA Space Flight Mechanics Meeting	Santa Fe, NM Contact: http://www.space-flight.org/docs/2014_winter/2014_winter.html	*Jun 13*	**2 Oct 13**
27–30 Jan†	Annual Reliability and Maintainability Symposium (RAMS) 2014	Colorado Springs, CO (Contact: Jan Swider, 818.586.1412, jan.swider@pwr.utc.com)		
2–6 Feb†	American Meteorological Society Annual Meeting	Atlanta, GA (Contact: Claudia Gorski, 617.226.3967, cgorski@ametsoc.org, http://annual.ametsoc.org/2014/)		

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
1–8 Mar†	2014 IEEE Aerospace Conference	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)		
30 Apr	2014 Aerospace Spotlight Awards Gala	Washington, DC		
5–9 May	SpaceOps 2014: 13th International Conference on Space Operations	Pasadena, CA	*May 13*	**5 Aug 13**
26–28 May	21st St. Petersburg International Conference on Integrated Navigation Systems	St. Petersburg, Russia (Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru)		
16–20 Jun	AVIATION 2014 (AIAA Aviation and Aeronautics Forum and Exposition) **Featuring:** 20th AIAA/CEAS Aeroacoustics Conference 30th AIAA Aerodynamic Measurement Technology Conference AIAA/3AF Aircraft Noise and Emissions Reduction Symposium 32nd AIAA Applied Aerodynamics Conference AIAA Atmospheric Flight Mechanics Conference 6th AIAA Atmospheric and Space Environments Conference 14th AIAA Aviation Technology, Integration, and Operations Conference AIAA Balloon Systems Conference 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 11th AIAA/ASME Joint Thermophysics and Heat Transfer 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 7th AIAA Theoretical Fluid Mechanics Conference	Atlanta, GA		**15 Nov 13**
22–27 Jun†	12th International Probabilistic Safety Assessment and Management Conference	Honolulu, HI (Contact: Todd Paulos, 949.809.8283, secretariat@psam12.org, www.psam12.org)		
15–18 Jul†	ICNPAA 2014 – Mathematical Problems in Engineering, Aerospace and Sciences	Narvik University, Norway (Contact: Seenith Sivasundaram, 386.761.9829, seenithi@aol.com, www.icnpaa.com)		
28–30 Jul	Propulsion and Energy 2014 (AIAA Propulsion and Energy Forum and Exposition) **Featuring:** 50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference 12th International Energy Conversion Engineering Conference	Cleveland, OH		**Nov 13**
2–10 Aug†	40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events	Moscow, Russia http://www.cospar-assembly.org		
5–7 Aug	SPACE 2014 (AIAA Space and Astronautics Forum and Exposition) **Featuring:** AIAA/AAS Astrodynamics Specialist Conference AIAA Complex Aerospace Systems Exchange 32nd AIAA International Communications Satellite Systems Conference AIAA SPACE Conference	San Diego, CA		**Feb 14**
7–12 Sept†	29th Congress of the International Council of the Aeronautical Sciences (ICAS)	St. Petersburg, Russia (Contact: www.icas2014.com)		**15 Jul 13**

For more information on meetings listed above, visit our website at www.aiaa.org/calendar or call 800.639.AIAA or 703.264.7500 (outside U.S.).

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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.

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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.

From the Corner Office

IDENTITY CRISIS?

Klaus Dannenberg, Deputy Executive Director

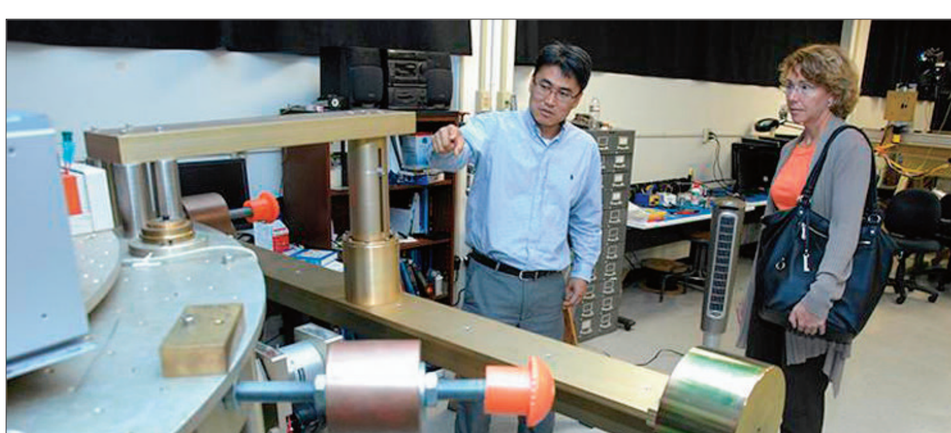
If you've been reading these Corner Office columns over the past few months, you'll know that Mike, Sandy, and I have been discussing our Strategic Plan and many of its planning aspects as we move forward. We've had discussions covering key upcoming changes: from a greater emphasis on engaging our members at the Section level to a revamped business and operations model for our premier annual events. We could easily discuss many other changes in our processes: changes in delivery mechanisms to include social media, upcoming changes in our publications, updating *Aerospace America* to appeal to younger professionals, among others, both at significant levels and tinkering at the margin with our current products and services. Many of these changes are overdue and have been under evaluation for some time. But to be honest, we were reluctant to fiddle with formulas that have worked for decades. We (and every other professional and trade association) have been dismayed by the business impacts resulting from today's environment, that is the ugly combination of declining membership coupled with sequestration and ultra-tight budgets, all of which have been "supersized" for associations with meetings as a result of the fallout of the GSA and IRS scandals. Many associations are struggling to maintain their business viability. Our technical quality and strong reputation have sustained us so far, better than many of our sister associations. We think they will continue to do so for a while, especially as we adapt to the current environment with some of the changes mentioned above. But we ignore the need for more fundamental change at the risk of becoming obsolete and irrelevant. That is the hidden benefit of the severe and challenging business environment we are experiencing right now—it really has forced us into an identity crisis! Who are we? What do we want to be 5 years from now? Or 10?

As Mike addressed last month, the center of our profession's work emphasis today has changed from what it was a just a couple of decades ago. Today, most of our industry works in integration of technical disciplines and details to produce products that meet a business need. The aviation and space platforms that have been the object of our attention for many decades are now just pieces of a big applications puzzle. They are big and important key pieces for sure, but the focus of innovation has changed dramatically to adapting these elements for new and changing missions. For example, the same Unmanned System can be used for firefighting in the American West or for monitoring and catching big game poachers in Africa as well as more classic applications like Intelligence, Surveillance, and Reconnaissance. Each mission has its own requirements for sensor types, resolution, data transmission, and other specifications, but they almost always include cost and business objectives too. These constraints define and bound the systems engineering design challenges faced by practitioners today. On a larger scale, we must also usually enable several of these systems to work together, adding communications requirements, time and space positioning requirements, and cyber security requirements as well as the challenges of integration into an operational environment. Now a key question relevant to professional associations like ours becomes " How do we integrate the operators, users, and associated parallel technologies involved in the application of aerospace systems into our network of professionals?" Do we create operator, end user, and/or mission-oriented Technical Committees, publications, and conferences? To me, it would appear that would spread our community too thin to be productive, but we need to include these new constituencies. How? Will teaming with other societies work? Or will that create too much technical and business overlap? In addition to our legacy missions of moving people and goods by air and providing defense capabilities for our military, some of today's key mission areas that we have not historically dealt with in a meaningful way include climate research, homeland security, law enforcement, and space tourism. But each area requires inclusion of technical, business, and operational issues to be meaningful to the practitioners active in that area.

This is the major strategic question we need to answer as soon as we can: "What constituencies will represent the AIAA of the future?" I suspect that we will always have propulsion, structures, guidance & control, avionics, airplanes, launch vehicles and spacecraft, among others. But how do we incorporate and engage users, operators, and missions? Or investments, insurance, operational risk mitigation, and other critical aspects? These are interactions that are not occurring today, but that need to happen! When we have an answer to that, we can tailor products and services for those constituent groups while actively engaging their practitioners. The Institute Development Committee and the Executive Committee are holding a joint off-site on exactly this subject late in August. We will let you know the results. *But better yet, we eagerly solicit your comments and thoughts on this subject.* You can always reach me at klausd@aiaa.org. Help us with our identity crisis and give us your opinions. We want to hear your thoughts and will actively incorporate them into our discussions and plans. I can hardly wait to see how we will evolve!

On 18 July 2013, AIAA Executive Director Dr. Sandy Magnus was given a tour of the Bifocal Relay Mirror Spacecraft Laboratory by Naval Postgraduate School (NPS) Department of Mechanical and Aerospace Engineering Research Assistant Professor Jae-Jun Kim.

Dr. Magnus met with NPS faculty and leadership and conducted an information sharing session with students. She concluded her visit by meeting with AIAA members representing the organization's Point Lobos Section (PLS). NPS serves as a base for the AIAA Point Lobos Section.



EDITORIAL: STANDARDS, ITAR, AIAA, AND THE UNITED STATES IN THE AEROSPACE UNIVERSE

Dave Finkleman, Ph.D., Lifetime Fellow

Mike Griffin stated in the latest *Bulletin* serious concerns about the future of AIAA as membership, participation, and revenues decline. AIAA is the only aerospace professional body that encompasses industry, government, and academia. This representation is critical to the role of the United States in global, even universal, aerospace. Industrial organizations such as the Aerospace Industries' Association and the Satellite Industry Association represent important commercial interests. The American Astronautical Society is "Astronautical." None but AIAA can draw on the broad spectrum of aerospace expertise and interests. None but AIAA is composed mainly of individuals furthering their critical profession. AIAA cannot fail.

The AIAA standards enterprise is essential to the Institute's health and future. Mike stated that the VP for Technical Activities may be the most important AIAA officer. But none of the officers stand alone. TAC conferences are a major source of Institutional revenue. But TAC cannot advance research and practice without publications and standards. We cannot all attend many conferences or publish many scholarly papers. The duties and responsibilities of most members do not allow that. But we all do something generally related to aerospace practice. As graduates of arguably the most rigorous and difficult university curricula, members are able to assess whether standards in progress are clear, objective, and feasible even in unfamiliar disciplines. Virtually everyone can contribute to developing standards that have immense national and international value.

Federal ITAR and international commerce authorities have declared Standards Development free of ITAR restrictions. Not just exempt, but free. This is because standards deal with what to do, not how to do it. For example, standards for screw threads establish thread pitch, depth, and other parameters but they do not tell anyone how to machine a screw. Space standards deal with interfaces and approaches to formatting and transmitting orbit data. They do not mandate how to achieve those interfaces or determine orbits.

Federal comptrollers recognize the significance of standards with guidance to sustain travel and other essential elements of standards development despite sequestration.

Members serve the AIAA standards enterprise generally as expert engineers and scientists, not as representatives of their employer or institution. Standards must be developed by persons representing diverse interests, such as industry, academia, and government, with no individual interest dominating. AIAA standards recognize co-authorship, providing surrogate publication opportunities.

Members can contribute outside of normal duty hours. The work is completely voluntary; therefore, no employer should prohibit such involvement outside of work and without compensation, although many allow such effort during duty hours.

We exhort members to participate in developing AIAA standards to enhance the Institute's stature and influence, to contribute directly to furthering the aerospace professions, to keep abreast of worldwide developments and needs within whatever the ITAR might be, and to disseminate and endorse the practices of United States industry. We also need members to gain experience to lead AIAA standards activities and accede to leadership.

NEW STANDARDS AVAILABLE: AIAA SPACE PLUG-AND-PLAY ARCHITECTURE

For the first time ever, AIAA is releasing a full set of standards (10 total) dedicated to plug-and-play (PnP) capabilities. This technology, which evolved from the desire to quickly and reliably assemble spacecraft, has been a challenge since the 1960s. In the 1990s the international computer market noted a similar need to quickly and reliably assemble computers and computer accessories. The invention of PnP capabilities is now assumed for any modern terrestrial computer system. In these Space Plug-and-Play Architecture (SPA) standards, the focus is on the technical approaches to adapt the various computer PnP capabilities to small spacecraft and the space environment, aiming to reduce the cost and timeline of getting spacecraft into operational use. The set comprises eight standards and two guides; highlighted features include:

- A general description of a data-centric spacecraft model to form the on-board PnP network with illustrations to indicate clearly how this works.
- A common ontology to allow for a profile-specific Common Data Dictionary (CDD) so that a stable set of terms may exist.
- Interfaces between devices to simplify the implementation of PnP at the device level.
- Descriptions of PnP protocols identified to date, as well as descriptions of the adaptations needed for space application.

The SPA standards may be accessed individually or as a set:

*AIAA G-133-1—Space Plug and Play Architecture: Standards Development Guidebook (provides an overview for spacecraft platform (system), subsystem, and component (including payload) developers with spacecraft plug-and-play architectures to promote rapid design, fabrication, integration, and test)

AIAA S-133-2—Space Plug-and-Play Architecture Standard: Networking (specifies the overall SPA network methodology, the approach to abstraction of unique transport details, and methods of communicating across multiple similar and dissimilar networks)

AIAA S-133-3—Space Plug-and-Play Architecture Standard: Logical Interface (the conceptual boundary through which components are able to participate in a SPA system)

AIAA S-133-4—Space Plug-and-Play Architecture Standard: Physical Interface (identifies the significant features of the SPA interface connector(s) and the associated cabling to allow SPA device and cable manufacturers to build systems that interconnect successfully with SPA-enabled spacecraft)

AIAA S-133-5—Space Plug-and-Play Architecture Standard: 28V Power Service (establishes specifications regarding the quality of the power service such as voltage ripple, transients, and interruptions)

AIAA S-133-6—Space Plug-and-Play Architecture Standard: System Timing (establishes a common method for providing common timing within a system of networked SPA components)

AIAA S-133-7—Space Plug-and-Play Architecture Standard: Ontology (establishes the electronic data sheet for SPA for application in the space environment)

AIAA S-133-8—Space Plug-and-Play Architecture Standard: Test Bypass (defines the current state of practice for test bypass, which is the mechanism by which test data may be injected into the running SPA system, or by which operational data may be extracted from various test points within the system during integration and test)

AIAA S-133-9—Space Plug-and-Play Architecture Standard: SpaceWire Subnet Adaptation (specifies the means by which the SPA features of networked component registration and message routing to endpoints on a SpaceWire network are facilitated)

AIAA G-133-10—Space Plug-and-Play Architecture Guide: System Capabilities (outlining the basic principles of the architecture and the services that a SPA system provides)

For more information, please contact the Director of Standards, Nick Tongson, at nickt@aiaa.org.

*Please note that the adaptation of terrestrial plug-and-play technologies to the space environment requires more than a simple IT protocol adaptation. While SPA primarily deals with data structure and movement, examination of other aspects of the spacecraft architecture are also necessary. These documents describe necessary form factors ("plug" factors) and discovery/operation factors ("play" factors) for a SPA system. Reviewing the SPA Guidebook first is recommended to get oriented.

BARBEE AWARDED 2013 HAL ANDREWS YOUNG ENGINEER SCIENTIST OF THE YEAR

On 6 June, **Brent Barbee** was awarded the Hal Andrews Young Engineer Scientist of the Year at the National Capital Section's (NCS) Annual Awards Banquet in Arlington, VA. He was recognized "For innovative astrodynamics research in human exploration of near-earth asteroids; for pioneering analysis leading to new methods of locating human accessible asteroids; and excellence in teaching."

Mr. Barbee earned his B.S. and M.S. in Aerospace Engineering at University of Texas at Austin in 2003 and 2005. He has been a Flight Dynamics Engineer at NASA Goddard Space Flight Center for the past three years. As technical lead for NASA's Near-Earth Object (NEO) Human Space Flight (HSF) Accessible Targets Study (NHATS), Barbee developed embedded trajectory grid methods implemented in a software package to compute the complete multi-dimensional round-trip trajectory design space in a sufficiently efficient manner to permit the calculation of all possible round-trip trajectories to all known NEAs using distributed parallel processing. Barbee has published over 15 papers in technical journals and conferences. In addition, he teaches classes in astrodynamics at the University of Maryland.

From left to right, Prof. Norman M. Wereley, Chair, AIAA-NCS Honors and Awards Committee and University of Maryland; Brent Barbee, Daniel Solomon, NASA Goddard; and M. Bruce Milam, AIAA NCS Chair

NEW HISTORIC SITES DESIGNATED

The AIAA Historic Sites Program recently designated Pitcairn Field, in Willow Grove, PA, as a Historic Aerospace Site. The field was purchased by Harold Pitcairn, who started an air passenger service and aircraft company shortly after World War I. With a partner, Agnew Larsen, Pitcairn established the Pitcairn Aviation Company, and their first plane was the PA-1 Fleetwing. They bid on and won a Contract Mail Route, C.A.M. 19, but realized that all the aircraft of the time were so slow that they were not profitable. To overcome that, the Pitcairn Company created the PA-5 Mailwing, which proved to be so popular that it was used by 13 other mail route contractors.

Pitcairn Field, however, is truly known for its work on rotary aircraft. Harold Pitcairn had become fascinated with the Autogiro and the work of Juan de la Cierva in Spain, and purchased the rights to manufacture the C.8 Autogiro in the United States. The unpowered revolving blades on the top of an autogiro had great implications for safe vertical landings, and Pitcairn continued to tinker and then create his own Autogiro designs. For their work, Pitcairn and his associates were awarded the 1930 Collier Trophy by President Herbert Hoover.

The helicopter eclipsed the Autogiro during World War II because of its capability to hover, but the helicopter would not have been invented were it not for the work of de la Cierva and Pitcairn on the Autogiro. Unfortunately, Pitcairn's company became embroiled in a patent dispute with the U.S. government that was not resolved until 17 years after Harold Pitcairn's death.

In 1948, the field was sold to Tinius Olsen, a testing machine manufacturing company, which is still in business on the property. Jay Millane, Chairman of the Board of Tinius Olsen, spoke at the AIAA ceremony, as did Carl Gunther, a relation of Harold Pitcairn and the historian of the Pitcairn family. AIAA Region I Director Ferd Grosveld presided at the ceremony, along with Brett Hoffstadt of the Greater Philadelphia Section.

Region I Director Ferd Grosveld unveils the Pitcairn Field plaque with Pitcairn family historian Carl Gunther and Tinius Olsen Chairman Jay Millane on the site of Pitcairn Field.


A PA-2 Pitcairn Autogiro landing at the White House during the Collier Trophy ceremony, 22 April 1931.

CALL FOR NOMINATIONS

Nominations are being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 October**. Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines to view nominee eligibility, page limits, letters of endorsement. All nominations must comply with the limit of 7 pages for the nomination package; see details on the webpage (**https://www.aiaa.org/secondary.aspx?id=230**).

Premier Awards & Lectureships

Distinguished Service Award gives unique recognition to an individual member who has provided distinguished service to the Institute over a period of years.

Goddard Astronautics Award is the highest honor AIAA bestows for notable achievement in the field of astronautics.

International Cooperation Award recognizes individuals who have made significant contributions to the initiation, organization, implementation, and/or management of activities with significant U.S. involvement that includes extensive international cooperative activities in space, aeronautics, or both.

Reed Aeronautics Award is the highest award AIAA bestows for notable achievement in the field of aeronautics.

Dryden Lectureship in Research emphasizes the importance of basic research to the advancement in aeronautics and astronautics and is a salute to research scientists and engineers.

Durand Lectureship for Public Service is given for notable achievements by a scientific or technical leader whose contributions have led directly to the understanding and application of the science and technology of aeronautics and astronautics for the betterment of mankind.

von Kármán Lectureship in Astronautics recognizes an individual who has performed notably and distinguished himself technically in the field of astronautics.

Wright Brothers Lectureship in Aeronautics emphasizes significant advances in aeronautics by recognizing major leaders and contributors. (Presented odd years)

Technical Excellence Awards

Aeroacoustics Award is presented for an outstanding technical or scientific achievement resulting from an individual's contribution to the field of aircraft community noise reduction.

Aerodynamics Award is presented for meritorious achievement in the field of applied aerodynamics, recognizing notable contributions in the development, application, and evaluation of aerodynamic concepts and methods.

Aerodynamic Measurement Technology Award honors continued contributions and achievements toward the advancement of advanced aerodynamic flowfield and surface measurement techniques for research in flight and ground test applications.

Aircraft Design Award is given to a design engineer or team for the conception, definition, or development of an original concept leading to a significant advancement in aircraft design or design technology.

Chanute Flight Test Award recognizes significant lifetime achievements in the advancement of the art, science, and technology of flight test engineering. (Presented even years)

de Florez Award for Flight Simulation is presented for an outstanding individual achievement in the application of flight simulation to aerospace training, research, and development.

Engineer of the Year is given to a member of AIAA who has made a recent significant contribution that is worthy of national recognition. Submit nominations to your AIAA Regional Director.

Fluid Dynamics Award is presented for outstanding contributions to the understanding of the behavior of liquids and gases in motion as related to need in aeronautics and astronautics.

Ground Testing Award is given for outstanding achievement in the development or effective utilization of technology, procedures, facilities, or modeling techniques or flight simulation, space simulation, propulsion testing, aerodynamic testing, or other ground testing associated with aeronautics and astronautics.

Hap Arnold Award for Excellence in Aeronautical Program Management is presented to an individual for outstanding contributions in the management of a significant aeronautical or aeronautical-related program or project.

Hypersonic Systems and Technologies Award recognizes sustained, outstanding contributions and achievements in the advancement of atmospheric, hypersonic flight and related technologies. (Presented every 18 months)

F. E. Newbold V/STOL Award recognizes outstanding creative contributions to the advancement and realization of powered lift flight in one or more of the following areas: initiation, definition and/or management of key V/STOL programs; development of enabling technologies including critical methodology; program engineering and design; and/or other relevant related activities or combinations thereof that have advanced the science of powered lift flight.

Losey Atmospheric Sciences Award recognizes outstanding contributions to the atmospheric sciences as applied to the advancement of aeronautics and astronautics.

Otto C. Winzen Lifetime Achievement Award is presented for outstanding contributions and achievements in the advancement of free flight balloon systems or related technologies. (Presented odd years)

Piper General Aviation Award is presented for outstanding contributions leading to the advancement of general aviation. (Even years)

Plasmadynamics and Lasers Award is presented for outstanding contributions to the understanding of the physical properties and dynamical behavior of matter in the plasma state and lasers as related to need in aeronautics and astronautics.

Jay Hollingsworth Speas Airport Award is given to the person(s) judged to have contributed most outstandingly in the recent past toward achieving compatible relationships between airports and/or heliports and adjacent environments. Award consists of a certificate and a $10,000 honorarium. Cosponsored by AIAA, the American Association of Airport Executives, & the Airport Consultants Council.

Theodor W. Knacke Aerodynamic Decelerator Systems Award recognizes significant contributions to the effectiveness and/or safety of aeronautical or aerospace systems through development or application of the art and science of aerodynamic decelerator technology. (Presented odd years)

Thermophysics Award is given for an outstanding singular or sustained technical or scientific contribution by an individual in thermophysics, specifically as related to the study and application of the properties and mechanisms involved in thermal energy transfer and the study of environmental effects on such properties and mechanisms.

James Van Allen Space Environments Award recognizes outstanding contributions to space and planetary environment knowledge and interactions as applied to the advancement of aeronautics and astronautics. (Presented even years)

Service Award

Public Service Award honors a person outside the aerospace community who has shown consistent and visible support for national aviation and space goals.

For more information, contact Carol Stewart, Manager, AIAA Honors and Awards, carols@aiaa.org or 703.264.7623.

AIAA HOUSTON SECTION'S ANNUAL TECHNICAL SYMPOSIUM (ATS 2013)

Dr. Steven E. Everett and Douglas Yazell

AIAA Houston Section held its 2013 Annual Technical Symposium (ATS) at the NASA Johnson Space Center Gilruth Center on 17 May, for affiliates from the space center and the numerous surrounding companies and education institutions in South Texas. Before a crowd that grew to over 120 by day's end, General Chair Ellen Gillespie introduced the morning's first keynote speaker, Alires Almon, Orchestrator of Engagement for the 100 Year Starship (100YSS) project. Almon began the discussion by showing the manifesto video of the nonprofit foundation. 100YSS was funded in 2011 by grants from DARPA and NASA Ames Research Center. The task is to achieve human interstellar travel capabilities in the next 100 years. After reviewing the group's vision and mission, Almon stressed that despite the far-reaching goals of the program, the development effort would benefit Earth now in ways such as revitalization of research, as a guide for collaboration, job creation, and acceleration of technology development. She continued by listing 100YSS Foundation partners, from SETI to Nichelle Nichols of Star Trek fame. Almon then talked about upcoming public outreach events, including the 19–22 September 100YSS Public Symposium in Houston.

AIAA Houston Section then welcomed Anousheh Ansari as the morning's second keynote speaker. She is the first Iranian in space and cosponsor of the Ansari X Prize. She provided comments on the inspiration for the X Prize Foundation, potential additional X Prizes, and the importance of space travel in improving life on Earth and understanding ourselves. Ansari showed a video highlighting her self-funded trip to the International Space Station (ISS). Ansari was also present for the remainder of the day to sign copies of her 2011 book, *My Dream of Stars: from Daughter of Iran to Space Pioneer* (available from Amazon).

Anousheh Ansari

The day proceeded with three simultaneous tracks on a range of themes such as

- Aeronautics/Astronautics
- Propulsion
- Guidance, Navigation & Control (GN&C)
- Systems Engineering
- Aerosciences
- Extra-Vehicular Activity (EVA)
- Climate Change
- Automation
- Space History and Education

During lunch, questions were posed to a panel (listed as they appear from left to right below) comprised of

- Anousheh Ansari, co-founder and CEO of Prodea Systems and the first female private space explorer;
- Franklin Chang Diaz, seven-time Shuttle astronaut and president and CEO of Ad Astra Rocket Company;
- Art Dula, space lawyer, patent attorney, and founder of the private spaceflight company Excalibur Almaz;
- Beth Fischer, Director of the Engineering Center of Excellence for Honeywell Technology Solutions, Inc.;
- Mike Fossum, Space Shuttle astronaut and ISS Expedition 29 Commander;
- Jack Bacon, noted futurist and technological historian;
- Richard Phillips, founder and president of Phillips & Company;
- Paul Spudis, Senior Staff Scientist at the Lunar and Planetary Institute in Houston;
- Scott Kelly, three-time Space Shuttle astronaut and ISS Expedition 26 commander; and
- Alires Almon, 100 Year Starship Orchestrator of Engagement

The esteemed panel members provided their perspectives on questions posed by panel moderator Beatriz Kelly-Serrato, including their visions for life beyond low Earth orbit, the benefits of space exploration, and the risks and rewards of space travel.

In addition to the continuing sessions after lunch, attendees were treated to a display of NASA's next generation Z-1 spacesuit and the working mock-up of NASA's Small Pressurized Rover. This moon rover would provide a mobile, shirt-sleeve environment for two to four astronauts on the lunar surface. The rover has the capability for entrance and exit without vehicle depressurization thanks to spacesuits docked to the rover. A lucky few drove the rover around the grounds outside the Gilruth Center.

Among the afternoon's more popular sessions was a demonstration of some of the advanced exploration and robotics technologies. Amy Ross arranged for her teammates to be presenters talking about the new NASA spacesuit while it was on display at this event. In the history track, a panel discussion was held with engineers Ken Young, Gary Johnson, and Allen Louviere. They presented a retrospective on the NASA Skylab program in honor of its 40th anniversary. They were followed by Dr. Albert A. Jackson IV, making a presentation about a weekly magazine's eight 1952–1954 installments of articles, the *Collier's*

ATS 2013 General Chair Ellen Gillespie drives the Constellation moon rover.

Dr. Steven E. Everett, our Section GN&C technical committee chair, is shown in beside the spacesuit display, which was arranged by Amy Ross, NASA JSC. Image credits for all photos: Dr. Steven E. Everett and Douglas Yazell.

series "Man Will Conquer Space Soon!" Jackson called attention to the *Horizons' Collier's* project. *Horizons* is the bimonthly newsletter of AIAA Houston Section, and it appears to be the first to reprint this series page by page in high resolution. The original articles were created by a team of writers, editors, and artists led by Wernher von Braun.

The 2013 symposium was a great one thanks to a team led by General Chair Ellen Gillespie. Presentation charts from about twelve of the speakers are already online at the AIAA Houston Section ATS 2013 web page (http://www.aiaahouston.org/2013-annual-technical-symposium).

OBITUARIES

AIAA Associate Fellow Pao Died in January

Sui-Kwong Paul Pao, 72, died on 12 January.

Dr. Pao Paul was born in Lanzhou, China, and attended the National Taiwan University, receiving a B.S. in civil engineering. He came to the United States to attend the University of Florida, from which he received his M.S. and Ph.D. in engineering mechanics.

He began his engineering career in Huntsville, AL, in 1967, working on the Saturn V rocket at Wyle Laboratories and teaching at the University of Alabama. In 1973, he came to NASA Langley Research Center, working as a researcher and manager in aeroacoustics and computational fluid dynamics until his retirement in 2010.

He authored more than 50 publications and was awarded the NASA Exceptional Achievement Medal, among many other awards. He loved his work, and he especially enjoyed mentoring the next generation of aeronautical engineers. Dr. Pao joined AIAA in 1967; he was a very active member of the Hampton Roads Section.

AIAA Senior Member Zemansky Died in March

Stanley D. Zemansky died on 1 March 2013 at the age of 98.

Mr. Zemansky graduated from MIT in 1937 with a degree in aeronautical engineering. He then worked for North American Aviation in Los Angeles helping to design the B-25 Mitchell and the P-51 Mustang, but that work was interrupted when he volunteered for the Navy during World War II. He served overseas in a PBY-5A Black Cat Squadron in the Pacific Theater.

After the war, he returned to North American Aviation and retired from there as a purchasing agent after 25 years. Subsequently, he worked for Martin Marietta Aviation and finally as the purchasing agent for the City of Baltimore. During this time, he was also President of the National Institute of Government Purchasing (NIGP). He won many distinctions in his field and published numerous professional papers. He also established a scholarship program for the NIGP.

Mr. Zemansky had been an AIAA member since 1935.

AIAA Associate Fellow Gogan Died in April

Harry L. Gogan died on 26 April 2013. He was 91 years old.

Mr. Gogan studied engineering at the University of Alabama, where he enlisted in the Army Air Corps in 1942. He was assigned to the 57th Fighter Group, 66th Fighter Squadron, 12th Air Forces, and stationed in Corsica, Italy, flying P-40 Warhawks and P-47 Thunderbolts. On 20 December 1944, he suffered severe injuries when his plane was shot down in the Brenner Pass, and he spent the next five months in a German POW camp. He was awarded the Purple Heart and Air Medal. After the war, he returned to complete his B.S. in Engineering at the University of Alabama.

After working for NASA in Virginia, he was hired at the Air Force Special Weapons Center at Kirtland Air Force Base in Albuquerque, NM, where he rose to the rank of GS-16. From 1963 to 1964, Mr. Gogan attended the Harvard School of Government, where he earned a Master's Degree in Public Administration. After a long and satisfying career, which included DOD projects and design of the Space Shuttle propulsion systems, he retired in 1987. Mr. Gogan had been a member of AIAA since 1948.

AIAA Fellow Lowson Died in June

Professor Martin Lowson, Emeritus Professor of Advanced Transport and former Head of Aerospace Engineering at the University of Bristol, died on 14 June. He was 75 years old.

In 1955, Professor Lowson started an undergraduate apprenticeship with Vickers Armstrong (Weybridge) and saw the manufacture of Valiants for the RAF. His education continued at Southampton University in the Department of Aeronautics and Astronautics, and he was awarded B.Sc., Hons (first class) in 1960, followed by a Ph.D. in 1963.

His doctoral work in the University's Aeronautics and Astronautics Department was on "The Separated Flows on Slender Wings in Unsteady Motion." After receiving his Ph.D., Prof. Lowson spent a year in the Institute of Sound & Vibration Research where he worked on aeroacoustics. Three of his 1960s papers—"The Sound Field for Singularities in Motion", "A Theoretical Study of Helicopter Rotor Noise," and "Theoretical Analysis of Compressor Noise"—are considered to be of fundamental significance in the theoretical understanding of noise generation. His lifetime contribution to the field of acoustics was recognized in 2011 by the AIAA Aeroacoustics Award.

From 1964 to 1969, Prof. Lowson held the post of Head of Applied Physics at the Wyle Laboratories in Huntsville, where he worked on the Saturn V rocket for the Apollo Program. From 1969 to 1973, he was the Rolls-Royce Reader in Fluid Mechanics at Loughborough University. In 1973, he was appointed Chief Scientist and later Director of Corporate Development for Westland Helicopters. He is a co-patentee of the BERP rotor system, which, when mounted on a Lynx, gained the world speed record for helicopters in 1986.

In 1986 he was appointed the Sir George White Professor of Aeronautical Engineering at the University of Bristol. Under Prof. Lowson's leadership, the Department thrived and by 2000, its international reputation was secure.

During the 1990s, Lowson's interest turned to ground-based transport systems, attempting to understand why so few people used public transport. He set up his own company, ULTRA, in 1995 and for the period from 2000 onward spent his waking hours promoting his Personal Rapid Transit scheme. In 2005, ULTRA was awarded a contract to provide the transport system for passengers to transfer from the car parks to Terminal 5 at Heathrow; this has been carrying paying customers for the past two years to commercial and passenger acclaim.

Prof. Lowson was a Fellow of the Royal Academy of Engineering, Fellow of the Royal Aeronautical Society, and an AIAA Fellow. His many other honors include the RAeS Award for contributions to world's first manpowered flight (1961) and the Busk Prize of Royal Aeronautical Society for best paper in Aerodynamics (1992).

AIAA Fellow Seltzer Died in July

Sherman M. Seltzer, 85, passed away on 17 July.

Mr. Seltzer was a veteran of the Korean conflict and worked at NASA for Dr. Von Braun on the Apollo Space Project and Skylab. He co-founded Control Dynamics and SVS, Inc., both aerospace companies. He was an AIAA Fellow.

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

Upcoming AIAA Continuing Education Courses

8–9 September 2013
Courses at SPACE 2013 Conference
www.aiaa.org/space2013

Introduction to Space Systems

Instructor: Mike Gruntman

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

Satellite Communications, Today and Tomorrow: Technical Basics and Market and Technology Trends

Instructors: Edward Ashford and Joseph N. Pelton

This course provides and introduction to those aspects of RF transmission technology that are important to and govern the design of satellite communication systems. The physics underlying relevant RF communications topics concerning establishment of RF links between Earth and a satellite (and vice versa) will be presented and explained, as well as the mathematical concepts governing the digitization and transmission of information over these links. Easily grasped intuitive explanations of the need for and methods of coding and decoding of information sent over satellite links will be presented.

11 September 2013
Webinar
www.aiaa.org/webinars

Missile Defense: Past, Present, and Future

Instructor: Peter Mantle

This webinar reviews the historical threats and attacks against the United States together with the past and present proposed national missile defense systems with their shortcomings. The technology of new defense systems currently in the laboratories is reviewed to postulate possible new air and missile defense systems for the future. The webinar is liberally filled with actual historical and technical data on all aspects of the threat and the necessary defense.

23–24 September 2013
Stand-Alone Courses
http://www.aiaa.org/standalonecourses/

Gossamer Systems: Analysis and Design

Instructor: Christopher Jenkins

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.

Senor Systems and Microsystems: From Fabrication to Application

Instructors: Gary W. Hunter, Peter Hesketh, and Larry Oberle

The course is designed to appeal to a wide market audience. Every vehicle subsystem can be positively impacted through the proper design and implementation of sensor technology. This course provides a significantly improved understanding of emerging sensor technology through lessons in microsensor fabrication, sensor development, and aerospace sensor implementation.

13–17 January 2014
Courses at Science and Technology Forum and Exposition (SciTech)*
www.aiaa.org/scitech2014

*Courses will be announced in the October 2013 issue of the *AIAA Bulletin*.