March 2014

AEROSPACE AMERICA

Ready, set EXPORT

Tech export overhaul brings new complexity, and also hope page 28

China's Jade Rabbit explained, *page 26*
Mars or bust, *page 38*

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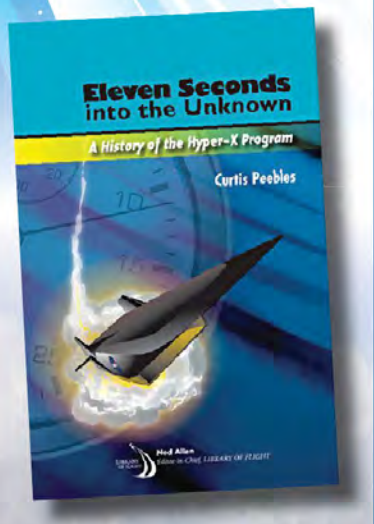

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John A. McKenna
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AIAA
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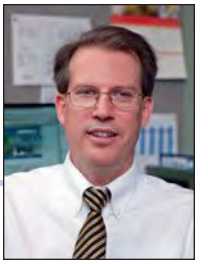
Editor's Notebook



A heart-to-heart on space exploration

My hope is that this month's edition will spark lots of good conversation about the role of human explorers versus robots; our choices of exploration targets; and our investments in the launch technology that will make it all possible.

I'm not so naïve that I expect a consensus on these issues. What I do know is that doing great things in space will require more unity of purpose than we have today in the U.S. or internationally. Aerospace America provides food for thought in this month's edition:

"Mars or bust," Page 34, makes the case for sending humans to Mars, but it does so without varnishing the technical hurdles and the need to muster national or even international motivation for such a vast undertaking.

"Choose your launcher," Page 38, looks at the capabilities of the rockets that will send humans into space and the political back story behind NASA's proposed Space Launch System.

"Saving Kepler," Page 20, explains how engineers hope to resume science with the wounded planet-hunting telescope.

Here are some questions these articles raised for me:

- Is Mars really as scientifically interesting as we're assuming? My sense is that humanity's worldview would be rocked at least as much by a picture of an earthlike planet as by fossilized microbes on Mars. Our investments don't treat these goals as close to equal. The Kepler team is fighting for survival in its mission of cataloging planets. The price of Kepler's proposed successor, the Transiting Exoplanet Survey Satellite, is capped at $228 million, plus launch costs.
- What would happen if humanity threw in the towel on human exploration of deep space? It's tempting to argue that advances in autonomous computing could fill the void — that amazing discoveries lie ahead if we channel billions more into this technology. There's a major flaw in that line of reasoning: Social and political considerations can never be divorced from policy debates, as much as we might wish otherwise. Investments in robotic technologies might well stagnate if they were not tied to a long-term vision of sending humans explorers out there to work with rovers, unmanned planes or planetary submarines. The point of space exploration is that we might want to go there someday — or that we might have to.
- Will the need to keep up with China provide the missing motivation for human deep space travel? Probably not. Deep space travel is going to be so complex and expensive that no nation working alone will get very far. If the West is indeed in a geo-political competition with China, the smartest strategy would be to let China go broke trying to send humans to deep space.

Rather than using space to divide, the better course would be to use it to unify.

Ben Iannotta
Editor-in-Chief

The Vinci engine nozzle glows orange in this photo from a September 2013 test.

Snecma

Clarification

An article in the December issue, "A rich mix of new liquid engines," Page 58, should have been clearer about corporate responsibilities within Europe's Vinci rocket engine program. Safran's Snecma company is developing the engine in Vernon, France, under contract with Airbus Defence and Space, formerly Astrium. The engines will be used on Ariane rockets.

Missing ingredients in climate article

Two points need to be made about the cover story of the February issue, "Target: Climate Change." First, in an article about global warming, a graph of average surface temperature over the eons was conspicuously missing, perhaps because it would reveal that the Earth has been warmer many times in its history than it is now and that there has been no global warming since 1998. Second, just listen to the language used by the global warming alarmists in the article. They pejoratively described those who dare to disagree with them as "wacky" and "hav[ing] the luxury of believing in 'Santa Claus.'" Since when is it acceptable for a "scientist" to insult people in such a manner? That is revealing about the character and methods employed by the global warming alarmists.

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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: beni@aiaa.org.

Events Calendar

MARCH 1-8
IEEE Aerospace Conference, Big Sky, Mont.
Contact: Erik Nilsen, 818.354.4441; erik.n.nilsen@jpl.nasa.gov; www.aeroconf.org

MARCH 12
Congressional Visits Day, Washington, D.C.
Contact: Duane Hyland, duaneh@aiaa.org

MARCH 24-26
Forty-ninth International Symposium of Applied Aerodynamics, Lille, France.
Contact: Anne Venables, 33 1 56 64 12 30; secr.exec@aaaf.asso.fr;

Correcting a photo credit

This photo by Mark Usciak accompanied the article, "'Moonwalking' with Buzz Aldrin," on page 24 of the February issue. The article ran with an incorrect photo byline.

Billions allocated for European aerospace research

The European Union's latest €79-billion ($128 billion) seven-year research and development spending plan, called the Research and Innovation Programme Horizon 2020, started on January 1. Around €6.3 billion ($10.3 billion) has been set aside directly for transport research — road, rail and air — between 2014 and 2020, of which €2.8 billion ($4.6 billion) will be spent directly on aerospace research. This is a 40-percent increase in the previous seven-year EU transport research program — Framework Program Seven — which was completed at the end of 2013, according to ADS, the U.K. Aerospace, Defence, Security and Space industries trade association.

Europe's Horizon 2020 initiative will support efforts to test more fuel efficient aircraft like the Eurocopter X3.

Space research will receive €1.9 billion of EU funds, while further support will go to aerospace companies and research organizations working in related research areas such as security, development of micro- and nano-technologies, advanced materials and advanced manufacturing. Research into alternative fuels for aviation will be funded under the Secure, Clean and Efficient Energy research category; high-risk research will fall within the Future and Emerging Technologies area.

European Commission technology research grants have until now been matched equally by industry or academic technology investments and confined to "pre-competitive" research activities, but the Horizon 2020 funding mechanism is different. It allows for certain single projects to be 100 percent funded from the EU — "except for innovation actions, where a 70 percent maximum will apply for profit making entities," according to European Commission guidelines. The research activities are to cover the full research value chain, from developing basic principles to building advanced technology demonstrators.

One of the main direct beneficiaries of Horizon 2020 will be partners in the Clean Sky 2 research program, which aims to reduce aviation-related carbon dioxide emissions by 50 percent, nitrogen oxide emissions by 80 percent and perceived noise levels by 50 percent over 2011 levels, all by 2020. This will be done through building flying test-beds of more fuel-efficient technologies — for large passenger aircraft, regional airliners and fast rotorcraft. Further operational integrated technology demonstrators covering airframes, engines and aircraft systems sectors will also be funded.

Clean Sky 2 will cost European industry €4 billion to implement over the next seven years, with a further €1.8 billion to be provided from Horizon 2020 funding, according to Eric Dautriat, executive director of the Clean Sky 2 research consortium, speaking at a conference in November in Brussels.

Companies and research organizations have until April to get their bids in for the first €7.8 billion of EU research funds, to be awarded this year in areas such as nano-technologies and advanced materials (€500 million available) and space (€128 million available). The space funds will be used for:

- Europe's Copernicus program, which includes Earth observing satellites and airborne instruments.
- The Galileo navigation satellites and three GPS augmentation satellites, called the European Navigation Geostationary Overlay Service.
- Protecting satellites and objects on Earth from asteroids and other space debris.
- Promoting the competitiveness of the European space sector. ■

Visualizing helicopter noise

Researchers from the German Aerospace Center DLR report they have developed a new imaging system to track the vortices around rotor blades, a phenomenon responsible for most helicopter vibration and noise.

This is the first time it will be possible to visualize the main cause of what makes helicopters so noisy in the air, according to a statement from the DLR in early January and data included in a January 2014 research paper, "Blade tip vortex detection in maneuvering flight using the Background Oriented Schlieren technique."

"Validation data obtained with this new method will allow for improved vortex wake predictions with numerical codes," says Professor Markus Raffel, who heads the Department of Helicopters at DLR's Goettingen facility.

When a rotor blade slices through air, air rushes around the tip due to the pressure, and the result is a concentrated vortex behind the tip. Noise is produced when the next rotor blade collides with this vortex.

Measuring the scale and dynamic structure of these vortices in meaningful detail has been a big challenge. "Huge national and multi-national

Rotor blade vortices and exhaust are visible in this Background Oriented Schlieren image, a technique pioneered by German researchers.

projects all over the world focus on rotor wake vortex measurement in wind tunnels, but these do not allow for the measurement of maneuvering flight conditions, which are of great importance," says Raffel. "Helicopter rotor wakes cannot yet sufficiently be predicted by numerical methods."

Using a new visualization technique, DLR researchers say they have been able to record and measure a substantial proportion of an in-flight helicopter's rotor blade during different phases of flight.

The visualization technique is based on the method called Background Oriented Schlieren, meaning "streaks" in German. This technique measures the refraction of light caused by fluctuations in air density, as on hot summer days when the air above a section of the road seems to shiver. But this is observable only against a suitable background. In 2013, DLR scientists conducted experiments to record images of blade vortices against several different backgrounds. During one test, a Swiss Air Force Cougar helicopter maneuvered in front of a rocky background in the Alps. In other tests, a German BO 105 research helicopter flew over fields near Salzgitter and Braunschweig while researchers in a microlight aircraft acquired images from above the helicopter. In a more recent test, the BO 105 descended into a quarry and the pilot performed a number of rocking maneuvers in a confined space while the loose scree littering the excavated rock face served as a backdrop. Ten cameras set up at various angles yielded images of such quality that a substantial proportion of the in-flight helicopter's rotor blade vortices could be visualized in three dimensions, according to the DLR in a press statement.

"Currently we are aiming the three-dimensional reconstruction of a vortex system from multi-scopic two-dimensional BOS [Background Oriented Schlieren] data from 10 cameras," says Raffel. "This will allow for the reconstruction of the three-dimensional vortex system of a full-scale helicopter operated under unsteady flight conditions out of ground effect."

The next round of flight tests taking place in June of this year involve fitting helicopters with measurement equipment, enabling a direct comparison between the vortices recorded and the control inputs from the pilot.

The ultimate aim of the research is to develop new blade shapes or modified rotor controls that enable a reduction in blade tip vortices and their interaction with the blades trailing behind. "This would help helicopter manufacturers to compare various rotor blades under realistic conditions and to select the quieter option," says André Bauknecht, leader of the current experiments at Braunschweig. As a result, there will be new opportunities to make future helicopters quieter and more comfortable, according to the DLR. ■

Turning point for long-haul, low-cost airlines?

Thai AirAsia X, Jetstar and NokScoot plan to open new routes from Thailand this year, in the latest sign of burgeoning competition in the nascent long-haul, low-cost airline market in Asia.

Airlines around the world have yet to produce any long-term successes in their efforts to simplify services to their essentials and create a new low-cost market for long flights, analysts say. But new aircraft, new in-flight services and a better understanding of how to compete with entrenched full-fare airlines are leading to the establishment of a new generation of long-haul, low-cost carriers, say analysts.

"Long-haul low-fare airlines have had limited success so far, but things could be changing: Carriers such as Norwegian are taking advantage of passengers' willingness to accept less comfort in return for lower fares and are building a long-haul network to the U.S. and Middle East," says Ian Lowden, director at Infrata, an international transport consultancy in London. "Improved seat technology and in-flight entertainment have made economy long haul almost as much fun as flying on carriers such as Etihad, Emirates and British Airways, and these product improvements should now work for all-economy flights."

AirAsia Berhad

Jetstar Asia Airlines

Scoot Pte Ltd

Thai AirAsia X, Jetstar and NokScoot plan to open new routes from Thailand this year, in the latest sign of competition in the nascent long-haul, low-cost airline market in Asia.

With roomier, more comfortable cabins and increasing connectivity for all classes of passengers, the Boeing 787 and Airbus A350 have opened the door for a new type of competition in long haul. Over the past 18 months, new long-haul, low-cost carriers have established themselves in Asia and are building up substantial fleets. AirAsia X has 10 Airbus A350-900s on order; Scoot has 20 Boeing 787s ordered; Jetstar has three Boeing 787-8s in operation already and another 11 on order.

This time there are several reasons to believe these carriers will succeed – mainly because many are backed by established network carriers. NokScoot is owned by Thai Airways and Singapore Airlines, and Jetstar by Qantas — creating new "hybrid" low-cost airlines that can access the connecting services of their parent companies. "I think the hybridization process, coupled with the very low fare tendencies of many Asian users, will see de facto long-haul low-cost principles applied across the market in the next five years — regardless of how the airline is classified," says Peter Harbison, executive chairman of the Centre for Asia Pacific Aviation, based in Sydney, Australia.

"For both short haul and long haul, the lines between low-cost carriers and network carriers is continuing to merge, especially in markets that are more developed in terms of air services," says Mark Clarkson, commercial director at London-based airline analysts OAG. "Arguably, the major LCCs [low-cost carriers] can no longer be termed as such, and the terminology is increasingly redundant as the need for network and market share growth dictate that a greater focus on a wider spectrum of passenger (and therefore product) segments is required."

But the story is slightly different on Atlantic routes, where recent startup Norwegian Air — with three Boeing 787s in operation and another seven on order — is pioneering the concept of low-cost long haul. Air Canada's rouge subsidiary has also started to test out the concept, but many airline analysts expect that, should the Asian long-haul airlines survive and prosper, a number of European and U.S. short-range, low-cost carriers will be encouraged to enter the long-haul market and launch services over the next 18 months — just as passenger traffic is returning to growth in North America and Europe. Michael O'Leary, the chief executive of Ryanair — a short-haul low-cost carrier based in Ireland — said in October at the U.K. Airport Operators Association conference that he wanted to start long-haul low-cost services within the next three to four years but was being hampered by a lack of delivery slots for the Boeing 787.

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2014 Aerospace Spotlight Awards Gala

Wednesday, 30 April 2014

Ronald Reagan Building and International Trade Center
1300 Pennsylvania Ave NW, Washington, DC

Reception begins at 1830 hrs in the Oculus
Dinner and Awards begin at 1930 hrs in the Atrium

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- AIAA Foundation Award for Excellence
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- Public Service Award
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- Daniel Guggeheim Medal

Host a young professional at your table. AIAA has formed a partnership with the Future Space Leaders Foundation (FSLF) the Society of Satellite Professionals International (SSPI) and the Achievement Rewards for College Scientists (ARCS®) Foundation, as we all share a common interest in encouraging and facilitating young professionals to pursue aerospace-related careers.

Also, we are pleased to coordinate with Women in Aerospace (WIA) as they host Aerospace 2014, a day-long conference on issues of importance to women and men in the aerospace industry worldwide. For more information, please visit: www.womeninaerospace.org.

For reservations, please visit **www.aiaa.org/gala2014** or contact Merrie Scott at **703.264.7530** or **merries@aiaa.org**

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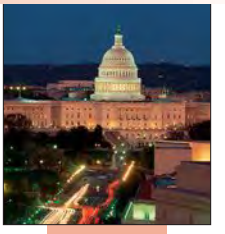

Clues to causes of Asiana crash

The final report on the cause of the July crash of Asiana Flight 214 in San Francisco is due to be issued at mid-year by NTSB — the National Transportation Safety Board. Its findings haven't been revealed, but if it reflects the testimony of investigators at a December hearing on the subject, it will suggest that pilot error and poor communication among the flight crew were to blame.

The accident, which claimed three lives and injured 181 people, has shaken up the airline industry. The ensuing investigation has shone a light on airline pilots' over-reliance on cockpit automation, and on problems with flight crew teamwork — known in industry parlance as crew resource management.

The NTSB's hearing, held at its conference center in Washington, D.C., brought together experts from Boeing, training specialists from government and industry, scientists and emergency personnel in an attempt to get at the root cause of the accident.

FAA Chief Scientist Kathy Abbott was among the experts called to testify at the courtroom-like proceedings. She said that airline pilots tend not to pay enough attention to their computer's flight management mode. Their tendency is to "monitor the raw data on airplane performance much more than they look at the flight mode annunciation," she said during a December 11 webcast of the hearing.

Indeed, much of the early part of the hearing focused on how Capt. Lee Kang Kuk, who was flying the Boeing 777 200ER at the time of the accident, had inadvertently deactivated the airliner's auto-throttle, which holds a preselected airspeed.

But the auto-throttle was not the only pilot aid that played a role in the crash. The sequence of events began because the glide-slope portion of San Francisco International Airport's instrument landing system was not

Asiana Airlines Flight 214 crash landed in San Francisco in July.

National Transportation Safety Board

working. The glide-slope transmitter sends a radio beam to the plane's cockpit to let pilots know they are coming down at the proper angle. Because of the malfunction, the pilots had to fly the airliner onto the runway manually. This should not have posed a problem that day, which was clear with light winds.

But things went badly wrong. The 777 came in at an angle that was far shallower than normal. The aircraft also was flying far more slowly than it was supposed to and at a far lower altitude. As a result, the jet crashed into a seawall short of the runway. The impact tore off the plane's tail, its engines and parts of its landing gear. As the aircraft skidded down the runway, it rotated 330 degrees on its belly and eventually caught fire.

The December hearing further solidified what many aviation industry safety experts were expecting — that the South Korean crew had made a number of crucial errors both in basic airmanship and crew resource management, for several reasons.

Chief among these was that pilot Lee Kang Kuk — who was undergoing his "check ride" to qualify on the 777 — was uncomfortable landing the aircraft manually, says aviation safety consultant Hans Weber, president of San Diego-based Tecop International. Moreover, the pilot ignored cues from the aircraft's instruments as well as warnings from other crewmembers that the 777 was approaching its stall speed. By the time the pilot recognized his error, it was already too late to save the aircraft.

But flying a plane manually is a basic skill that is learned from the first day of pilot training. So the obvious question is, how could this have happened? The problem is that the hand-flying skills of many commercial pilots have declined because of the high level of automation on modern jetliners like the 777 or Airbus A330, says Keith Mackey of Mackey International, a Florida-based aviation safety consultancy.

Many modern aircrews rely almost exclusively on an aircraft's flight management system. The problem is especially prevalent in parts of the world where many aviators have less robust flying experience than pilots in the U.S. have, Mackey says.

This overreliance on automation is acute — some pilots have stopped watching their plane's airspeed during their instrument scan, says Mackey. Traditionally, a pilot would monitor airspeed and altitude like a hawk, especially during takeoff and landing, where stalls are more likely to occur.

In fact, Weber notes, in the case of Asiana 214, the aircrew not only had inadvertently deactivated the autothrottle but also had failed to notice that the plane was approaching the stall speed. NTSB investigator Bill English noted that the 777's throttle was set at idle power even as the aircraft continued to lose airspeed — slowing to some 37 knots below the 137-knot target speed. By the time the pilots realized their error, it was too late, but their reaction was also incorrect, Weber says. Instead of flying their aircraft, the pilots attempted to correct the problem via the flight management system.

Crew resource management, a problem in many previous crashes, appears to have been a significant factor in this one, says Mackey. Weber says the hierarchical structure of South Korean culture may have prevented the instructor pilot and the relief pilot sitting in the cockpit from speaking out more forcefully. In fact, transcripts from the cockpit show that one of the pilots — most likely Bong Dongwon — tried to warn the pilot flying that the plane was sinking much faster than it should.

But this phenomenon is not unique to Korea — the U.S. airline industry also had a hierarchal culture during the 1950s and 1960s but has evolved since then, after a number of accidents forced a change in training methodology, Mackey says.

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Coming soon: A secret report on nuclear missiles

While personnel scandals in the Air Force's Minuteman 3 nuclear missile enterprise have grabbed headlines in recent months, the future of the aging weapon system itself is quietly undergoing scrutiny.

A classified review examining modernization options for the intercontinental ballistic missile is due to be completed in June, says Kathryn Blais, a spokeswoman for Air Force Global Strike Command.

The study, formally known as the Ground Based Strategic Deterrent analysis of alternatives, is assessing a potential replacement or upgrade for the inventory of 450 Minuteman 3s. The weapons, first deployed in 1970, are housed in underground silos at three Air Force bases: Malmstrom in Montana, Minot in North Dakota and F.E. Warren in Wyoming. Blais says the study "has not been affected" by allegations that some Minuteman officers cheated on proficiency tests and possessed illegal drugs.

The Air Force says the roughly 18-meter-long Minuteman 3 "currently

(Continued on page 13)

U.S. Air Force

The U.S. is weighing upgrades or replacements to Minuteman 3 missiles.

Engineering the revolution

For unmanned planes to change naval aviation forever, they'll need to meet lofty requirements without busting budgets. Rear Adm. Mathias Winter is determined to put the U.S. Navy on that path in his role as program executive officer for unmanned aircraft and strike weapons.

Rear Adm. "Mat" Winter has a big job. He must acquire unmanned aircraft that are so safe and affordable that the Navy's warfighting brass will jump at the chance to incorporate them into fleet operations. That includes combat and intelligence flights from the decks of aircraft carriers, a last bastion of the Navy's dashing, white scarf flyers. Winter was aboard the USS George H.W. Bush carrier last year when the X-47B combat demonstrator made its first takeoffs and arrested landings, feats he compares to the Navy's first shipboard flights in 1910 and 1911. But like any wise pioneer of unmanned craft, Winter knows not to use the "R" word — replacement. He spoke to Dave Majumdar in his office near the banks of the Chesapeake Bay.

What prompted the Navy to embark on this path of developing a carrier-based unmanned aircraft?

It wasn't the Navy per se. Back in around 2004-2005, the Quadrennial Defense Review identified the need for persistent long-range unmanned aviation capability. And in that, the Air Force and the Navy joined forces and the Joint Unmanned Combat Air Systems demonstrator program was established.

When we say the Navy, it really was the [Defense] Department realizing that the future capabilities in the air domain could greatly benefit from the advantages of what unmanned aviation brings to the table in terms of persistence, in terms of flexibility, in terms of dollars per flight hour. The X-47B was selected to be the demonstrator that the Department would pursue to explore, understand, discover: Can we actually take a full-scale unmanned air vehicle [and] make it a part of a truly feasible, operationally relevant unmanned system and execute appropriate mission context activities?

What happened to the joint program with the Air Force?

Then, [through] what I call the volatility, the uncertainty, complexities and ambiguities of the Department of Defense budget and funding of our legislative process, the X-47 became the Navy Unmanned Combat Air System, and the Navy continued to large-sized unmanned carrier aircraft capability. Obviously the Air Force wouldn't pursue carrier-based. So the demonstration objectives were clear and crisp, with a focus on demonstrating the feasibility of operating a tactical size unmanned air vehicle in the dynamic, harsh, unquestionably the most electromagnetic and sea-engaged environment that the Navy operates in. Can we do that? You've been out on that ship with us. You've seen the benefits and the challenges, the opportunities, and some other issues that we've had to embrace.

Without being able to show that it can be integrated with the carrier flight deck, isn't it useless to the Navy?

I wouldn't say useless, but part of that carrier environment is the launch and recovery onboard our aircraft carriers. When we took X-47 to their carrier, we were demonstrating not only its ability and feasibility to operate, but we were also confirming and updating our models, our simulations, our test and evaluation processes and growing a whole new way of doing verification and validation of unmanned systems. We don't have a lot of deep knowledge and experience on unmanned systems verification and validation. The X-47 doing the 26 different landings, touch-and-goes, catapults, arrested landings, wave-offs, circles — what we call "pattern work" — allowed us to truly verify and validate that our technical approach, our testing verification strategies and our ability to do this with other unmanned systems is going to be realistic and affordable.

What more can you learn from the X-47B at this point?

There is still verification to be gained by flying the X-47 and doing catapults and arrested landings and making sure that our precision navigation algorithms, our autonomous software algorithm architecture, and our deck handling communications and algorithms are valid and all of those are transportable to any air vehicle. I usually say the air vehicle is a USB stick and that the USB [port] we want to be able to bring it to is an aircraft carrier.

What are the next steps for the X-47B program?

We will also expand the dynamic environment. We will fly X-47 in much more demanding wind-over-deck, sea

states and other environmental conditions. We did enough to convince ourselves that we've got something that can work, but we have to continue to do that.

We also plan this summer — later this year — to do cooperative operations of manned carrier aircraft and the X-47B. As you'll recall, what you saw out on the ship was the X-47B launching and recovering. The F/A-18 chase airplane [was] there for safety.

You didn't see everybody taxiing the manned aircraft while they're also taxiing [unmanned planes]. We're going to do that. We are going to start to mature and discover and understand the best way to do CONOPS — concept of operations — of manned and unmanned aviation in the carrier environment. That's very important.

Why does the Navy need an aircraft like the UCLASS [unmanned carrier launched airborne surveillance and strike]?

I'll sum it up in one word — it's persistence. In the unmanned aviation domain, persistence allows capability to be present when other capabilities cannot. So what we have put together for aviation is a top-level multi-tiered unmanned aviation strategy, which is a complementary, manned and unmanned capability strategy for Broad Area Maritime Surveillance — that's our Triton, BAMS-D, and the P-8 together. It's in our tactical realm [with] our Fire Scout, MQ-8s, with our H-60s on our Littoral Combat Ships. And into our carrier environments, it's our UCLASS with our manned carrier air wings.

Rear Adm. Mathias Winter with the X-47B.

U.S. Navy

This is not just happenstance. This is a thought-out deliberate strategy as we look at what we do on the carrier and the carrier strike groups: power projection to fight the fight; and it's forward deployed presence for humanitarian, show the flag and deterrence.

How does the UCLASS fit into the carrier air wing?

The unmanned system fits like a glove to provide that carrier strike group persistent ISR [intelligence, surveillance and reconnaissance], situational awareness and continuity of operational picture. UCLASS will be providing that persistent 24/7 organic situational awareness to the strike group commander.

That's what it's going to be. That's its primary role as it's been laid out today. In the technology development phase, we are going to mature the technology and make sure that we can do that capability. But the fleet is also going to operate it, and they may say, "We do need ISR at that level, but we also might need aerial tanking." We might need it to do something we don't know.

That's what a technology development phase affords us – the opportunity to understand the best way to utilize this. There is no vision or intention in the Department of the Navy to transition to a fully unmanned aviation domain. We will always deploy, we will always fight [with] manned and unmanned capabilities.

Are the requirements more or less settled at this point?

There are multiple different kinds of requirements, and the two requirement bins that are absolutely essential to understand the difference [are] warfighter requirements and the design requirements. I want to make sure it's clear here.

The warfighter requirements for the UCLASS had been stable and have not changed. The CNO's [chief of naval operations] capability development document, CDD, was signed out last spring and has not changed. What the acquisition community is mandated to do is to translate those warfighter requirements into what we call a systems specification, that adequately ensures that when you take that specification and design something, it gives you the warfighter requirements.

Take for example that tactically significant range 24/7 ISR off the carrier that – I just said that in about 12 seconds – and you can say that's five requirements. That will explode into somewhere around a thousand design attributes, such as how fast, how high, what vibration level, what humidity and salinity of the air do you want? These are the things we need to understand, because if you had something that was not capable of operating in a maritime environment, and delaminated or corroded too fast, it's not suitable. That's why it's important. The design requirements have been refined. The warfighter requirements have been stable and solid, so we're ensuring that we are getting those design requirements right.

In the PDRs – preliminary design requirements – review with the vendors, we are making sure that we've [not] translated them potentially into a non-coherent set of design requirements. We don't think we've done that, but we want to make sure we get it right.

The focus on this program is very intense, and it provides us the opportunity to get leadership help. But we also have to make sure that we do it right. The design requirements [are getting] the final refinement over the next two weeks, and we will go back and brief the assistant secretary of the Navy, Mr. [Sean] Stackley, in the middle of the February timeframe. And we will get the senior leadership review of that to make sure that we've gotten it right. When we get it right, we will have a two-week time period before we believe we'll be able to release the draft RFP. I am not going to give you a date, because I can't give you a date.

What do you say to those critics who have said the UCLASS requirements are not strenuous enough in terms of long-range strike?

I'm the acquisition professional who translates the warfighter requirements into affordable, executable program plans that we can deliver that capability from that warfighter requirement. I have my personal thoughts on warfighter requirements, but in a media interview, if [the] question you want to answer is "why the set of requirements," then it's important to go to the OPNAV [Office of the Chief of Naval Operations] staff. Now the UCLASS warfighter requirement has tactically significant ranges for ISR and medium- to long-range strike capabilities. They're in that requirement. So the warfighter requirement, all of that is translated down into the draft to the spec. Proposals have to be able to be compliant to all of that, so I'm not going to talk about threat scenarios, countries, that type of thing.

Where does this all go eventually, looking past UCLASS? Could this potentially fundamentally alter the shape of naval aviation?

The integration of an unmanned carrier system into the carrier strike group is revolutionary. This isn't just the next-generation helicopter or next-generation strike fighter. This is a new capability. It is along the lines of when [Eugene] Ely did his first cat and trap. This is historic. We are writing the history books for the next century.

The aircraft carriers we have today and the Ford that we're about to christen and bring forward will be around for literally 50 to 100 to 150 years. Carrier aviation will be around for a while, and when you look at our current footprint of carrier aircraft, and the next generations – the JSF, the E-2D, and the Growler, and so forth – those aircraft and those capabilities will be around for 50 to 100 years. There is no intention again to have unmanned aviation and unmanned aircraft on the flight decks only and nothing else. But the UCLASS is a program, and we will go forward and we will integrate UCLASS with its ISR, potential tanking, and its limited strike capability as the complementary force-multiplier persistent capability that will ensure the carrier strike group mission is even more effective than it is today.

(Continued from page 9)

provides a robust deterrent," but that an enhancement or successor will be needed to maintain that capability, according to a September report by the Government Accountability Office. Options include a new guidance system for the existing missile, and a new fixed-site or mobile missile, the GAO says.

The Air Force does not plan to release the study team's report publicly because it will contain sensitive information. Yet to be determined, however, is whether the Obama administration's fiscal year 2016 budget request will reflect a decision on which modernization approach to pursue, says Blais.

Defense Secretary Chuck Hagel underscored the importance of the review by mentioning it during a January visit to F.E. Warren. Hagel told airmen there that "we are continuing to invest our focus and our time and our effort … in this nuclear deterrent strategy."

The Minuteman is the land-based leg of the U.S. strategic nuclear deterrent, or "triad," which also includes submarine-launched ballistic missiles and long-range bomber aircraft. Replacements for the aging bombers and subs are in the early planning stages.

Whether the nation can afford to modernize all three legs — or even needs to in the post-Cold War era — will likely be a topic of intense debate in Washington. But Hagel insisted that the U.S. should keep updating the triad, because "unfortunately, the world is very dangerous" and "it's going to stay dangerous. And we're going to [have to] continue to … count on a strong, second-to-none nuclear deterrent."

Marc Selinger
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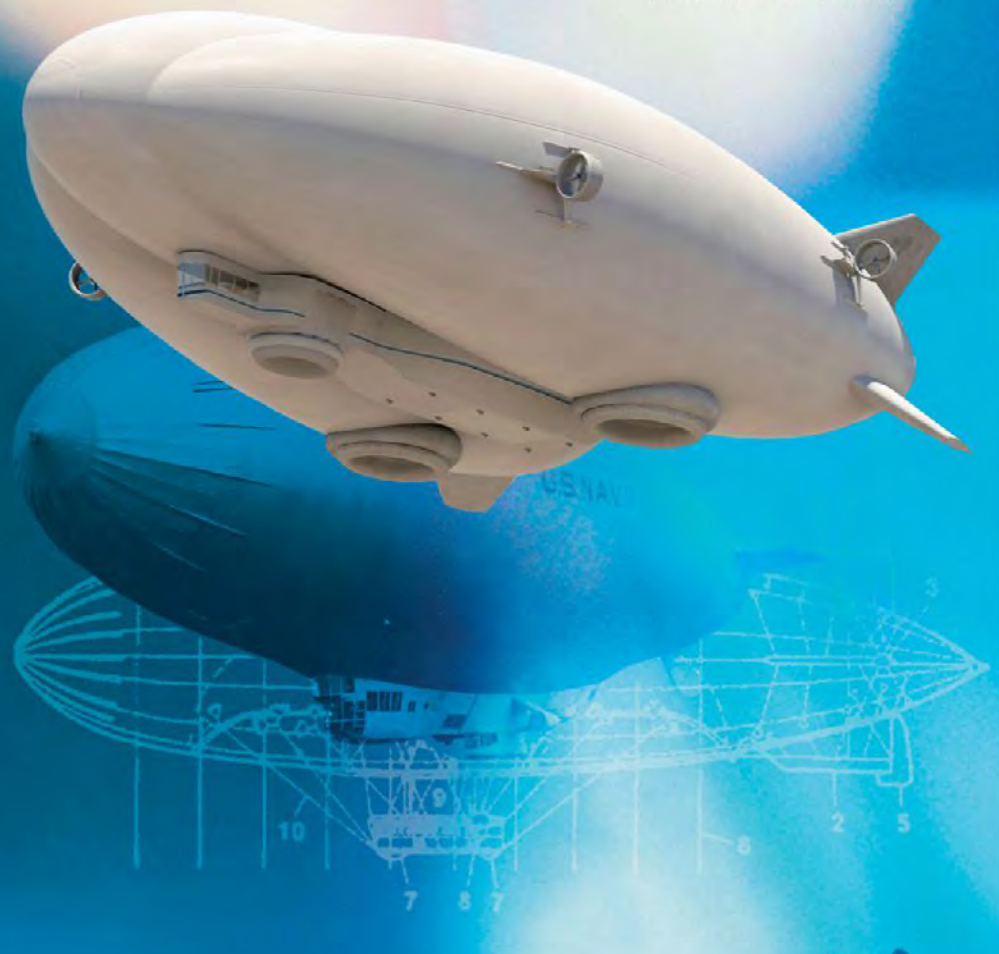
A Minuteman 3 during a test launch from Vandenberg Air Force Base, Calif.

U.S. Air Force

Fundamentals of Aircraft and Airship Design

Volume 2—Airship Design and Case Studies

Grant E. Carichner
Leland M. Nicolai



Joseph A. Schetz
Editor-In-Chief

AIAA EDUCATION SERIES

Fundamentals of Aircraft and Airship Design, Volume 2 – Airship Design and Case Studies

Grant E. Carichner and Leland M. Nicolai

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About the Book

Fundamentals of Aircraft and Airship Design, Volume 2 —Airship Design and Case Studies examines a modern conceptual design of both airships and hybrids and features nine behind-the-scenes case studies. It will benefit graduate and upper-level undergraduate students as well as practicing engineers.

The authors address the conceptual design phase comprehensively, for both civil and military airships, from initial consideration of user needs, material selection, and structural arrangement to the decision to iterate the design one more time. The book is the only available source of design instruction on single-lobe airships, multiple-lobe hybrid airships, and balloon configurations; on solar- and gasoline-powered airship systems, human-powered aircraft, and no-power aircraft; and on estimates of airship/hybrid aerodynamics, performance, propeller selection, S&C, and empty weight.

The book features numerous examples, including designs for airships, hybrid airships, and a high-altitude balloon; nine case studies, including SR-71, X-35B, B-777, HondaJet, Hybrid Airship, Daedalus, Cessna 172, T-46A, and hang gliders; and full-color photographs of many airships and aircraft.

About the Authors

GRANT E. CARICHNER'S 48-year career at the Lockheed Martin Skunk Works includes work on SR-71, M-21, L-1011 Transport, Black ASTOVL, JASSM missile, stealth targets, Quiet Supersonic Platform, ISIS high-altitude airship, and hybrid airships. He was named "Inventor of the Year" in 1999 for the JASSM missile vehicle patent. He also holds design patents for hybrid airship configurations. He is an AIAA Associate Fellow.

LELAND M. NICOLAI received his aerospace engineering degrees from the University of Washington (BS), the University of Oklahoma (MS), and the University of Michigan (PhD). His aircraft design experience includes 23 years in the U.S. Air Force, retiring as a Colonel, and 32 years in industry. He is an AIAA Fellow and recipient of the AIAA Aircraft Design Award and the Lockheed Martin Aero Star President's Award. He is currently a Lockheed Martin Fellow at the Skunk Works.

"Leland Nicolai and Grant Carichner have succeeded in providing a cutting-edge two-volume aircraft design text and reference addressing probably the most productive modes of air transportation: fixed-wing aircraft and the promising low-speed hybrid cargo airship."
– Dr. Bernd Chudoba, The University of Texas at Arlington

"This volume combines science and engineering covering the steps required to achieve a successful airship design. It represents an excellent effort to consider every aspect of the design process."
– Norman Mayer, LTA Consultant, AIAA Associate Fellow and Lifetime Member

"Carichner and Nicolai have created the definitive work on modern airship design containing many techniques, ideas, and lessons learned never before published. In addition, they have collected a set of case studies that will enable tomorrow's designers to learn from the experience of many who have gone before them."
– Dr. Rob McDonald, California Polytechnic State University at San Luis Obispo

Get involved, get ahead — a case study for success

Claudia Corcho is a sophomore at the University of Florida. She's on the Rocket Team and the Small Satellite Design Club. She helps organize hackathons. She's treasurer of the university's Chi Sigma IO group for aspiring national security professionals. She's an active AIAA member. She scours the scholarship scene for support and will go into her career with a good chunk of her degree covered. That includes $2,000 received last November as the first recipient of the Pete Rustan Courage to Innovate Scholarship. Like Rustan, Corcho is an immigrant from Cuba, and she hopes to one day work at the National Reconnaissance Office, where Rustan was a senior manager and UF alumnus. Corcho's active life is no accident. It's part of a purposeful strategy tied to her career goals. She spoke with Ben Iannotta.

Ben Iannotta
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Photo by William A. England/The Independent Florida Alligator

Claudia Corcho's fascination with space began at age 5, when she first watched a televised rocket launch.

Get advice >> The first time I went to my [academic] adviser, I was like, tell me what classes I need to take, and I was done. The next time — my freshman year, second semester — I wanted to see if there were different organizations that I just didn't know about. It turns out that UF had this website where you can look up every single, possible organization.

Get involved >> Every time I talk to a recruiter or a professor, I'm asking them for tips on things I can do to improve my resume, and the first thing they always tell me is experience. I haven't applied for any internships yet, because I'm a sophomore and I haven't taken any hardcore engineering classes to really get a good internship. So I figured the best way to start getting experience would be to join competitions. And I started out with the Small Satellite Design Club, because they build satellites and that's always what I've been most interested in. From there, I learned about the Rocket Team, and that they build rockets. I joined that team too. It's stressful at times combined with all the school work I have to do, to be involved in so many competitions, but to me it feels like that's the best thing I can do with my spare time. I feel like I almost learn more from being in those competitions than I even do in some of my classes.

Find scholarships >> I think the best thing most students can do to begin with is see if there are any local scholarships from where they live, because those are usually a lot easier to get than national ones. Most of the scholarships I have I got from local Lions and local Kiwanis organizations, because they probably get to know you more.

Be open minded >> I've come to learn the hard way that even though you have a lot of plans, sometimes things don't work out the way you

want. So, even though I think I want to work at the National Reconnaissance Office and I think I want to work with satellites, I'm trying to just learn a whole bunch of different things. I don't want to be close-minded. I want to learn about a whole lot of different fields in the aerospace industry and things I can do in case satellites just doesn't work or I find something more interesting.

Try related fields >> The [hackathon] competition is basically where you have to bring your own computer, and you have to be able, through programming, to decipher codes. I personally didn't write any of the codes, because there's a bunch of computer engineering majors here who know how to do this stuff better than I do. But I did attend the event and attempted to decipher some of those things. I helped organize it and bring in various speakers.

Beat math phobia >> Math is not something that can be done just once and then it applies to everything else. The more problems I practice the more confident I get that I can work them out. There really is no easy way of getting over math phobia. All engineers can do is practice until it makes sense because it is not a subject that we can avoid. I will be using math for the rest of my life, and the more comfortable I get with it in college the easier it will be later to implement it into my career.

> *"I have to step out of my comfort zone constantly."*
>
> —Claudia Corcho

Not just for men >> In all the organizations that I am involved with there are very few women. To be honest it can be a little intimidating sometimes, but I definitely think that is part of what makes engineering interesting for me. I have to step out of my comfort zone constantly. I do believe that women can bring a different insight and perspective into engineering that can lead to innovative ideas. Women are definitely underrepresented in engineering, but if any girl wants to get into the field I highly encourage her to, because she can bring new things to the table that can be used to target more consumers. Who better to design something meant for women than a woman herself.

Trust your inspiration >> I just remember looking at the TV screen [at age 5] and seeing this launch, and I was just mesmerized by it. After seeing that launch, every time I would go to the library I would always pick up books on airplanes or rockets, anything NASA-related.

Stretch yourself >> We presented at the AIAA conference last year in North Carolina [about] everything we did with the high altitude balloon [developed to test sensors for a planned small satellite]. I got to get up there and talk, which I wasn't used to, but I'm trying to get out of my comfort zone.

Stay informed >> I actually learned about becoming an AIAA member through the Small Satellite Design Club, because the project leader for the high altitude balloon project wanted to present our findings at the student conference, and in order to present at the conference I had to become a national student member. It ended up being very beneficial, because now I can read Aerospace America and the daily newsletters, which keep me up to date with things in the aerospace field.

Fixing U.S education

Aerospace engineer Amir S. Gohardani has seen the U.S. education system up close as a graduate researcher and educator at the University of Arizona and the University of Florida. He holds five degrees, including a Ph.D. in aerospace engineering. Having emigrated to the U.S. from Sweden, he now has a personal stake in a vibrant American aerospace sector. He offers some ideas for how to improve the American system.

VIEWPOINT
By Amir S. Gohardani

Amir S. Gohardani is an aerospace engineering manager at L'Garde of Orange County, Calif. He is the project manager for a national security initiative as well as for an unrelated orbital debris project, and he is a contributor to the Sunjammer Solar Sail Technology Demonstration Mission for NASA. He is also a director at large of the AIAA Orange County section.

Global competition has transformed the aerospace domain. China's Chang'e 3 robotic spacecraft achieved its objective on the nation's very first attempt to conduct a landing on an extraterrestrial body. India has a scientific probe headed to the red planet under its Mars Orbiter Mission. With an increasing number of spacefaring nations and an unprecedented investment in aerospace activities, U.S. leadership in this domain is no longer a given. Leadership will require reconsideration of key elements of the country's education system.

Why is it necessary to re-consider a system that has hitherto proved successful at turning out aerospace innovators? The short and concise answer to this specific question is summarized in one single noun: change. Countries around the world are improving the education of their populations, and the U.S. must continue to make positive educational changes too if it wants to retain its aerospace leadership.

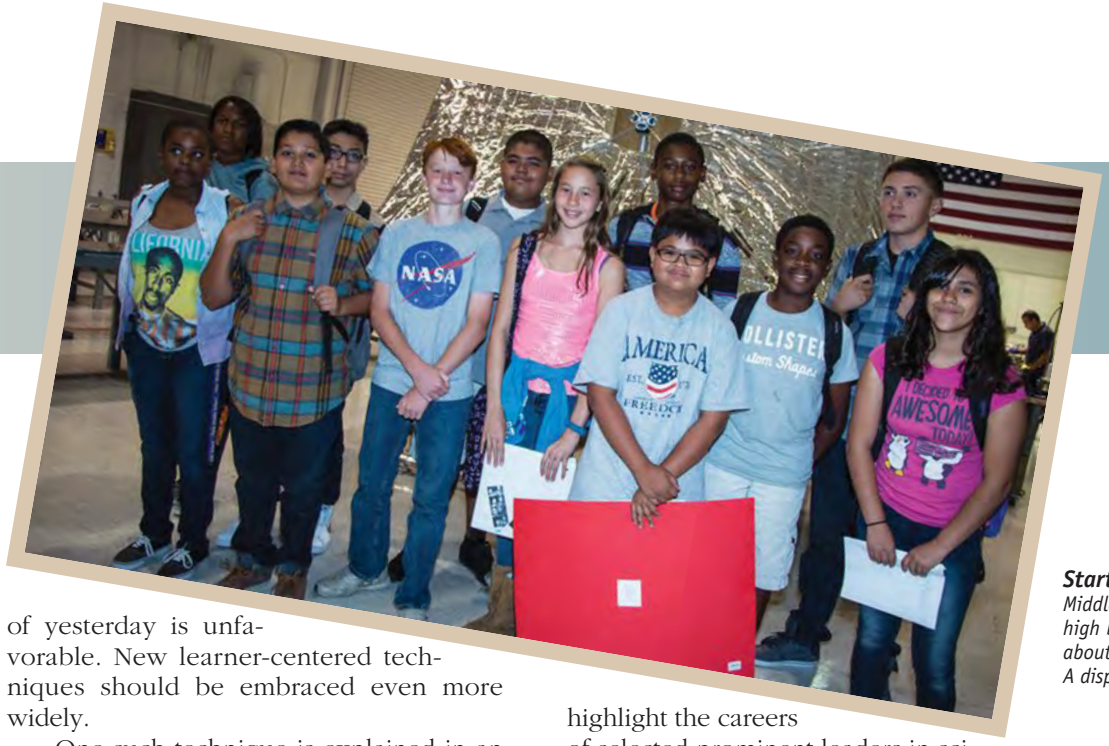
To be sure, there has been much progress in the U.S. over the decades. By 2010, Americans led the nations of the OECD, the Organisation for Economic Co-operation and Development, in average years of education. Americans reported receiving an averaged 13.46 years of schooling, followed by Sweden with 13.40 years.

Years of schooling are not all that matters, however. Educational performance and the pace of improvements must be considered against what is happening in competing nations. By that metric, there is much reason for alarm, and noticeably not just in terms of math and science but for reading skills too. Since 2009, American 15-year-olds have slipped from 25th to 31st place in math performance; from 20th to 24th place in science, and from 11th place to 21st in reading, according to the U.S. National Center for Education Statistics. The Nation's Report Card for 2013 was worrying too. Just 36 percent of 8th grade boys and 35 percent of girls scored proficient on the math assessment. Just 31 percent of 8th grade boys and 42 percent of 8th grade girls scored proficient on the reading assessment. Scores have been improving since 1990, but not enough to keep pace with competing nations.

One factor could be that students continue to get a later start in the U.S. than in other nations. The U.S. currently ranks 28th among the OECD nations with regard to the enrollment rates of 4-year-olds in early learning. Investments in early education are still pending.

Somewhat ironically, despite it all, graduate aerospace programs remain a magnet for international students, which is a tribute to the American culture of freedom and reputation for aerospace excellence and innovation. These students provide a positive learning influence at universities, and they experience a very different culture than that which they came from. But in the end, most of these students will either choose to go home or will be required to do so, and they will take their skills and knowledge with them. This emerging trend is underappreciated. These students have a positive impact, but they cannot form the engine for future U.S. aerospace success. What is the answer? It would be a mistake to artificially limit foreign student participation, because this would harm the learning environment. Instead, ways must be found to equip and encourage more U.S. permanent resident students to participate in these higher level programs together with international students.

Curricula and teaching techniques need to be modernized to keep pace with the constantly modified global education spectrum. In today's dynamic atmosphere, a stagnant approach relying on the curricula



Starting early:
Middle-schoolers visited L'Garde's high bay in September to learn about the Sunjammer solar sail. A display model is in the background.

of yesterday is unfavorable. New learner-centered techniques should be embraced even more widely.

One such technique is explained in an article I wrote with my brother and fellow aerospace engineering doctorate Omid Gohardani, in NASA's Ask magazine, "Attracting Tomorrow's Engineers." Simply put, too many students in the U.S. fear math, and this fear can deflect talented people from the aerospace profession or make others hesitant to pursue their educations at the highest levels. It does not have to be that way. There are ways to make math education more accessible, valuable and memorable to students. Students are more engaged about learning airfoil/wing aerodynamics if they also go to a wind tunnel and watch a wing drop because of stall. Students who are denied such experiences will lack a valuable sense of déjà vu when solving complex engineering problems later in their careers.

Engaging students in a state-of-the-art learning experience is something I most recently witnessed in the L'Garde-led Sunjammer solar sail project for NASA. At one particular event, students were able to watch the Sunjammer team conduct a test deployment of a solar sail quadrant; such an experience is unforgettable.

No one would question America's history of aerospace achievements through the decades. The 1960s brought us the Boeing 747 and the Apollo missions. The 1970s and '80s gave us the space shuttle, followed by GPS and now unmanned aircraft. That history can sometimes mislead casual observers to assume that this record of innovation will continue into the future, no matter how U.S. students perform compared to those in other nations. This belief amounts to gambling with the nation's aerospace future.

A related fallacy comes when observers highlight the careers of selected prominent leaders in science and technology and refer to their schooling or college drop-out status as somehow a predictor of success. Undoubtedly, human ingenuity and creativity may flourish even without formal schooling. But if one considers the major aerospace achievements since the 1960s, highly educated individuals were essential to each.

More often than not, those who succeed with limited education do so despite the lack of education, not because of it. Only a tiny percentage of people will succeed in such an unstructured environment, and they could still make that choice if the U.S. were to modernize its education system. These individuals nearly always have more discipline in educating themselves than the rest of society, as they voluntarily invest time and effort in the subjects that interest them, without abiding by formal schooling attendance regulations. A classic example of this kind of dedication is documented from the early days of aviation. Years before their first flight on December 17, 1903, at Kitty Hawk, the Wright brothers searched for information on aeronautics from their local library. On May 30, 1899, Wilbur Wright even wrote to the Smithsonian Institution (with Samuel P. Langley as a secretary), asking for Smithsonian publications on aeronautics and suggestions for other readings. That Wilbur Wright educated himself at the start of the 20th century should not suggest that this strategy can carry America through the 21st century. A modernized U.S. education system is essential.

The opinions expressed do not necessarily reflect the views of any organizations with which the author is affiliated.

Saving Kepler

The Kepler space telescope has been wobbling around the sun for almost a year now, its photometer no longer scanning the stars for Earth-like planets. The industry-government team in charge of the $650-million planet hunter has come up with a proposal for restarting science work with the wounded spacecraft. Soon that team will learn whether NASA HQ will authorize the new K2 mission at a cost of perhaps $11 million a year. Erik Schecter explains.

If reviewers at NASA headquarters give their blessing, the malfunctioning Kepler space telescope could be back in action, this time balancing itself largely with the pressure of charged particles from the sun as it hunts for exoplanets, supernovae and other phenomena.

Ironically, this very same solar pressure posed a problem for Kepler last May, when a second reaction wheel failed inside its navigation system. Kepler and other spacecraft spin reaction wheels at different speeds to stay properly oriented. With only two reaction wheels, Kepler could have used up all its fuel trying to keep the solar wind from turning its telescope aperture toward the sun and its damaging rays. Engineers at Ball Aerospace in Boulder, Colo., and scientists at NASA's Ames Research Center in California rushed to get the spacecraft wobbling safely around the sun in an orbit that would minimize its fuel use and give them time to figure out how they might resume science work with just two reaction wheels. The team expects to find out in May if the proposed mission they call K2 will proceed. This is the story of what went wrong with Kepler, and the workaround the Kepler team devised.

Reaction wheels begin to fail

For four years, scientists at NASA Ames Research Center employed Kepler to find Earth-like planets orbiting sun-like stars at distances that could support liquid water and possibly life. Some 150,000 stars in the constellations of Cygnus and Lyra were scanned for intermittent drops in light output that scientists expect to see when a planet

Kepler space telescope on its upper stage on the Delta rocket.

NASA


Ball Aerospace

Kepler's mirror could be shifted to a new field of view every 80 days.

crosses, or transits, in front of a star. By the time of the second reaction wheel failure, Kepler had discovered 3,538 potential planets, 246 of which have so far been confirmed by other telescopes.

When Kepler was launched in 2009, it had four reaction wheels in separate housings. Each wheel weighs 2.3 kilograms and resembles a squashed aluminum top hat 33 centimeters in diameter. The reaction wheels must spin at just the right speed to generate momentum to counter any unwanted turning of the spacecraft. Friction is the enemy inside these reaction wheel assemblies, so the wheels are attached to Kepler by lubricated ball-bearing assemblies and axles. The temperatures are controlled by plastic patch heaters commanded from the ground.

Only three reaction wheels are required for this sort of balancing act, but "it's very common practice for spacecraft to fly with four, having the wheels in skewed axes, so you can afford to lose any one of the four wheels and still control the spacecraft," says Charlie Sobeck, an electrical engineer and NASA's Kepler deputy project manager.

The Kepler team was aware that losing a reaction wheel was a possibility, because it's happened on other NASA spacecraft. The reliability of reaction wheels has always been a challenge because moving parts tend to wear out, says Ball's John Troeltzsch, an aerospace engineer and the company's Kepler mission program manager.

NASA'S Sobeck puts it like this: "As best I can determine, reaction wheels are born either good or bad…If they are bad, they're going to fail, and if they are good, they are going to last forever. And there's no ready way to tell one from another."

Kepler's reaction wheels were built by Ithaco Space Systems, which has since been bought by UTC Aerospace. A spokesman for UTC Aerospace referred any questions about reaction wheels to NASA.

In July 2012, during a routine semi-weekly check-in with Kepler, Ball ground control staff realized that a reaction wheel had failed. NASA and Ball experts were unsure what caused this failure, but they were not panicking. The spacecraft's "hot spare" meant the science mission could continue unaffected. In the meantime, NASA scientists reviewed data from the defective reaction wheel to see if it had shown any overlooked signs of trouble. They discovered that, yes, six months prior to failure, the motor turning the wheel was drawing more current than normal, suggesting it was taking more energy to keep the wheel turning at the right speed.

The Kepler team was already exploring ways to prolong the lifespan of the remaining reaction wheels when, in January 2013, a second reaction wheel began drawing more current. This was a far more serious development, but it was hard to know what to do, because no one was sure why the wheels were failing. "So we did a number of things," Troeltzsch says.

More current was sent into the plastic patch heaters to raise the temperature inside the housings by a few degrees. The idea was to re-lubricate the bearings.

In addition, the Kepler team didn't let the wheels spin more slowly than 300 rpm. "There was some theory that if you ran them very, very slowly, then any damage in the [ball] bearing could compound," Troeltzsch says. Ball engineers also didn't let the wheels change rotational direction, which is sometimes done to counteract solar pressure.


Kepler's focal plane array detects the dip in intensity when a planet crosses in front of a star.

NASA/Ball Aerospace

Flying on two reaction wheels

Despite it all, the second wheel failed last May, and the spacecraft turned its solar panels flat toward the sun, exposing them to the force of the solar wind. This potentially could have caused Kepler to twist so far that the sun would shine inside the telescope and deform the black-coated interior of its barrel. A bigger danger was that too much fuel would be expended trying to keep the spacecraft stable. The team used the vehicle's eight thrusters, each about half the size of a white-board marker, to right the spacecraft. They accepted that Kepler would need to orbit in a wobbly rest state to use as little as possible of its remaining five-and-a-half kilograms of hydrazine fuel.

As the situation stood, the two remaining wheels could control pitch and yaw, but not the roll of the vehicle. This meant it could point anywhere in the sky, but then it would drift, making the stars appear to rotate. Any images would be blurry, so the 4.7-meter-long telescope ceased operation and was left pointing in the general direction of the North Star while the team tried to figure out how Kepler might get back to work.

The breakthrough came from Doug Wiemer, a staff consultant for Ball. He suggested using the sun itself to control the roll, which he had seen done with the U.S. Navy's GeoSat Follow-On satellite, a radar altimetry spacecraft whose reaction wheel electronics wore out after 10 years. The idea was to tip Kepler over on its side so the sun's pressure would fall evenly on the solar panels, keeping the vehicle from rolling.

The tradeoff was that the telescope would have to point in the plane of its own orbit around the sun. The new reliance on this delicate combination of reaction wheels, solar pressure and thrusters ruled out maintaining Kepler's original, constant field of view. Every 80 days controllers plan to shift to a new field of view. The team will use the time between each pair of fields as an opportunity to download the light curves — graphs of light intensity — collected from the stars observed, explains Sobeck.

There's also a new communications challenge. The Kepler team will need to pause collections once every 80 days to communicate with the spacecraft, which means a heavy dose of automation will be required in between. "What we do is we give it a playbook. We write the entire playbook up, and we load it up to the spacecraft and say, 'Here's what we want you to go do for 80 days,'" says Troeltzsch. Should something go wrong during that period, Kepler will reorient itself vis-à-vis the sun and go into "rotisserie" spin, sweeping its antenna into space and eventually in the direction of Earth.

The honeycombed blank for Kepler's primary mirror in a clean room.

K2: Proposed science mission

NASA officials canvassed the astronomy community in August for ideas about how they might utilize a K2 mission. A few dozen replies came back. As expected, many suggested their pet projects, but says NASA Kepler project scientist and astrophysicist Steve Howell, there were common themes, including the continued investigation of extrasolar planets (albeit smaller ones going around smaller stars), studying black holes at the center of active galaxies, and scanning for supernovae.

Those hunting for supernovae hope that K2, by scanning distant galaxies, will chance upon a supernova with an early light curve, one in its infancy, a phenomenon that could not be captured from Earth. This might offer scientists insight into what actually exploded. Right now, no one is sure what creates a supernova, whether it is a single or binary star, says Howell. Other researchers wanted to find black holes still bombarding their galaxies with high-energy X-rays and gamma rays.

The Ball and Ames team submitted a Senior Review Proposal for the K2 mission to the NASA astronomy committee in January. The team was scheduled to follow up with an oral presentation detailing the results of a 30-day test of its K2 concept. If the committee accepts the scientific case made on behalf of the mission, it will then decide how much funding K2 should get, sending along its recommendation to NASA Headquarters for a final decision in late May.

Howell says the competition for K2 funds will be tough because of its home in the NASA Astrophysics Division, which includes Hubble, the Chandra X-ray observatory "and all these sorts of famous missions NASA has launched."

Still, Ball officials think the K2 mission has a very good shot at being accepted. "We are very confident that NASA is going to approve this idea… based on what I've heard from the astronomers, based on what I've heard from NASA, based on the validity of our idea, and the huge investment that's been made in Kepler," says Troeltzsch.

Erik Schechter
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Jade Rabbit explained

China's lunar rover mission ran into technical troubles in January, troubles that space experts say have put the mission at risk. Here are 8 facts to know about the mission, no matter how things turn out:

■ The 1,200-kilogram lander touched down in December on a plain called Mare Imbrium, an area that forms the right eye of the "man in the Moon."

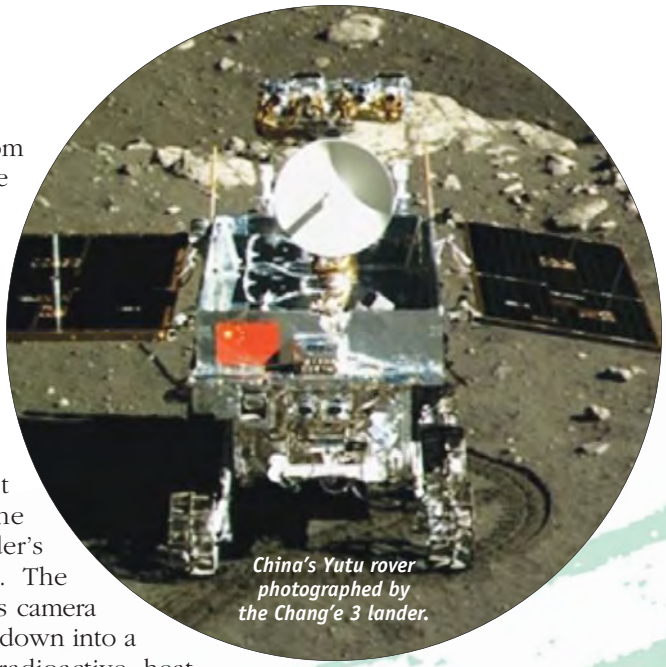
■ The mission is called Chang'e 3, which is also what Chinese scientists call the lander. The rover that rolled out of the lander is called Yutu, which means Jade Rabbit, a mythical pet that in Chinese legend traveled to the Moon with the goddess Chang'e (pronounced "Chong-euh"). The rover's first drive on the lunar surface took it about 18 meters from the lander.

■ The lunar night lasts for two weeks. During these bitterly cold, dark periods, the Yutu rover and Chang'e 3 lander must hibernate.

NASA/GSFC/Arizona State University

The landing zone:
The Chang'e 3 lander (large arrow) and rover (small arrow) as seen by the Lunar Reconnaissance Orbiter.

■ Meters away from each other, the rover and lander survived their first night, lasting about 14 Earth days. This was a crucial test for the multi-layer insulation and radioisotope heater technology that must keep the Chang'e 3 lander's electronics warm. The Yutu rover folds its camera mast and antenna down into a box that has a radioactive heat source and is covered by a solar panel. The rover's other solar panel tilts down to catch the rays of the rising sun.



China's Yutu rover photographed by the Chang'e 3 lander.

Chinese Academy of Sciences

■ The mission's landing site is roughly 1,750 kilometers from Tranquility Base, where Neil Armstrong and Buzz Aldrin put humanity's first footprints on the moon during Apollo 11.

■ China plans to return a lunar sample in 2017 on a future Chang'e mission.

■ Chinese experts quoted in press reports wonder if lunar materials that are scarce on Earth will spark a new space race for mining the Moon.

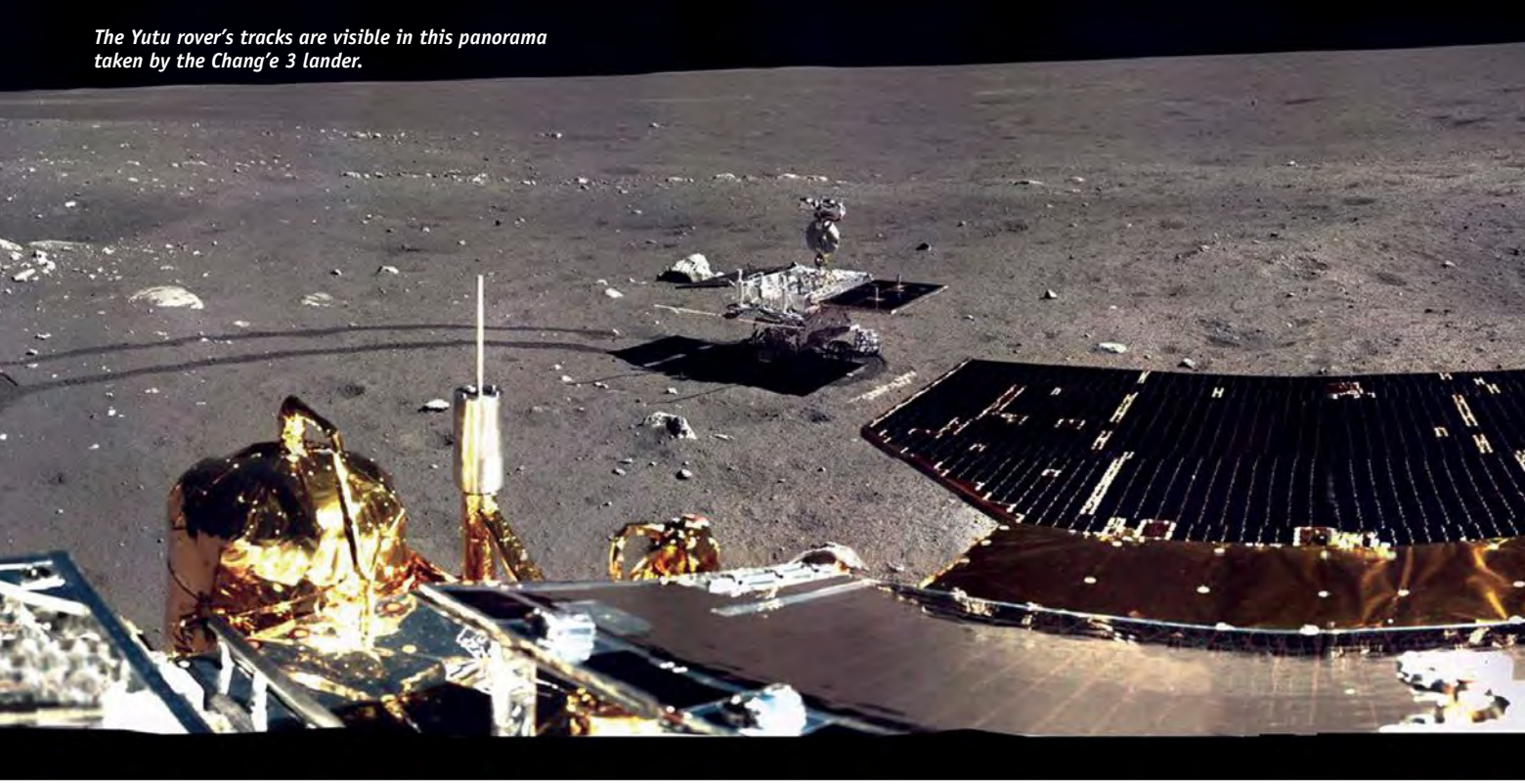
■ On Jan. 25, the Yutu rover experienced a "mechanical control abnormality," according to Chinese news services. As another long night began, engineers were trying to solve the problem, which was caused by the "complicated lunar surface environment," said the news reports. As the lunar day returned, the mission team waited to see if Yutu would come back to life. They say the rover has already provided much useful scientific information and imagery.

by Leonard David

China's Chang'e 3 lander, photographed by the Yutu — Jade Rabbit — rover.

Chinese Academy of Sciences

The Yutu rover's tracks are visible in this panorama taken by the Chang'e 3 lander.



Chinese Academy of Sciences

Ready, set, EXPORT

Arms trade reforms mean big adjustment for industry

by Debra Werner

Coarse sun sensors don't sound very dangerous. They're analog devices that track the sun's position so satellites can stay properly oriented. Stan Kennedy installed hundreds of them into spacecraft while working for Lockheed Martin Space Systems and, before it closed its doors, Comtech AeroAstro.

The sensors were made by putting aluminum harnesses around Japanese-made commercial photo diodes and attaching wire "pigtails" to measure the current. For the devices to work properly, they had to be calibrated for pointing accuracy, and that's where things got expensive.

It wasn't the technical work that drove the cost. It was the paperwork. Because the sensors were calibrated for use in a spacecraft, they automatically moved onto the U.S. Munitions List, a tally of 20 types of equipment, services and related technologies that are subject to a 165-page set of rules called the International Traffic in Arms Regulations, or ITAR.

These rules govern whether and under what conditions knowledge and equipment, including missiles, can be exported. For each customer, Comtech AeroAstro had to assess whether the export would be allowed, and document the steps it would take to ensure that the customer did not acquire the intellectual know-how behind the sensors and did not intend to resell the sensors.

Comtech AeroAstro was not alone. Today, nearly every aerospace company has an export compliance team that reviews, logs and redacts, when necessary, every paper or electronic document sent to a for-

Boeing

eign customer. Even press releases must be reviewed for ITAR-covered details, because they are freely available to foreign governments or companies. When foreign customers visit offices or factories, U.S. companies conduct background checks on each person and log the minutes to every meeting. Lawyers are often retained to assure compliance. One industry official estimated that his firm employed 17 people and spent approximately $4 million a year to comply with U.S. government export rules.

In the case of Kennedy's sun sensors, he figures the ITAR process turned a $1,000 or $2,000 item into a $1,500 to $3,000 item, all to protect a technology already widely available from other vendors internationally.

Years of ITAR heartburn in the U.S. aerospace industry have prompted the

For American aerospace companies, the outlook for exports could be brightening now that the Obama administration has begun overhauling the controversial International Traffic in Arms Regulations. The changes will add complexity, and executives are anxious to learn exactly how the revised system will work. Debra Werner explains.

U.S. Air Force

New rules:
The Commerce Department gets authority to oversee exports of many military aircraft parts and components. The State Department continues to oversee technology that could give the military an edge, such as the stealth technolgy in the B-2 bomber and the retired F-117 fleet, and targeting components in the B-1 bomber.

Obama administration to begin revamping the country's export licensing process largely through federal rulemaking. The strategy was already underway before President Obama's January announcement that he'll use his executive powers more often because of the gridlock in Congress. The rules are being rolled out piecemeal, and they are supposed to add up to a new process that will work like this: Technologies that are thought to give the U.S. military an edge and are not already available outside the country will remain on the State Department's Munitions List. Technologies that don't meet those criteria will be handed off to the Commerce Department for export oversight. The result? State would oversee a much shorter Munitions List, and Commerce would be responsible for a revised and extended Commerce Control List.

The big question is whether this closely held approach of parsing technologies into divided authorities will simplify the export process after a transition period, or whether the additional complexity will force companies to hire more lawyers and expand export teams. Industry officials interviewed for this article were by and large optimistic about the changes, but also anxious to see the final versions of the new rules and the changes they will require in their internal processes.

The end of 'absurdity'?

Aerospace industry officials say the ITAR rules have irritated international customers and made some potential buyers shun U.S. suppliers. They're hopeful about the overhaul: "We think it's a major step in the right direction," says Chris Hoeber, Space Systems Loral's vice president of technology and innovation. "We don't know exactly what the final regulations are going to look like, but the direction is positive and should be very beneficial to the U.S. aerospace industry in general."

Executives anticipate a challenging adjustment period, though. "Remember it's ITAR relaxation, not simplification, because it actually gets much more complicated," says Jay Hennig, president of Moog Space and Defense Group.

For the industry, the existing rules have been the devil they know — a drag on exports, yet a licensing process they understand. Any item initially designed or modified for military use was considered a military item and placed on the State Department's Munitions List, making it subject to ITAR. That has historically included military fighter planes, spacecraft components like Kennedy's sun sensors, and even nuts, bolts and screws no more sophisticated than those at Home Depot.

"We are moving from a system that had a lot more certainty, but also a lot more absurdity," says Remy Nathan, vice president for international affairs at AIA, the Aerospace Industries Association.

Under the new export system, different procedures will apply to different items. If all goes as planned, the "absurdity" decried by the industry would end, because companies won't need a license to sell many common consumer items abroad, even if the hardware is used in military jeeps or aircraft. The Commerce Department would oversee dual-use equipment, things like tires that can be used on military and commercial jets.

Someone must decide which military and space-related items should be available for export and under what conditions, and a team of experts from the departments of Defense and State have been working on that since 2011. The team has concluded that commercial communications satellites and aircraft engines are not critical to U.S. national security and are widely available outside the U.S. The Com-

To export or not to export?

*The **green** shows categories of the Munitions List that a panel of experts has scoured for technologies that should be made easier to export. The **red** categories were still in the works. Firearms, guns and ammunition, shown in **blue**, will be addressed separately.*

Category 1	firearms
Category 2	guns
Category 3	ammunition
Category 4	launch vehicles, missiles
Category 5	explosives
Category 6	vessels of war and naval equipment
Category 7	tanks and military vehicles
Category 8	aircraft and associated equipment
Category 9	military training equipment
Category 10	protective personal equipment and shelters
Category 11	military electronics
Category 12	fire control, range finding, optical, guidance and control equipment
Category 13	auxiliary military equipment
Category 14	toxicological agents
Category 15	spacecraft systems
Category 16	nuclear weapons
Category 17	classified articles, technical data
Category 18	directed energy weapons
Category 19	gas turbine engines
Category 20	submersible vessels and oceanic equipment

merce Department would oversee the export of those, still subject to laws that set embargoes or bar military or space exports to specific countries. Among the items remaining on the Munitions List will be rockets, unmanned aircraft and advanced weapons. Those would still require State Department export licenses.

Whether an item is ultimately exported would vary based on its destination:

• No export license would be needed for most Commerce Control List items destined for 36 close U.S. allies, meaning most European nations, Argentina, Australia, Canada, Japan and New Zealand. The exporters will need only notify the State Department about the transaction and show that the purchaser agreed to abide by the rules, such as not reselling the items.

• For nations that are neither among the 36 closest U.S. allies nor considered state sponsors of terrorism, export rules will vary based on the item for sale, its intended use and the buyer.

• The changes would not undo existing prohibitions on exporting space or defense technology to a long list of countries, including China and countries the U.S. considers state sponsors of terror.

The process sounds complicated, and the Obama administration knows there will be a learning curve. "We in the administration fully understand that in the transition period, companies are going to have a little bit of pain in terms of having to read through and understand the new rules and change internal classifications and compliance procedures," says Kevin Wolf, assistant secretary of commerce for export administration. "But the only way you get to the point of moving things off the U.S. Munitions List to a more tailored list is if you go through that transition."

To ease the pain, the new rules won't take effect immediately. Final rules will become effective six months after they are published in the federal register. In addition, companies with existing State Department export licenses can continue to sell based on that authority for up to two years.

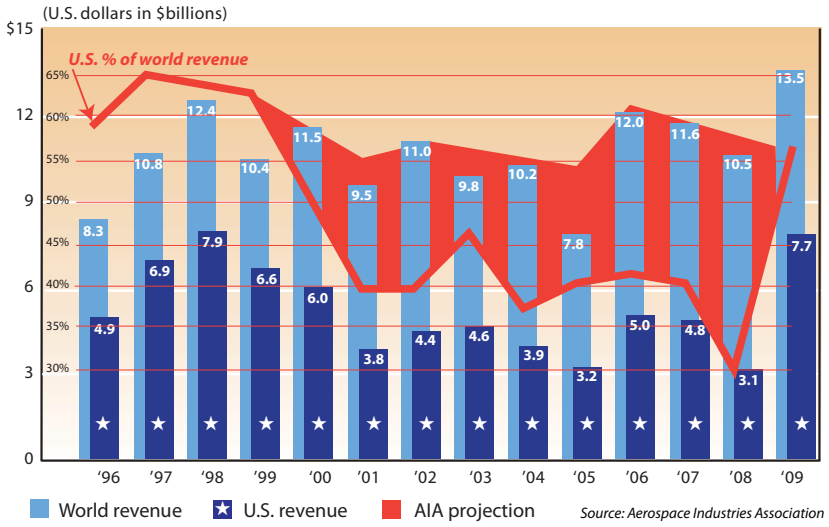
Space tech exports

The Obama Administration needed legislative help on one kind of technology: satellite exports. Congress had to reverse a provision of the 1999 National Defense Authorization Act that placed all spacecraft and related items on the Munitions List. The provision was a response to allegations by congressional investigators that American contractors shared missile secrets with China. At the time, Chinese Long March rockets were prone to crashing, sometimes with U.S.-built satellites aboard, and contractors had a vested interest in better reliability. The 1999 provision ended the practice of launching those satellites on Chinese rockets, and it also made it harder for U.S. companies to export commercial satellites elsewhere. The Clinton administration opposed the provision and so did the Obama administration on its arrival. Then-Defense Secretary Robert Gates urged Congress to change the law, and lawmakers obliged in the 2013 National Defense Authorization Act by restoring the authority of the president to decide whether space exports should be overseen by the Commerce or State Department. Final rules for spacecraft are expected to appear in the Federal Register in April. If that schedule holds, "folks would have the summer to read it, get to know it and ask questions" before it goes into effect," Wolf says.

Companies also plan to spend those months establishing separate processes for handling items that will remain on the Munitions List and those that will move to the Commerce Control List. "Having to maintain two systems for proper reporting and controls could potentially add costs for small business," says Kennedy, who established Oakman Aerospace in Littleton, Colo., after the Comtech AeroAstro closure.

SEEING RED

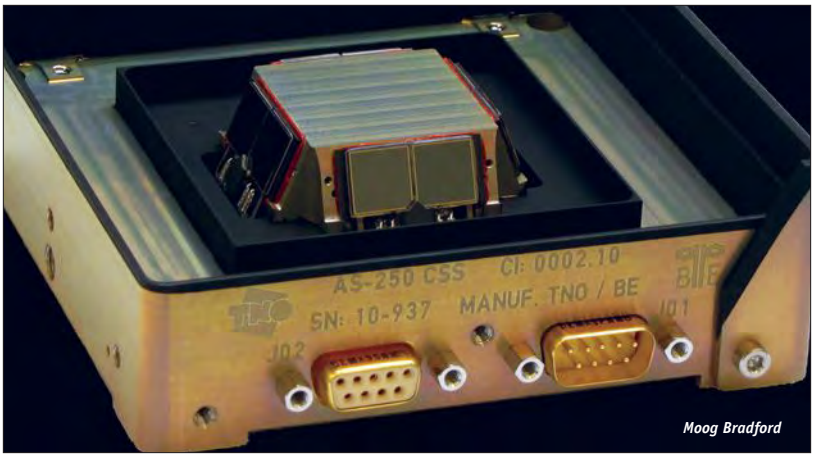
Revenue loss: **$20.8 billion**
U.S. jobs lost: **27,000 annually**



Source: Aerospace Industries Association

Costly overreaction?

The U.S. Aerospace Industries Association says the U.S. lost billions in potential revenues after Congress shifted commercial satellites and components to the State Department's Munitions List in 1999. The move came after congressional investigators accused contractors of sharing missile secrets with China while trying to diagnose technical issues with its Long March rockets. The rockets had destroyed American satellites and killed civilians in China in a string of failures. The Clinton administration opposed the shift, but the president could not easily veto it because it was part of the annual defense authorization.



Moog Bradford

The coarse sun sensors, a navigation component on satellites, would be easier to export under new U.S. rules.

"Over the years, small business has learned to deal with the State Department rules. It will take additional time and resources to review and comply with the resulting changes to both lists."

The coarse sun sensor, for example, is expected to move from the Munitions List to the Commerce Control List, while other more precise navigation technology is likely to remain under State Department control.

Suborbital rocket manufacturers were hit especially hard after 1999. They struggled to get State Department permission to publish guides informing scientists and industrial researchers about the characteristics of their vehicles: the temperature of the spacecraft cabin, time in microgravity, power supply.

"Each company had to go through quite a process to get the guide approved, because there is information in there that could be subject to ITAR, and putting it on the web" amounted to exporting it, says Alex Saltman, executive director for the Commercial Spaceflight Foundation. "They got the first version cleared. But if anything changes, they will have to go through the entire process again."

Complying with complex U.S. arms rules has been challenging for startups like Masten Space Systems, maker of the Xoie (pronounced Zoey) rocket.


NASA Dryden

Jumping through those hoops is particularly difficult for small companies like the 12-person start-up Masten Space Systems of Mojave, Calif., which is developing vertical takeoff, vertical landing spacecraft. "Everybody does everything," Saltman says. "So ITAR compliance takes time away from someone who is building something."

For large companies, ITAR closes off certain markets, industry officials say. U.S. satellite manufacturers comprise 50 percent of the international market, and American officials say the U.S. share would be higher if potential customers weren't scared off by possible ITAR complications. "Our foreign customers have become resigned to the ITAR process, but there is a small subset of the market that says, 'I'm not even going to try to deal with it. I'm just going to buy satellites in Europe,'" says one satellite industry official who asked not to be identified. "So ITAR reform is not going to cause massive growth, but it will broaden our potential customer base."

There's plenty of evidence to support this view: For years, Europe's Thales Alenia Space advertised an "ITAR-free" communications satellite, and a European Space Agency website advertises a coarse sun sensor similar to the one Comtech AeroAstro produced by noting it is "a European product, built with components free of export restrictions imposed by US ITAR legislation."

Nathan of the Aerospace Industries Association says he's confident the revised export control system will make U.S. industry more competitive by easing compliance requirements. "With the implementation of the new rules in the coming year, that burden will decrease significantly," he predicts.

Lingering issues

Although companies generally laud ITAR reform, none appear to be 100 percent satisfied with the draft and final rules published to date. Commercial satellite builders are disappointed with draft rules that would subject government-funded hosted payloads to ITAR. Many in the satellite remote sensing industry say they disagree with plans to require State Department licenses for camera-equipped satellites with mirror apertures greater than 0.35 meters — the wider the aperture, the more light, and the finer the resolution. They say international competitors already supply systems with much larger apertures. Suborbital vehicle manufacturers oppose a provision of the draft rules that would place manned commercial spacecraft on the U.S. Munitions List.

If the rules for suborbital craft stand, Virgin Galactic and XCOR Aerospace may have trouble following through with plans to take off and land at foreign spaceports. Even if the government approves an initial license for those operations, additional ap-

provals will be required whenever companies install new equipment inside their rockets or spaceplanes or provide technical information on proposed operations to local regulatory authorities, Saltman says.

The Commerce Department also heard complaints from manufacturers and suppliers eager to sell parts or components to foreign satellite builders whose spacecraft are available for sale to China, and from firms eager to start trading with China. Some "would like to be able to have access to those markets, but for larger national security reasons, the administration has been firm on that," Wolf says.

The new approach is intended to make it easier to make changes in the future. Because of its catch-all nature, the existing U.S. Munitions List hasn't required much updating. The new Munitions and Commerce Control List will need to be modified as companies adapt or improve technologies.

"Such a firm list absolutely requires regular maintenance and update," Wolf says. He declined to elaborate on how often that type of review might be conducted, but noted that government agencies already obtain the kind of industry input needed for periodic reviews. That input arrives through the Commerce Department's Technical Advisory Committees and the Defense Department's Defense Trade Advisory Group.

Those assurances have done little to ease the concerns of executives who say it's very difficult for the government to respond quickly to industry concerns. They point to the many years the space industry pressed for export reform without success. The turning point came only when Congress ordered the departments of Defense and State to assess the national security impact of the 1999 Munitions List decision. "Current law forces the U.S. government to continue to protect commonly available satellites and related items on the U.S. Munitions List, thus impeding the U.S. ability to work with partners and putting U.S. manufacturers at a disadvantage, but providing no noticeable benefit to national security," the Defense and State departments concluded in a 2012 document known as the "1248 report" for the section of the National Defense Authorization Act that required it.

Patricia Cooper, president of the Satellite Industry Association, a leader of the campaign for more flexibility in spacecraft exports, welcomed that report and the export reform process it prompted. Cooper says the long struggle to convince the U.S. government to stop treating all space-related products as munitions has led to a new sensitivity. "We in the satellite sector have provided a specific experience that demonstrates that getting it wrong can affect an industry that matters," she says. "That has changed the way policymakers look at export controls."

Dollars and sense

Today, companies must pay a minimum of $2,250 to the State Department to register their companies with the agency's Directorate for Defense Trade Controls. Frequent exporters pay $2,750 plus $250 for every export license application after the first 10. This adds up quickly for companies that export hundreds of different types of equipment and components annually.

Under the new approach, companies will not need to pay any fees to sell items on the expanded Commerce Control List to be managed by the Commerce Department. Fees will still be paid to the State Department to register and apply to export items on its Munitions List, but that list will become much shorter.

XCOR Aerospace

Virgin Galactic

If export rules for suborbital craft stay the same, Virgin Galactic and XCOR Aerospace may have trouble taking off and landing at foreign spaceports.

Critics want a complete re-examination of U.S. launch strategy, including the multi-billion-dollar Space Launch System. Natalia Mironova explores whether they have a case.

Choose your launcher

Garry Lyles wanted to build big rockets since he was a little kid. He remembers visiting NASA's Marshall Space Flight Center in Huntsville, Ala., when he was 10 years old and staring in awe at the eight massive engines of the Saturn 5 rocket — the rocket that would carry Apollo astronauts to the moon — and wondering how something that big could ever fly. "It was an exciting time for a 10-year-old. It never left me," he says.

Today Lyles is doing exactly the job he dreamed of as a young boy: Building the biggest rocket ever. Lyles is the chief engineer of NASA's Space Launch System — A 70-meter-tall stack of expendable rocket engines topped by a crew capsule.

If Congress and the White House fund the SLS to completion, it will be a multi-faceted workhorse with the brawn to carry cargo and crew beyond Earth's orbit, making it possible for astronauts to travel back to the moon, to an asteroid, and even to Mars.

It looks like completing SLS will require overcoming increasingly vocal critics. A former high-level NASA official has taken public aim at the policy underpinnings of the SLS program; outside experts are questioning the wisdom of devoting so much of NASA's budget to one program — nearly $3 billion out of $17 billion in each of the next five years. The biggest new factor could be this: What once looked like a risky gamble to invest some money in commercially designed rockets and capsules — as opposed to government blueprints like the ones for SLS and its Orion capsule — has paid off with a string of picture-perfect cargo launches to the International Space Station. Still to come are commercial crew flights to low Earth orbit, and anything beyond that is a question mark.

A long-shot policy fight like this one will require branding, and critics are trying to label SLS "a rocket to nowhere." They question the fiscal feasibility of the promised manned trips to deep space, and they note that NASA has plans under way for only one such trip, a mission to an asteroid, notionally targeted for 2021. The money planned for the SLS, they argue, would be better invested in further developing com-

by Natalia Mironova

Artist's rendering: *The first unmanned test flight of NASA's Space Launch System is scheduled for 2017.*

mercial alternatives for human space travel.

Pushing back

Lyles has heard the criticism, but for him there is no question about the need for SLS. "It will be the most capable rocket ever built," he says. Two incarnations are in the works — an initial one with 70-metric-ton lift capability and an "evolved" 130-metric-ton lift version. Both are being designed to interchangeably carry cargo or the Orion crew capsule, which is currently being developed for NASA by Boeing.

Even the smaller version of the SLS will be a beast of a launcher, taller than the Statue of Liberty and weighing 5.5 million pounds — the equivalent of seven-and-a-half fully loaded Boeing 747 jets. At liftoff it will produce 10 percent more thrust than the Saturn 5, the only NASA rocket comparable to the SLS. The evolved SLS model will be able to lift the equivalent of 143 one-ton pick-up trucks to orbit, with a cargo compartment big enough to fit nine school buses. In both versions of the SLS, the core stage will be propelled by four RS-25 space shuttle main engines. The 130-metric-ton version will employ the J-2X engine in its upper stage — an updated variant of the engine originally designed for the 1968 Saturn 5 lunar mission.

The initial version of the Space Launch System will be capable of sending 70 metric tons to low Earth orbit.

In fact, engineers consider the SLS Saturn's "grandchild." According to Lyles, its technology was "evolved from the Saturn through the space shuttle program." The SLS has the same sleek look of the Saturn rocket, and it's stacked the same way. Moreover, the space shuttle main engine

was itself derived from the J-2 engine on the Saturn 5. According to Lyles, NASA made a deliberate choice to base the design of the SLS on proven technology, incorporating improvements within the tried and true elements. "It's a lower risk approach, and it's more cost effective," says Lyles. "To build something brand new that has never flown comes with a high risk and at a high cost, with no advantage to capability. We believe the most efficient way to approach this is through evolution."

This cautious approach has been viewed by some critics as too cautious, even redundant. The most noticed reproach came from space expert Lori Garver, who left her position as NASA deputy administrator in September and in January went public with criticism of the SLS in an appearance on National Public Radio: "The rocket is so similar, and it's built off of 1970s technology. The very engines we're going to use are space shuttle engines that were developed in the 1970s. Would you really go to Mars with a technology that's 50 years old? That's not what innovation and our space exploration program should be all about," Garver said on NPR's Diane Rehm show. She stood by those comments when contacted by Aerospace America.

Lyles has heard the "old technology" criticism before, and he says it's off the mark: "We're not flying the same RS-25 engine that flew 30 years ago." Within the proven elements of the basic design of the liquid-fuel cryogenic engine design lies a tremendous amount of new technology, he says. All of the electronics are state-of-the-art, as are some of the manufacturing technologies like friction stir welding, a U.K.-developed technique in which a rotating head turns metals into a "plastic-like state" that's mixed into a bond, according to NASA. "We're using some of the most advanced manufacturing technologies in the world today," says Lyles.

Politics and priorities

But Garver's focus in criticizing the SLS went beyond its perceived lack of innovation. In the same NPR discussion, she portrayed SLS as a product of politics. "It was something that Congress dictated to NASA. It had to do with the Orion spacecraft. It is a holdover from Constellation, which the `Obama administration tried to cancel. And it's $3 billion a year of NASA's $17 billion. Is that how you would be investing in a space program?"

Garver is referring to the Constellation rocket and capsule program started by the Bush administration in 2004. Constellation's mandate was to carry astronauts back to the moon. It comprised design work on the Orion crew capsule — described by then-NASA Administrator Michael Griffin as "Apollo on steroids" — and the Ares heavy-lift rocket. The Obama administration cancelled the Constellation program in 2010.

RAND Corporation researcher Peter A. Wilson says Constellation was doomed from the start because of the costs of the wars in Afghanistan and Iraq. "The reality is that the [Bush] White House, much to NASA's frustration, under-funded the effort because they had a war to worry about. Going back to the moon was hardly a priority for the [Bush] administration; so the project languished," says Wilson.

The 2009 review of the Constellation program by the United States Human Space Flight Plans Committee, also known as the Augustine Commission, determined that the program could not be completed without major increases in funding. The move triggered some complicated parliamentary maneuvers. The president's NASA budget request for fiscal year 2011 announced cancellation of the Constellation program, but also called for a total of $3.1 billion over five years for heavy-lift and propulsion research and development. The NASA Authorization Act of 2010 — the NASA budget bill sent to the president by Congress — added in development of the SLS as a follow-on to the shuttle program.

Congress was first to use the term Space Launch System when it added the program during work on the NASA Authorization Act of 2010, which Obama signed in October 2010.

Wilson's theory, which could not be independently verified, is that the SLS emerged as a political "senate mandated"

NASA's SLS plan includes an evolved version for lifting 130 metric tons

compromise between the Obama administration and the powerful senators from states including Alabama, Texas and Florida, who championed Constellation and were disappointed when the funding was cut.

Asked about this by email, Garver didn't reference a specific deal made behind closed doors, but she made a related point: "SLS being congressionally mandated is simply a matter of fact. The administration did not request the SLS (or Orion) in its annual budget submission. The Congress added the program(s) into the NASA budget (and cut other administration priority programs such as Earth science, technology and commercial crew). The president did not veto the legislation—thus accepting the Congress' direction. This is a matter of record. There were many meetings and discussions during this time, but the simple process is the same as always. The federal budget process is quite simple: The president proposes, the Congress disposes," Garver said in an email.

The SLS will be using the Orion crew capsule originally commissioned for the Constellation program and designed by Boeing, and a very similar engine technology derivative from the space shuttle and the Saturn 5, giving its critics reason to argue that the SLS is basically Constellation redux.

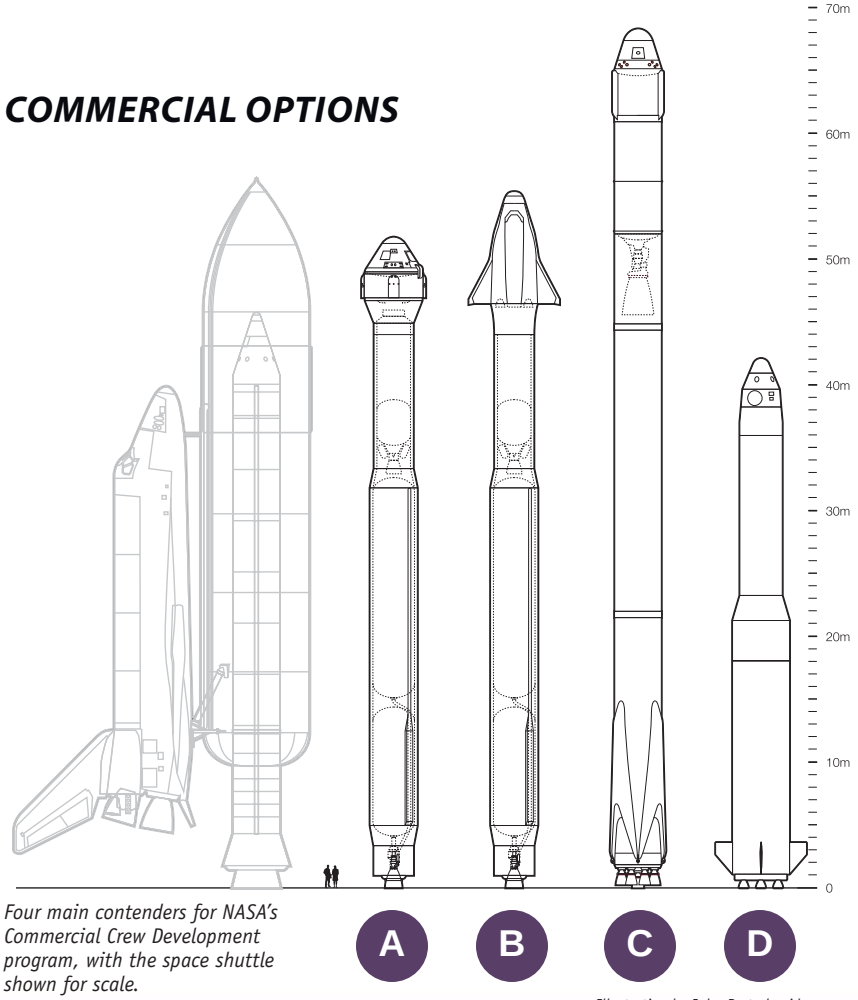
Affordability factor

Wilson is not a fan of the SLS, to put it mildly. He penned an op-ed for an April issue of Aviation Week & Space Technology, titled: "Kill the Space Launch System to save human spaceflight." He calls the SLS "a 15-billion-dollar mistake." He said in an interview, "It's a 'field of dreams' strategy: If you build it, they will come." Wilson argues that spending money on a huge undertaking like the SLS is a luxury the U.S. taxpayer simply can't afford in this day and age.

"The manifest for this very large rocket, as we speak, is two flights. One [unmanned flight] in 2017, which is ridiculously close at hand. And then another flight which is supposed to take place sometime in 2021 with some human beings on board; initially it was supposed to be just a fly-by around the moon, and then NASA realized that seemed ridiculous since they've done that in 1968. And now they took up this asteroid mission to at least have the justification to why you'd want to carry it out. The Congress itself is skeptical

(Continued on page 45)

COMMERCIAL OPTIONS



Four main contenders for NASA's Commercial Crew Development program, with the space shuttle shown for scale.

Illustration by John Bretschneider

A Boeing's Crew Space Transportation-100
The CST-100 would accommodate up to seven people. It would be reusable for up to 10 missions and has a weldless"design, according to the company. The first test flight is currently scheduled for late 2016, the first manned mission for 2017.

B Sierra Nevada's Dream Chaser
The Dream Chaser would hold seven people within its reusable winged lifting body. It would maneuver through space, dock with other spacecraft, including the International Space Station, and land on a conventional runway.

C SpaceX's Falcon 9v1.1/Dragon
The SpaceX Falcon 9v1.1 is a larger successor to the original Falcon 9. In 2012 the Dragon capsule became the first commercial spacecraft to deliver cargo to the International Space Station and return to Earth. Dragon's first manned test flight is expected to take place in two to three years.

D Blue Origin
The dimensions of Blue Origin's yet-unnamed orbital spacecraft have not been revealed – the artist's rendering is notional only. The company says only that the craft would be launched on a reusable first-stage booster that would separate from the upper stage, descend to Earth, and perform a powered, vertical landing. Blue Origin was established by Amazon.com founder Jeff Bezos.

Mars or bust

The case for optimism

NASA

Mars in an image from the Curiosity rover. Inset: scene from the movie "Mission to Mars," Buena Vista Pictures

As NASA's lead writer from 2002-2009, Edward Goldstein wrote speeches and opinion articles for two administrators, Sean O'Keefe and Michael Griffin. Goldstein earned his Ph.D. from George Washington University in 2007 with a dissertation on the history of NASA's Earth Science Program.

ANALYSIS
by Edward Goldstein

Sending human explorers to Mars is an idea that has seemed to many in the space community as elusive as a mirage on a red-hued desert planet, but it's something they've thought about for decades. Indeed, rocket pioneer Wernher von Braun advocated the idea in a Collier's magazine article in 1954, well before NASA came into being.

For dyed-in-the-wool space exploration advocates. there's a sense that for far too long we've been on a path that's led to roadblocks, detours and dead ends. After all, weren't we promised Mars in earnest by one vice president, Spiro Agnew — leader of the post Apollo-11 Space Task Group — and two president Bushes, only to have such plans disappear into the dustbin of history?

And let's not forget that four years ago in his Kennedy Space Center space policy address, President Obama asserted, "By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth. And a landing on Mars will follow." But of course that was in the heady pre-sequestration days, when his administration was proposing $6 billion in new funding for NASA over five years — with a big increase for technology development — on top of the $1 billion in extra stimulus funding the agency received in 2009. After the budget deal reached by Congress and the president in December, NASA has a fiscal year 2014 budget of $17.65 billion, roughly $1 billion lower than its FY 2010 budget — not exactly a good trajectory.

No plan, no funds, no ride

According to Scott Pace, director of George Washington University's Space Policy Institute, if NASA's budget today had the same purchasing power it had 20 years ago, it would be around $24 billion. I asked Pace, who is also former NASA associate administrator for program analysis and evaluation, to judge the likelihood of a viable human mission to the surface of Mars in the 2030s. His response: "Absolute zero. A mission doesn't exist. There is no plan, there is no funding, there's no near-term capability in place. The political conditions don't exist for it. The economic conditions don't exist for it. I might as well be talking about long-term plans for interstellar flight."

Similarly skeptical is former NASA chief historian Roger Launius, now associate director of collections and curatorial affairs at the Smithsonian Institution's National Air and Space Museum. "My question for anyone who thinks we should go off and send a human mission to Mars is simply this: What is the trigger mechanism, the set of economic, political, social or whatever factors … that would come together and create an environment in which the appropriate response to that challenge, whatever that challenge might be, is a trip to Mars?"

Edward Goldstein asked fellow Mars exploration advocates about the near-term prospects for sending humans to the Martian surface. Below are some of their responses, and a discussion of current approaches to achieving the goal.

said Launius. "I don't envision us finding that trigger. So I don't think it's real…There are enthusiasts, and that enthusiasm is real. But they don't have the size or the influence necessary to make a human mission to Mars something that's going on the national agenda."

That said, there is work under way now that I believe could lend itself to a more optimistic view, that a little over two decades from now, people around the world will gather to watch a crystal-clear live video feed and hear the historic words transmitted about 10 minutes earlier from a distance of at least 35 million miles: "Houston, Eberswalde Base here, the Millennium Eagle has landed." Eberswalde Crater preserves a Martian river delta system and could hold evidence of early life.

Causes for hope

- ***Technology gains*** — NASA and its contractors are making significant progress on critical elements for a human Mars mission — the Multipurpose Crew Vehicle and SLS, the Space Launch System. Moreover, research onboard the International Space Station is helping NASA understand the long-term biomedical challenges of such missions and is providing experience with operating a complex environmental life support system.
- ***Planning continues*** — NASA is taking a steady-as-she-goes attitude toward its Design Reference Architecture 5.0, whose authors modestly call it "a vision of a potential approach for human Mars exploration." NASA Headquarters is considering sensible refinements to the document, which provides a "common framework for future planning of systems concepts, technology development, and operational testing," say its authors. It is the fifth in a series the agency began publishing in 1993 in attempts to produce a plausible architecture for human Mars exploration.

This document lays out scenarios for three lengthy expeditions to the Martian surface. In conjunction with the scientific community, the paper pinpoints 58 possible landing targets. All are tied to learning more about whether Mars at one time sustained life, and about the planet's geology, subsurface and atmosphere.

- ***Wise spending*** — Another reason for optimism is the agency's investment in the 16 top technology priorities deemed critical by the National Research Council for future NASA missions, including several related to interplanetary exploration. An area of significant progress is cryogenic propellant storage and transfer, says Michael Gazarik, NASA's associate administrator for space technology. Another important area of investment, he says, is in high power solar electric propulsion. "Those are the number one and number two high-priority technology areas for future exploration," he says. Being able to store and transfer cryogenic fluids on orbit "is a real enabler, saving significant mass for human or robotic exploration," says Gazarik. High-power solar

In a 1954 Collier's magazine article, rocket pioneer Wernher von Braun advocated the idea of sending human explorers to Mars.

The Orion Multi-Purpose Crew Vehicle undergoes testing at Lockheed Martin.

NASA

NASA

The Space Launch System is still an artist's rendering, but it could someday send a crew toward Mars.

electric propulsion is also "a very efficient way to move cargo as we explore the solar system," he says.

On the question of forward momentum, Gazarik sees broader signs of progress: "What we had in the past were a lot of studies. We had probably 40 studies or so over the last 30 years that have asked, 'what are the technologies you need to get to Mars?' that all say about the same thing…The difference we're making now in space tech is [that] we're working on them. We're working on laser and optical communication. We're working on advanced entry descent and landing. We need to put more mass on the surface, as we can't go around exploring the universe in a Mini-Cooper," which is the size of the Curiosity rover.

● ***International support*** — The latest Global Exploration Roadmap, released in August by the International Space Exploration Coordination Group — an information exchange organization that includes NASA — has become more Mars focused and includes a single reference mission scenario leading to exploration of the red planet after 2030. In December, Mars exploration stakeholders from NASA and the contractor community discussed human missions to Mars at a meeting hosted by Explore Mars Inc. and the American Astronautical Society at George Washington University. Their conclusion: With space agency budgets that keep pace with inflation, international partnerships and alternative acquisition and development methods — including streamlined government oversight and Skunk Works/Phantom Works-like structures — the "initial human missions to Mars are affordable under reasonable assumptions and with sustained international political support."

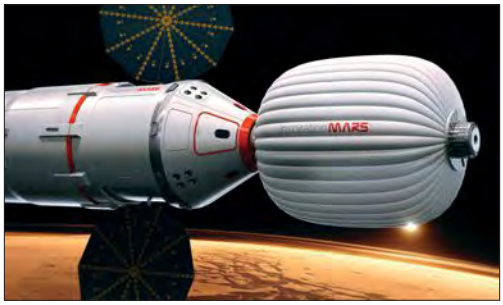
● ***Priceless opportunity*** — A final cause for hope is that Mars itself is in a cooperative mood. In 2033 and 2035, the planet's orbit relative to Earth is particularly favorable for minimum-energy trajectories, reducing the fuel required for sending a mission into Martian orbit, to the surface of Phobos or Deimos, or even to the planet's surface with spacecraft fueled by conventional propellants. This window may also occur during the "solar maximum" phase of the 11-year solar magnetic field. This is when the sun is at its most active state and provides protection against galactic cosmic rays, an insidious form of space radiation that can cause cancer and nerve damage in astronauts.

Also, because the 2033 and 2035 launch windows are unusually good ones, leading to a relatively shorter transition time to and from Mars — unlike in the Apollo era — the stay time for crews near or on the surface of Mars could be weeks to months.

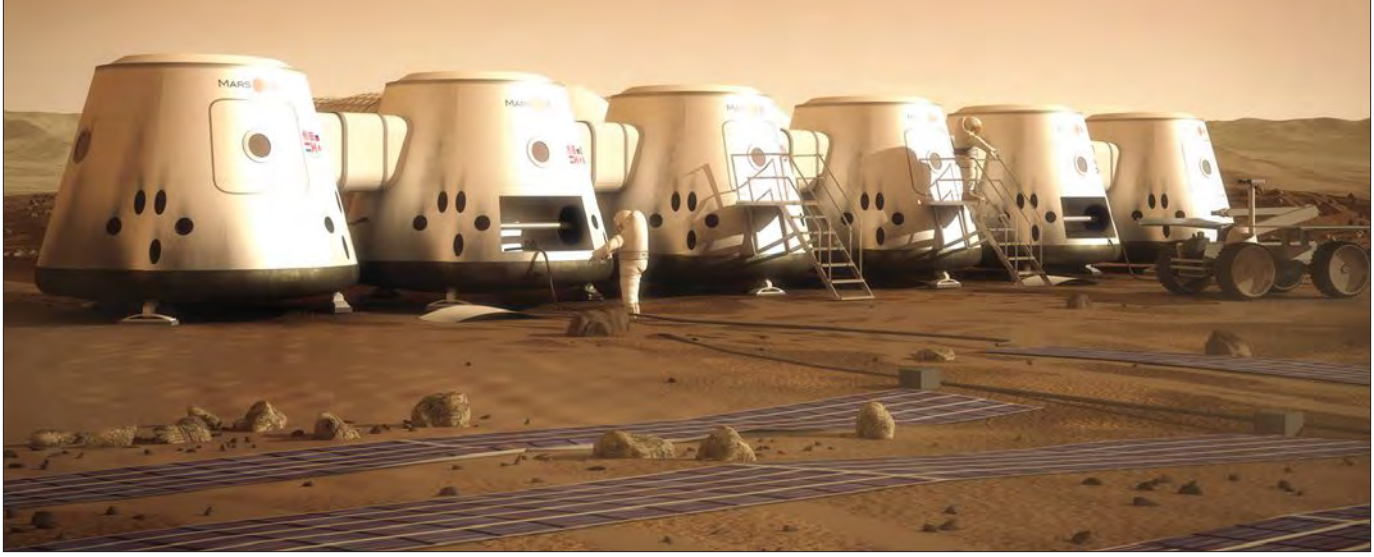
Indeed, there is growing optimism that NASA, with the support of international and commercial partners, can make a human Mars mission possible before the eightieth anniversary of the space age. Also, private sector ideas such as Mars One, Mars Direct and Inspiration Mars are viewed favorably

"I think that something in the early 2030s is achievable with the budget we have, if — and this is a big if — we can get international partners to come along and lay in other pieces of the infrastructure."

— James Crocker, Lockheed Martin Space Systems



Early artist's conception of Inspiration Mars capsule and habitat module.



NASA

Pressurized rovers would allow the crew to explore beyond the range permitted by their space suits and work in a shirtsleeve environment.

by many traditional space community professionals for stirring public interest about Mars, and for potentially pointing the way to new technological approaches or even meeting their bold objectives. It's worth noting, however, that NASA is not onboard with billionaire Dennis Tito's Inspiration Mars plan for launching a mission to the planet as early as 2017 using NASA's new Space Launch System.

In response to Tito's plan, David Weaver, NASA's associate administrator for public affairs, made this statement: "Inspiration Mars' proposed schedule is a significant challenge due to life support systems, space radiation response, habitats and the human psychology of being in a small spacecraft over 500 days. The agency is willing to share technical and programmatic expertise with Inspiration Mars, but is unable to commit to sharing expenses with them." The Inspiration Mars team is working on a revised plan for 2021 that seeks to address the issues NASA raised, and only time will tell if this new plan will gain acceptance.

But for the long haul, NASA appears committed to Mars, which "is today the ultimate destination in our solar system for humans and…a priority for NASA," said the agency's administrator, Charles Bolden, at George Washington University's Humans to Mars Summit in May. "Our entire exploration program is aligned to support this goal."

Confidence building

Mike Raftery, director of International Space Station utilization and exploration for Boeing, leads a team at his company examining Mars exploration architectures. "The community is starting to believe that we can make Mars happen, and that is a relatively recent thing," he says. Previously, the thinking was that Mars is "really big and hard and therefore too difficult and expensive to attempt," he says. But his experience with the ISS has given him a different view. Getting to Mars "isn't that much harder than what we've already done for ISS, with international cooperation and cost-sharing."

Raftery further argues the tonnage needed for a human Mars mission will be substantially lower than that required for ISS assembly and logistics flights, depending on the architecture and in-space propulsion technology used. The number of unique payloads needed will also be lower, he says.

The key to success, says Raftery, is to have an "architecture that takes advantage of the lessons learned from ISS and breaks down the overall requirements for a mission into as few pieces as possible, with as little revolutionary technology as possible."

Raftery describes a potential mission broken down into six basic elements: SLS for crew and cargo launch; Orion for crew return to Earth; a TransHab Module to carry crews to orbit around Mars; solar electric propulsion tugs to transfer cargo from high Earth orbit or cis-lunar space to a Mars orbit and/or the Martian surface; the Mars lander; and the Mars ascent vehicle. A launch campaign using an SLS or evolved SLS system for a landing mission would require five to seven launches for the crew — "if you don't push the technology too hard," says Bret Drake, principal editor of NASA's Design Reference Architecture 5.0 — with an additional four to seven launches needed to get cargo to the Martian surface.

In Raftery's view, nuclear electric propulsion, while desirable for reducing the transit time to Mars, should not be on the critical path. Some eight years after the Project Prometheus nuclear propulsion program was cancelled, NASA planners are still looking at this technology. However, it

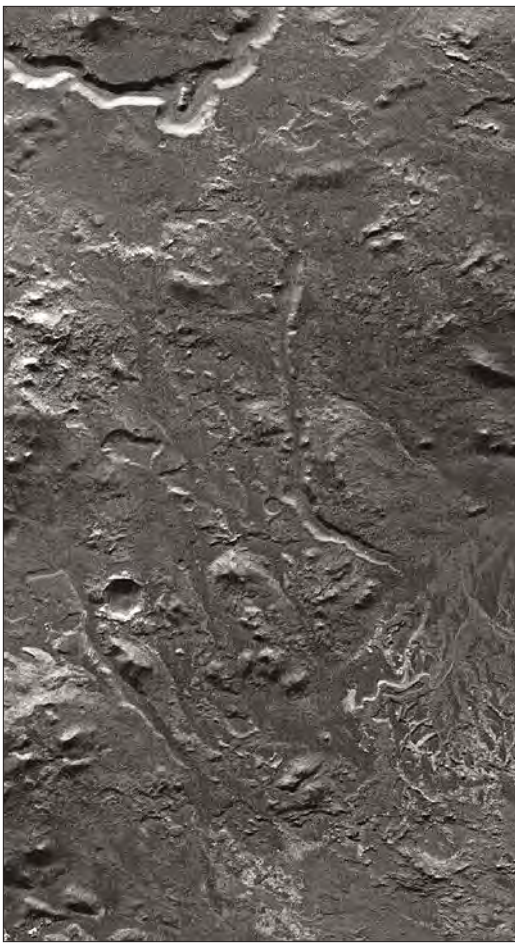
"[Getting to Mars] isn't that much harder than what we've already done for ISS, with international cooperation and cost-sharing."

— Mike Raftery, Boeing

would require a major, sustained funding commitment to achieve engineering viability and reliability in deep space. "Nuclear thermal propulsion is one area, along with efficient surface and spacecraft power… where everyone can see tremendous benefit," says NASA's Gazarik. "Given today's tough fiscal environment, and specifically where [the] Space Technology [Mission Directorate] stands, it's a tough one to go push on in a very large way….We have some moderate investments to keep nuclear systems alive." At NASA Marshall, "we simulate the nuclear part. And we are working with the Department of Energy on the thermal management part and the management and control of the system," to "move that forward as best we can" until more resources become available.

Step-by-step planning

Perhaps crucial to turning Mars visions into reality is completing a viable near-term stepping-stone plan once the SLS and Orion are ready. James Crocker, vice president and general manager of civil space at Lockheed Martin Space Systems, says that after those systems are available, the next



Landing sites: *Jezero Crater (left), Eberswalde Crater (middle),and Mangala Valles (right) are among the contenders.*

step would be to develop a series of manned flights. These would start in 2020 and "would allow us to continue developing the technology within the budget that NASA has — this is pay as you go." The series of steps would keep progressing, he says, and would have "the ultimate goal of getting to Mars as soon as we could and within the budget we have. I think that something in the early 2030s is achievable with the budget we have, if — and this is a big if — we can get international partners to come along and lay in other pieces of the infrastructure." Whether it's the Russians or Europeans, he says, "Most spacefaring nations are very interested in being part of this journey."

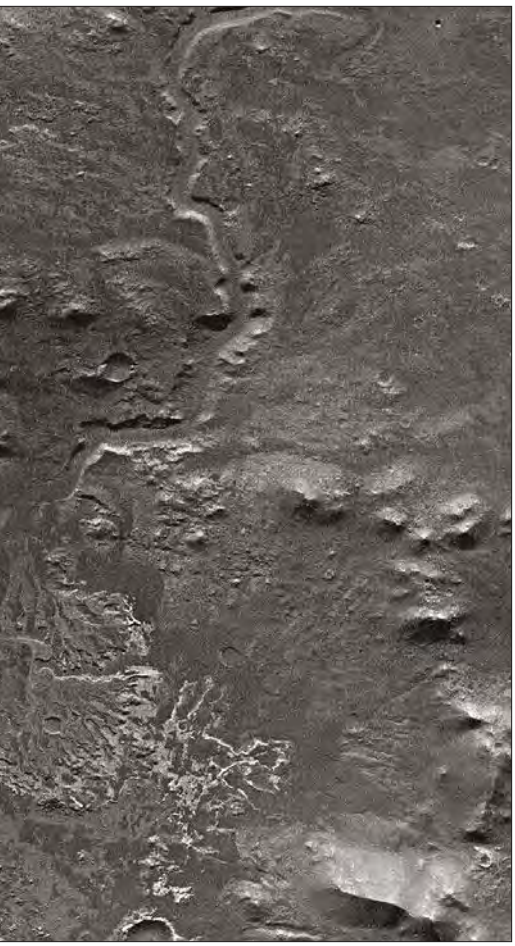
Adds Jason Crusan, director of NASA's advanced exploration systems division, "Every time we fly a mission, whether it's human or robotic, we evaluate it by the opportunity to increase the knowledge… and reduce the gaps that we have [on getting] from here to Mars." The 5.0 architecture is "pretty comprehensive in that regard," he says.

A major potential hurdle to overcome is the issue of crew radiation exposure, a concern that has already led to discussions about whether NASA's lifetime exposure limits — which are 20 percent lower for women than for men, because of greater risk for some cancers — would constrain flight opportunities for female astronauts. To deal with the overall risk, Gazarik reports the agency is in the early stages of studying advanced materials and other techniques for radiation shielding. And Crusan notes that NASA is looking at in-space systems such as the Mars Science Lab and Lunar Reconnaissance Orbiter for purposes of "revalidating some of our data related to plastics and their ability to absorb radiation and provide radiation shielding."

Big decision

If a concerted effort to conduct a human Mars mission does go forward, the potential landing sites are intriguing. NASA's 5.0 architecture document discusses at length sites such as Jezero Crater, where a standing body of water existed during the Noachian

All photos from NASA



NASA

Picking a landing site: *Data gathered by NASA's Mars Atmosphere and Volatile Evolution spacecraft, now on its way toward Mars, is intended to help.*

period, an early time in the planet's history. Another widely viewed target is Mangala Valles, an outflow channel that saw massive releases of water in the past and may contain icy near-surface deposits.

James Garvin, who co-chaired the NASA-chartered Human Exploration of Mars Science Analysis Group and is chief scientist at NASA Goddard Space Flight Center, cautions that it would be premature to select a landing site before additional information is gathered by the Mars Reconnaissance Orbiter and by upcoming missions such as NASA's Mars Atmosphere and Volatile Evolution, the ESA/Russian ExoMars and the NASA 2020 science rover missions. But he expresses a tentative preference for visiting a place such as the Eberswalde Crater, whose preserved river delta system could hold biosignatures in its rock record.

When asked if a human Mars mission would be worth the expense from a scientific standpoint, Garvin is emphatic: "Human flight systems would bring with them greater capabilities for accessing new places on Mars, and for returning 'high-graded' samples of rocks, ices and even atmospheric gases for study here on Earth," he says. Human explorers — ideally aided by robotic counterparts — would also accelerate the pace of discovery, "provided we can optimize where they should go and what specific questions they should pursue in earnest," he says. Indeed, human explorers "would enable progress that would otherwise have required decades….I do not think we have seen anything yet in terms of what Mars has to offer about our solar system, the prevalence of life and our role in the universe," says Garvin.

All the people I spoke with cite their career-long commitment and passion about the goal of getting humans to Mars. "I believe as a career NASA scientist with 28-plus years of service…that Mars is the optimal destination to give humanity the confidence to know that some day we can escape our precious Earth and go elsewhere, even in these 'pre-Warp' civilization days," said Garvin in an e-mail. "Mars is the place, and all we need is the dedication to make it our cathedral to the stars."

Lockheed Martin's James Crocker sums it up this way: "I know a young engineer, who happened to be me, who graduated just in time to get down to the Marshall Space Flight Center for the very last Apollo mission to the moon, Apollo. 17. And I was hurrying to get through Georgia Tech in four years, which was pretty challenging even in those days, because I was afraid they were going to get to Mars without me. Little did I know that it would take a long time for us to do that. I'm of the school that [says] we just ought to get on with it." ▲

(Continued from page 37)

about the asteroid rendezvous mission because it's a multi-billion-dollar effort. The question is, how is that going to be paid for?" said Wilson.

Wilson questions the need for a heavy-lift space launch vehicle destined for what he calls dubious deep space missions, when there is a promising program focused on manned flight within low Earth orbit that could use the funding currently being directed to the SLS: NASA's Commercial Crew Development program, or CCDev.

Closer to home

CCDev is an effort coordinated by NASA with private contractors bidding to develop a "space taxi," a crew vehicle that would ferry astronauts and potential space tourists to the International Space Station or any other future installations in low Earth orbit. The four main contenders in the program are Boeing's CST-100 spacecraft, SpaceX's Dragon, Sierra Nevada's Dream Chaser space plane and Blue Origin's orbital vehicle. The CCDev program's first scheduled flight was supposed to take place in 2015, but it has fallen behind schedule, with NASA Administrator Charles Bolden blaming funding issues. For fiscal year 2012 Congress appropriated only $406 million in funds, less than half of the $850 million requested by the Obama administration.

Proponents of CCDev look with envy at the money slated for SLS. According to Lyles, pitting the two against each other would be like comparing apples to oranges. Though the SLS can stand in as a space taxi if need be, its main purpose is deep space exploration: "The commercial launch vehicle industry is very complementary to the SLS. SLS is focused on beyond lower orbit," he says. "The commercial companies are taking over what NASA used to be responsible for — which is space travel to the lower orbit, essentially to the International Space Station, whether it be crew or cargo. The complementary effect is that we gain a large industry to go into lower orbit; at the same time we can now focus on beyond lower orbit with our launch system," says Lyles.

Reaching higher

And for going beyond low Earth orbit, Lyles says the SLS is the only game in town: "There is nothing there today that I know of that has the payload capability of SLS in its fully evolved configuration." There are commercial heavy-lift rockets currently flying or in development — Delta 4 Heavy, Atlas 5 and the Falcon Heavy. But experts say neither has enough payload capability to get a crew mission to the moon or beyond without resorting to alternative mission architectures that would involve, for instance, "fuel depots" — in-space "gas stations" where the launch vehicle would stop to pick up the additional fuel needed to proceed. The SLS is big enough to carry all the fuel it will need for a deep space mission.

Mission capability is key, according to Lyles. He says the SLS wasn't designed with a specific mission in mind, but as an evolvable rocket that could service any potential future mission — whether a manned flight to Mars, delivery of cargo to a future lunar orbital station or putting in orbit a large space telescope. In his view, just because NASA hasn't defined all those missions doesn't mean SLS is a rocket to nowhere. "The only reason we don't specify one mission is because we don't want to lock the capability" to one particular mission. Once specific missions are selected, NASA wants to feel confident that "we built in to SLS [the] capability to do any of those. So I don't have to spend money next time to develop something totally new," says Lyles.

For all the criticism, the SLS program seems to be chugging along, hitting the project milestones on schedule and getting its yearly funding approved by Congress. In fact, the SLS has some powerful backers on the Hill. Republican Senator Shelby of Alabama, home to NASA's Marshall Space Flight Center, where NASA is managing the program, is a strong, politically powerful supporter. Shelby said in an email, "If we are to maintain our proud role as the global leader in human space flight, then we must continue to push the current boundaries. Aside from SLS, there is no credible, near-term option to travel beyond low-Earth orbit. That is why I strongly support it." Shelby is vice chairman of the Senate Committee on Appropriations.

One industry veteran says that in a time of over-stretched budgets, having "friends in high places" is what will ultimately assure longevity for a NASA program like the SLS. Despite the heated discussion around the SLS, he says, what matters are the votes of the majority of the U.S. Senators on the Commerce, Justice and Science Subcommittee. If they are on board, the program will proceed. "The rest of the conversation, frankly, is just a bunch of hot air," he says.

Out of the

25 Years Ago, March 1989

March 6 ESA's Ariane 4 rocket launches Japan's first privately owned commercial communications satellite, JCSAT 1, along with the Meteosat MOP 1 European weather satellite. JCSAT 1 handles business communications and relays voice, video, facsimile and high-speed data. NASA, Astronautics and Aeronautics, 1986-90, Page 207; Aviation Week, March 13, 1989, Pages 29-30.

March 29 The two-stage Starfire suborbital rocket, developed by Space Services, lifts off at the White Sands Missile Range in New Mexico. This is the nation's first licensed launch of a commercial rocket designed for spaceflight. The test launch takes the rocket on a 198-mile ballistic trajectory. The flight lasts 15 minutes and carries several microgravity experiments. NASA, Astronautics and Aeronautics, 1986-90, Page 209.

50 Years Ago, March 1964

March 2 French aircraft designer Raymond Saulnier, known for a long line of Morane-Saulnier aircraft, dies. It was Saulnier who designed the Bleriot 11, the plane flown in 1909 by Louis Blériot when he became the first person to fly a heavier-than-air craft across the English Channel. But perhaps the most famous of his inventions was an interrupter gear, or gun-synchronizing device, produced during World War I. The device regulated the fire of a machine gun so as to enable its bullets to pass between the blades of the spinning propeller. Flight International, March 19, 1964, Page 407; Raymond Saulnier file, National Air and Space Museum.

March 5 A scientific payload weighing 589 kilograms is launched from the National Center for Atmospheric Research site near Palestine, Texas, and carried up to 97,000 feet by a balloon. The instrumented balloon, part of the Coronascope 2 project, takes photos to aid studies of the effects of the sun's corona upon Earth's magnetic field and upper atmosphere. Houston Post, March 6, 1964.

March 8 Air Marshal Sir Robert Hamilton Clark-Hall, one of Britain's earliest military pilots, dies at age 80 in New Zealand. Awarded his aviator's certificate in 1911, Clark-Hall served as the first specialist armament officer of the naval air wing and was involved in the first use of machine guns in aircraft. During World War I he also commanded the first seaplane carrier, HMS Ark Royal. After he retired, he volunteered and served again with the Royal New Zealand Air Force during World War II. Flight International, March 19, 1964, Page 450.

March 11 Britain's four-engine Siddeley Argosy Series 200 military transport and cargo aircraft, to be used by the Royal Air Force, makes its first flight, piloted by the company's chief test pilot, Eric Franklin. The 200 series has a larger freight hold and enlarged front and rear doors that allow it to carry standard-size cargo pallets. The plane also has a lighter redesigned wing, increasing the maximum range, and Rolls-Royce Dart 532/1 turboprops. Aviation Week, March 23, 1964, Page 28.

March 17 France launches its first missile submarine, the Gymnote, at Cherbourg. It carries solid-propellant ballistic missiles similar to those of the U.S. Polaris, each having vectored thrust chambers to aid steering. Flight International, March 1964, Page 482.

March 19 The octagon-shaped 120-pound Beacon Explorer A satellite, designed for a comprehensive survey of the Earth's ionosphere, is launched on a Delta rocket from Cape Canaveral, Fla. However, the Delta's third stage burns for only 22 seconds instead of 40 seconds, and the satellite fails to orbit. D. Baker, "Spaceflight and Rocketry," Page 164; Flight International, March 26, 1964, Page 480.

March 25 The first live TV transmissions are made from Japan to the U.S., using NASA's Relay 2 communications satellite. The spacecraft was launched on a Thor-Delta on Jan. 21. New York Times, March 26, 1964, Page 3.

March 26 For the first time, a mockup of the Apollo Lunar Excursion Module is shown to the press by its developer and builder, Grumman Aircraft, at the company's plant in Bethpage, N.Y. The module is designed to make manned landings on the surface of the moon for Project Apollo. Missiles and Rockets, April 6, 1964, Page 26.

March 27 Britain's second satellite, Ariel 2, is launched from Wallops Island, Va., by a four-stage solid-propellant Scout rocket. The 150-pound spacecraft is a modified version of Ariel 1 and carries British science instruments from the universities of Cambridge and Manchester and the Air Ministry Meteorological Office. Ariel 2 is to observe the ozone in the outer atmosphere, discern galactic noise and measure micrometeoroid impacts.

Past

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

D. Baker, "Spaceflight and Rocketry," Page 164.

March 29 Two California astronomers jointly announce their discovery of what is believed to be the most distant object identified to date. Named 3C-147, it is a quasar, a quasi-stellar radio source, several billion light-years away from Earth. One of the astronomers, Thomas A. Matthews at Cal Tech, located the object by observing its radio emissions with the university's twin antennas while Maarten Schmidt photographed the object from the Mt. Palomar Observatory. New York Times, March 30, 1964, Page 27.

March 30 NASA awards North American Aviation's Rocketdyne Division a $158.46-million contract for 76 1.5-million-pound-thrust F-1 rocket engines to power the first stages of the giant Saturn 5 rocket that will take astronauts to the moon for Project Apollo. NASA Release 64-48.

And During March 1964

–Aerojet General receives a $238-million contract for development of the M-1 liquid-hydrogen/liquid oxygen 1.5-million-pound-thrust rocket engine. It is to be more powerful than the F-1, although it does not become operational. Aviation Week, March 30, 1964, Page 35.

75 Years Ago, March 1939

March 3 The Royal Aeronautical Society awards Leslie L. Irvin the Wakefield Gold Medal for "outstanding and meritorious accomplishments in parachute design." Aircraft Year Book, 1940, Page 431.

March 5 Flying Stinson Reliants, pilots Norman Rintoul and Victor Yesulantes demonstrate a nonstop airmail system by picking up a mail sack from a pole at Coatesville, Pa., for All American Aviation, a predecessor of Allegheny Airlines. Aircraft Year Book, 1940, Page 432.

March 6-7 Italian pilots Maner Lualdi, Giuseppe Mazzotti and Ettore Valente set an international speed record of 242.9 mph for a nonstop flight from Rome to Addis Ababa, Ethiopia, in a Fiat BR.20L bomber. The total flight time is 11 hours and 15 minutes. Aircraft Year Book, 1940, Page 432.

March 24 Pilot Jacqueline Cochran sets a women's national altitude record of 30,052 feet over Palm Springs, Calif., in her Beechcraft. Aircraft Year Book, 1940, Page 432.

March 26 Pan American Airways begins a trial flight for its forthcoming North Atlantic U.S.-to-Europe service when its Boeing 314 Yankee Clipper leaves Port Washington, N.Y., for Horta in the Azores. The plane covers the 2,360-mile route at an average speed of 140 mph. On March 30, the survey flight continues to Lisbon and other European points. The Clipper carries 21 people on this experimental flight. Interavia, March 28, 1939, Page 9.

March 30 The Navy Department contracts with Newport News Shipbuilding and Drydock for the construction of the aircraft carrier USS Hornet for a cost of $31.8 million exclusive of armor and armament. Aircraft Year Book, 1940, Page 432.

And During March 1939

– Aircraft designer John K. Northrop, former vice president of Douglas Aircraft, announces the formation of Northrop Aviation. His distinctive flying wing designs, such as the N-1M, are among the company's many notable aircraft. Interavia, March 17, 1939, Page 5.

– The annual Lawrence Sperry Award for the greatest contribution to the advancement of aeronautics goes to Russell Conwell Newhouse "for the development and first practical application of the terrain clearance indicator." Also called an absolute altimeter, it was developed through Bell Telephone Labs and was publicly demonstrated in October 1938 in United Air Lines' Boeing 247–D "flying laboratory." Aero Digest, February 1939, Page 89.

100 Years Ago, March 1914

March 13 French pilots Antoine Destrem and Henri de L'Escaille fly two Nieuport floatplanes from St. Raphael across the Mediterranean to Ajaccio on Corsica. A. van Hoorebeeck, La Conquete de L'Air, Page 103.

AIAA Congressional Visits Day

On Wednesday, March 12, 2014, AIAA members will share their passion about aerospace issues on Capitol Hill.

With the impacts of sequestration rippling through the R&D workforce and the aerospace enterprise, your participation in the **2014 AIAA Congressional Visits Day Program** is more critical than ever!

Come to Washington, DC, to let your representatives hear how important aerospace is to our country's prosperity and security, and take an active role in helping shape the future of our industry.

Join us as we meet with congressional decision makers to discuss the importance of science, engineering, and technology to our national security and economic vitality.

For more information visit
www.aiaa.org/CVD2014
or contact Duane Hyland at **duaneh@aiaa.org**
or **703.264.7558.**

AIAA

14-174

AIAA Bulletin

During Engineers Week in February, AIAA staff gathered for this photo, thanking their members and all engineers for the remarkable way they have affected our lives.

MARCH 2014

AIAA Directory

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

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

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

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2014			
1–8 Mar†	**2014 IEEE Aerospace Conference**	Big Sky, MT (Contact: www.aeroconf.org)	
24–26 Mar†	**49th International Symposium of Applied Aerodynamics**	Lille, France (Contact: www.3af-aerodynamics2014.com)	
15–16 Apr	**NASA MaterialsLAB Workshop**	Arlington, VA (Contact: D. Griffin, dennis.e.griffin@nasa.gov, http://www.cvent.com/events/nasa-materials-lab-workshop/event-summary-f0ee4d29123a453b94c511ab660b81fa.aspx	
29 Apr	**2014 AIAA Fellows Dinner 2014**	Crystal City, VA (http://www.aiaa.org/FellowsDinner2014/)	
30 Apr	**2014 Aerospace Spotlight Awards Gala**	Washington, DC	
5–9 May	**SpaceOps 2014: 13th International Conference on Space Operations**	Pasadena, CA	**5 Aug 13**
14–19 May†	**International Space Development Conference (ISDC)**	Los Angeles, CA (Contact: 202.429.1600, pat.montoure@nss.org, http://isdc.nss.org/2014)	
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)	
26–29 May†	**6th International Conference on Research in Air Transportation (ICRAT 2014)**	Istanbul, Turkey (Contact: Andres Zellweger, 301.330.5514, dres.z@comcast.net, http://www.icrat.org/	
2–4 Jun†	**Global Space Applications Conference**	Paris, France (Contact: Lisa Antoniadis, +33 1 45 67 68 46, lisa.antoniadis@iafastro.org)	
5 Jun	**Aerospace Today ... and Tomorrow: An Executive Symposium**	Williamsburg, VA	
14–15 Jun	**Third AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III)**	Atlanta, GA	
14–15 Jun	**Business Management for Engineers**	Atlanta, GA	
14–15 Jun	**Optimal Design in Multidisciplinary Systems**	Atlanta, GA	
16–20 Jun	**AIAA AVIATION 2014 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **20th AIAA/CEAS Aeroacoustics Conference** **30th AIAA Aerodynamic Measurement Technology and Ground Testing 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** **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	**14 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)	
13–17 Jul†	**International Conference on Environmental Systems**	Tucson, AZ (Contact: Andrew Jackson, 806.742.2801 x230, Andrew.jackson@ttu.edu, http://www.depts.ttu.edu/ceweb/ices/)	
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	**AIAA 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	**14 Jan 14**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
31 Jul–1 Aug	**2nd AIAA Propulsion Aerodynamics Workshop**	Cleveland, OH	
31 Jul–1 Aug	**Missile Propulsion Design, Technologies, and System Engineering**	Cleveland, OH	
2–10 Aug†	**40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events**	Moscow, Russia http://cospar2014moscow.com/	**14 Feb 14**
3–4 Aug	**Decision Analysis**	San Diego, CA	
4–7 Aug	**AIAA 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	**21 Jan 14**
7–12 Sep†	**29th Congress of the International Council of the Aeronautical Sciences (ICAS)**	St. Petersburg, Russia (Contact: www.icas2014.com)	**15 Jul 13**
29 Sep–3 Oct†	**65th International Astronautical Congress**	Toronto, Canada (Contact: http://www.iac2014.org/)	
3–6 Nov†	**28th Space Simulation Conference**	Baltimore, MD (Contact: Andrew Webb, 443.778.5115, Andrew.webb@jhuapl.edu, http://spacesimcon.org/)	
2015			
5–9 Jan	**AIAA SciTech 2015 (AIAA Science and Technology Forum and Exposition 2015)** **Featuring:** **23rd AIAA/ASME/AHS Adaptive Structures Conference** **53rd AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Infotech@Aerospace Conference** **AIAA Spacecraft Structures Conference (formerly the AIAA Gossamer Systems Forum)** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **17th AIAA Non-Deterministic Approaches Conference** **56th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **8th Symposium on Space Resource Utilization** **33rd ASME Wind Energy Symposium**	Kissimmee, FL	
7–14 Mar†	**2015 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
25–27 Mar†	**3rd Int. Conference on Buckling and Postbuckling Behaviour of Composite Laminated Shell Structures with DESICOS Workshop**	Braunschweig, Germany (Contact: Richard Degenhardt, +49 531 295 3059, Richard.degenhardt@dlr.de, www.desicos.eu	
25–27 May†	**22nd St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia, (Contact: Prof. V. G. Peshekhonov, 7 812 238 8210, icins@eprib.ru, www. Elektropribor.spb.ru)	
22–26 Jun	**AIAA AVIATION 2015 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **21st AIAA/CEAS Aeroacoustics Conference** **31st AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **33rd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **7th AIAA Atmospheric and Space Environments Conference** **15th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference** **45th AIAA Fluid Dynamics Conference** **21st AIAA International Space Planes and Hypersonic Systems and Technologies Conference** **13th AIAA/ASME Joint Thermophysics and Heat Transfer Conference** **22nd AIAA Lighter-Than-Air Systems Technology Conference** **16th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference**	Dallas, TX	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
	AIAA Modeling and Simulation Technologies Conference **46th AIAA Plasmadynamics and Lasers Conference** **8th AIAA Theoretical Fluid Mechanics Conference**		
27–29 Jul	**AIAA Propulsion and Energy 2015** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **51st AIAA/ASME/SAE/ASEE Joint Propulsion Conference** **13th International Energy Conversion Engineering Conference**	Orlando, FL	
18–20 Aug	**AIAA SPACE 2015** **(AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA SPACE Conference**	Pasadena, CA	

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.).
†Meetings cosponsored by AIAA. Cosponsorship forms can be found at https://www.aiaa.org/Co-SponsorshipOpportunities/.
AIAA Continuing Education courses.

From the **Corner** Office

A TIMELY END?

Klaus Dannenberg, Deputy Executive Director

How many times have you had to deal with an untimely end? Too often, I'm afraid. And it isn't usually much fun. So today I want to discuss an end that is timely, that is the end of my time on the AIAA staff. This will be my final column since I am retiring and relocating to spend time with my kids and grandkids as they grow in their own lives and careers. My time and commitment to AIAA has been a wonderful blessing in my life—both as a volunteer member for 48 years with 10 years on the Board of Directors and as a staff member during the past 8 years. Having the opportunity to see both sides of this partnership has provided me some unique insights that most of our constituency never observes. The timing for my retirement is excellent for several reasons—our successful transition to the new event model, the successful completion of our first elected two-year presidency, and the successful transition of Executive Directors, only the third such transition in our history!

First, about the change in our event model. At this writing, we've just completed SciTech 2014. Despite the challenges we still must deal with because of the struggling economy and the government travel restrictions (resulting from the GSA and IRS scandals), the meeting was a great success and attendance was terrific! Since we initiated plans to move to the new event model, there have been many anxious moments about the change. Will it be accepted? Will it work? Will the professional and business communities like it? So far, the overwhelming answers to these and other questions has been "Yes! It was a good move at the right time!" Of course, there are always minor glitches, but those have been addressed and been quickly resolved. Overall, the technical communities seem to enjoy the cross-fertilization and exposure to broader topics of national interest. The sponsors and exhibitors appreciate the larger audiences and the greater exposure to executive management. Consequently, they are renewing for future events at an unprecedented rate. Mid-level management audiences are appreciative of the integration topics being addressed since they relate directly to their day jobs. So the anticipated benefits of the change in the event model all seem to be coming true and are being recognized as such by the various constituencies that have been involved, even the skeptics!

Second, It is extremely satisfying to see the results of our change to a two-year presidency. The rationale for this change was that the president needed continuity and enough time to implement change and make it work. The primary downside was the concern that we might not be able to get qualified people willing to make the extra commitment. That has worked out exceptionally well to date. Our first two-year president, Mike Griffin, has worked relentlessly on behalf of the Institute and has fully utilized the benefit of more time to see things through that were started during his tenure. His successor, Jim Albaugh, our president-elect, has been working equally as hard and doing so even before his term begins. Both have been exceptionally active in AIAA affairs, carrying our message to policymakers and decision makers throughout our community. Their increased focus and involvement in the Institute's strategic direction has already paid great benefits. And these will only increase as time goes on.

Finally, the transition to Sandy Magnus as AIAA's fourth Executive Director has been a dramatic and fulfilling one. Sandy will be the first to tell you that the job is not what she was expecting. With the extreme challenges of the economy coupled with the government travel restrictions and preceded by the Institute's first money losing annual results in well over a decade, she had the extreme dual challenges of managing ongoing activities for greater efficiency while simultaneously creating needed, but disruptive change. Leading the needed change actually makes the job of managing for efficiency a whole lot tougher. But she is meeting and exceeding those challenges and is setting the way forward to take AIAA into the future of relevance, excellence, and innovation that we all want to be a part of in our professional lives.

In summary, the timely end of my tenure on the staff comes as the Institute is entering a new phase of commitment from our industry leaders, and the staff and the membership work together to implement and institutionalize new content, new partnerships, and new products, all having substantially greater relevance throughout our global aerospace community. The partnership between the staff and the membership is critical to our success! The members define evolving professional interests and trends in our community that need discussion, but the staff enables those topics to be addressed in an objective and viable way from a business perspective. *We need both!* Today this partnership is stronger than ever, and it will need to be continually nurtured and maintained to remain effective.

I want to encourage each of you to become emissaries within our technical community to those who are aerospace professionals but are not yet members of AIAA. Membership in AIAA brings countless benefits: off-the-record technical and policy insights established through face-to-face dialogue; establishment of professional networks of mentors, friends, and acquaintances; and access to the latest technology breakthroughs, among others. This close-knit community has been an important part of my career and will continue to be so into my retirement. Most of my best friends and closest professional relationships have arisen through joint AIAA endeavors in activities where each of us and our employers all benefitted greatly. I encourage you to let AIAA be a part of your professional life if it is not already so. Working together with the membership and the staff, let's ensure that the Institute succeeds beyond our wildest dreams as we take the next critical steps in our path forward and mark a new beginning for AIAA.

CALL FOR NOMINATIONS—WALTER J. AND ANGELINE H. CRICHLOW TRUST PRIZE

AIAA invites you to nominate candidates for the Walter J. and Angeline H. Crichlow Trust Prize. The Prize is presented by AIAA every four years for excellence in aerospace materials, structural design, structural analysis, or structural dynamics.

Nominations should include any one or more of the following: environment and loads definition, utilization of advanced materials and fabrication processes, innovative structural configurations, determination of structural integrity by analysis and test, advanced mathematics and/or computer programming of general and advanced usage, weight-reliability-life cycle considerations, or adaptive structures. The Prize consists of a certificate of citation, an engraved medal, and an honorarium of $100,000. The recipient will be invited to receive the Prize at the 2015 AIAA Science and Technology Forum and Exposition (SciTech 2015).

Don't delay! Nominations for the 2015 award must be postmarked by 15 March 2014. To download regulations/procedures or a nomination form, please visit **www.aiaa.org/Secondary.aspx?id=20414**.

2014 AIAA ASSOCIATE FELLOWS HONORED

The 2014 Associate Fellows were honored at the AIAA Associate Fellows Dinner on 13 January at the Gaylord National Harbor Hotel and Convention Center, North Harbor, Maryland, in conjunction with the AIAA SciTech Forum.

Photos of the Associate Fellows from top to bottom: Region 1, Region II, Region III, and Region IV (Region IV photo includes family members of Jeff Moorehouse, who was made an Associate Fellow posthumously).

From top to bottom: Region V, Region VI, and Region VII.

Larry Brase, Chair, Associate Fellow Selection Committee, welcomes attendees

Associate Fellow Selection Committee with their Regional Directors: (L to R, front row) Jane Hansen, Region Director VI; Shirley Brandt, Region IV, AF Rep; Ferdinand Grosveld, Region I Director; Laura Richard, Region V Director; Alan Lowrey, Region II Director; (L to R, back row) Annalisa Weigel, VP-Elect, Member Services; Sivaram Gogineni, Region III Director and AF Rep; Larry Brase, AF Selection Chair; Merri Sanchez, VP, Member Services; Larry Leavitt, Region I AF Rep; Brandon Wegge, Region V Rep (not pictured: Edward "Ned" Peake, Region II AF Rep; Jayant Ramakrishnan, Region IV Director; Ranney Adams, Region VI AF Rep; Luisella Giulicci, Region VII Director; Klaus Broichhausen, Region VII AF Rep)

CALL FOR PAPERS FOR JOURNAL OF AEROSPACE INFORMATION SYSTEMS

Special Issue on Aerospace Human–Automation Interaction

The *Journal of Aerospace Information Systems* is devoted to the applied science and engineering of aerospace computing, information, and communication. Original archival research papers are sought that include significant scientific and technical knowledge and concepts. In particular, articles are sought that demonstrate the application of recent research in human–automation interaction to a wide range of practical aerospace problems in the analysis and design of vehicles, on-board avionics, ground-based processing and control systems, flight simulation, and air transportation systems.

Information about the organizers of this special issue as well as guidelines for preparing your manuscript can be found in the full Call of Papers under Featured Content in Aerospace Research Central; arc.aiaa.org. The journal website is **http://arc.aia.org/loi/jais**.

Key research areas included in the special issue are:

- *Metrics and Measures*, including real-time measures or techniques to measure mission effectiveness, function allocation, observability, mental models, and situation awareness.
- *Personification issues of advanced automation*. Should intelligent systems behave as agents with a personality and autonomy, or should advanced automation be built and used as a tool?
- *Novel analysis techniques for verification of automation*, *human, vehicle/device, and environment interaction*: including formal modeling, simulation, and the use of virtual environments. Certification of systems with human operators and advanced intelligent automation.
- *Design Methods*, including methods for the inclusion of etiquette into automation design, automation awareness of its own boundaries and limitations, and interfaces for static and adaptive automation
- *Human interaction aspects of future developments in automation for ATC and aircraft*, including monitoring systems, delegation of authority, and certification issues with advanced and adaptive automation.
- *Roles and effects of automation in all aspects of training*, including on skill development, college curricula, and certification of designers and engineers working on human–automation interaction as well as certification of operators and personnel working with advanced automation.
- *Joint Cognitive Systems*, collaboration and joint decisions taken by humans and automation, compatibility of automation, and human decisions and actions.

These areas are only indicative. Also, the special issue is open to manuscripts that are relevant to the applied science and engineering of aerospace computing, information, and communication in systems with human–machine interaction but do not fit neatly into any of the above areas. We do envisage, however, that successful manuscripts will include experimental results, sophisticated simulations of aerospace systems, or (in the case of a paper in the areas of education or policy) well-researched and thorough arguments for policies and their implementations.

Deadline: Submissions are due by **15 May 2014**.
Anticipated Publication Date: **September 2014**.
Contact Email: Karen Feigh, Karen.feigh@gatech.edu or René van Paassen M.M.vanPaassen@TUDelft.nl

AIAA FOUNDATION ANNOUNCES INTERNATIONAL STUDENT CONFERENCE "BEST PAPER" WINNERS

The AIAA Foundation is pleased to announce the winners of its 2014 AIAA Foundation International Student Conference "Best Papers" Competition. Awardees were honored on 13 January at the AIAA SciTech Forum held at the Gaylord National Hotel and Convention Center, National Harbor, MD.

- *Undergraduate*: Austin Ventura, AIAA 2014-0015, "Thermophoretic Force Measurements using a nano-Newton Thrust Stand"
- *Masters*: Andrew Fist and Joseph Majdalani, AIAA 2014-0006, "Improved Mean Flow Solution for Solid Rocket Motors"
- *Team*: Steven Ericson, Melissa Kelly, Nathan Marshall, Ryan Navarro, Christopher Newton, Jeffrey Parkhurst, Adam Pranaitis, and Robert Waldron, AIAA 2014-0101, "Autonomous Unmanned Aerial Vehicle"
- *Community Outreach*: Edward Nickel, "Miners in Space Microgravity Research Outreach"

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

Top photo: Austin Ventura (left) accepting the Undergraduate award from Chris Tavares, Chair, Student Paper Conferences and Chair, International Student Paper Conference. Bottom photo: Andrew Fist (left) accepting the Masters award from Chris Tavares.

Top photo: Adam Pranaitis (left) accepting the Team award award from Chris Tavares. Bottom photo: Edward Nickel (left) and Kevin King (center) accepting the Community Outreach award from Chris Tavares.

OBITUARY

AIAA Honorary Fellow Battin Died in February

Dr. Richard H. "Dick" Battin died on 8 February. He was 89 years old. He developed and led the analytic and software design of the Apollo spacecraft primary control, guidance and navigation system that made the lunar landing of Apollo 11 possible.

Dr. Battin received a Bachelor of Science degree in electrical engineering in 1945 and a Ph.D. in applied mathematics in 1951—both from MIT. He also received an Honorary Doctor of Science Degree in 1999 from Texas A&M University. From 1951 to 1956, he was an Assistant Director of the MIT Instrumentation Laboratory and from 1956 to 1958 a senior staff member at Arthur D. Little, Inc. In 1958 Dr. Battin returned to the Instrumentation Laboratory (later renamed the Charles Stark Draper Laboratory) and subsequently served as Technical Director, Apollo Mission Development and Laboratory Associate Director. He retired from Draper in 1987 as Associate Head of the NASA program department. After his retirement from Draper, Dr. Battin continued to teach at MIT, where he was a senior lecturer in the Department of Aeronautics and Astronautics from 1946 to 2010.

Battin's many honors included the 1972 AIAA Louis W. Hill Space Transportation Award (with colleague David G. Hoag), the the 1978 AIAA Mechanics and Control of Flight Award, the 1989 AIAA von Kármán Lectureship in Astronautics, the 2002 AIAA Aerospace Guidance, Navigation and Control Award, and the 1996 AAS Dirk Brouwer Award. His von Kármán lecture entitled "Some Funny Things Happened on the Way to the Moon," was given at dozens of AIAA local meetings throughout the country.

Battin also received the 1987 AIAA Pendray Aerospace Literature Award "for sustained and outstanding contributions to literature in astrodynamics, control, and applied mathematics which have led to significant advances in strategic missile and planetary navigation systems," and the 2002 AIAA Summerfield Book Award for the AIAA Education Series book, *An Introduction to the Mathematics and Methods of Astrodynamics*. He was the coauthor of *Random Processes in Automatic Control* (1956) with the late J. Halcombe Laning and author of *Astronautical Guidance* (1964).

In addition to being an AIAA Honorary Fellow, Dr. Battin was also a Fellow of the American Astronautical Society (AAS), a member of the National Academy of Engineering, and a member of the International Academy of Astronautics. As MIT Adjunct Professor, he taught and inspired many of the leaders in the guidance and control community. Three of the twelve astronauts who walked on the moon were, at one time, his graduate students. In 1981 he was recognized by the MIT Department of Aeronautics and Astronautics students for his outstanding teaching with their first Teaching Award.

CALL FOR NOMINATIONS

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

Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines to view nominee eligibility, page limits, and letters of endorsement instructions. All nominations, whether submitted online or in hard copy, 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**).

Aerospace Design Engineering Award recognizes design engineers who have made outstanding technical, educational, or creative achievements that exemplifies the quality and elements of design engineering. (Presented even years)

Aerospace Guidance, Navigation, and Control Award recognizes important contributions in the field of guidance, navigation, and control. (Presented even years)

Aerospace Software Engineering Award recognizes outstanding technical and/or management contributions to aeronautical or astronautical software engineering. (Presented odd years)

Children's Literature Award is presented for an outstanding, significant, and original contribution in aeronautics and astronautics. (Presented odd years)

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

Dr. John Ruth Digital Avionics Award
Presented to recognize outstanding achievement in technical management and/or implementation of digital avionics in space or aeronautical systems, including system analysis, design, development, or application. (Presented odd years)

Excellence in Aerospace Standardization Award recognizes contributions by individuals that advance the health of the aerospace community by enabling cooperation, competition, and growth through the standardization process. (Presented odd years)

Faculty Advisor Award is presented to the faculty advisor of a chartered AIAA Student Branch, who in the opinion of student branch members and the AIAA Student Activities Committee, has made outstanding contributions as a student branch faculty advisor, as evidenced by the record of his/her student branch in local, regional, and national activities.

Gardner-Lasser History Literature Award is presented for the best original contribution to the field of aeronautical or astronautical historical nonfiction literature published in the last five years dealing with the science, technology, and/or impact of aeronautics and astronautics on society.

History Manuscript Award is presented for the best historical manuscript dealing with the science, technology, and/or impact or aeronautics and astronautics on society.

Information Systems Award is presented for technical and/or management contributions in space and aeronautics computer and sensing aspects of information technology and science. (Presented odd years)

Intelligent Systems Award recognizes important fundamental contributions to intelligent systems technologies and applications that advance the capabilities of aerospace systems. (Presented even years)

Lawrence Sperry Award is presented for a notable contribution made by a young person to the advancement of aeronautics or astronautics. The nominee must be under 35 years of age on **December 31** of the year preceding the presentation.

Mechanics and Control of Flight Award is presented for an outstanding recent technical or scientific contribution by an individual in the mechanics, guidance, or control of flight in space or the atmosphere.

Pendray Aerospace Literature Award is presented for an outstanding contribution or contributions to aeronautical and astronautical literature in the relatively recent past.

Structures, Structural Dynamics and Materials Award is presented for an outstanding sustained technical or scientific contribution in aerospace structures, structural dynamics, or materials. (Presented even years)

Survivability Award recognizes outstanding achievement or contribution in design, analysis implementation, and/or education of survivability in an aerospace system. (Presented even years)

Summerfield Book Award is presented to the author of the best book recently published by AIAA. Criteria for the selection include quality and professional acceptance as evidenced by impact on the field, citations, classroom adoptions and sales.

Sustained Service Award recognizes sustained, significant service and contributions to AIAA by members of the Institute. A maximum of 20 awards are presented each year.

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

SpaceOps 2014
13th International Conference on Space Operations

SpaceOps 2014: Explore Innovation

5–9 May 2014
Pasadena, California
www.SpaceOps2014.org

Conference Overview

The capability of our space missions and the supporting ground infrastructure is growing, fueled by exciting new technologies, but with that growth comes increased complexity, and daunting reliability and security challenges. And like most complex enterprises, space operations are being asked to do more with less. In order to deliver cost-effective space operations services we must explore innovative ways to build and operate our systems, and integrate operations personnel into the space operations equation. Innovation is the engine that drives progress in today's high-tech global economy.

SpaceOps 2014 provides the opportunity for you to share your experiences, challenges, and innovative solutions with colleagues from around the globe, and take home new ideas and new connections. Be it civil or military applications, educational, scientific, or commercial objectives, space segments or ground segments, the space operations community greatly values and benefits from collaboration and the sharing of ideas. To this end, we enthusiastically invite you to Explore Innovation!

Hosted by NASA Jet Propulsion Laboratory (JPL) and organized by AIAA, SpaceOps 2014 will bring together the space operations community to address state-of-the-art operations principles, methods, and tools. Held biennially since 1990, the conference attracts technologists, scientists, and managers from space agencies, industry, and academia, and fosters managerial and technical interchange on all aspects of space mission operations, including robotic and human spaceflight, Earth orbit and deep space missions, lunar and planetary missions, and orbital and surface operations.

JPL and AIAA are combining our expertise to organize and host SpaceOps 2014. We all look forward to welcoming you to beautiful Pasadena for a thought-provoking and innovative exchange of ideas and concepts.

Conference Program

Discover the latest in space operations, development, and technology. SpaceOps 2014 provides the opportunity for you to share your experiences, challenges, and innovative solutions with colleagues from around the globe, and take home new ideas and new connections.

Monday, 5 May 2014

Welcome Messages and Opening Session
Charles Elachi, Director, NASA JPL, California Institute of Technology
William Gerstenmaier, Associate Administrator for Human Exploration and Operations, NASA Headquarters

Highlight Talk
Jeff Norris, Manager, Mission Operations Innovation Office, NASA JPL

Tuesday, 6 May 2014

Plenary Panel: Control Center of the Future
Jeff Norris, Manager, Mission Operations Innovation Office, NASA JPL
Jean-Luc Froeliger, VP of Satellite Operations and Engineering, Intelsat
Bill Possel, Director of Mission Operations and Data Systems Laboratory for Atmospheric and Space Physics (LASP) University of Colorado at Boulder
Martin Wickler, Deputy Head of Mission Operations Department, DLR

AIAA Programs

Wednesday 7 May 2014

Plenary Panel: Smallsat Operations

James Cutler, Department of Aerospace Assistant Professor, University of Michigan
Peter Allan, Head of the Space Data Division, Deputy Director of RAL Space Rutherford Appleton Laboratory
William Devereux, Applied Physics Lab
Hakan Kayal, Computer Science, Universitat Wurzburg
Robbie Schingler, Co-founder, Planet Labs, Inc.

Awards Dinner Highlight Talk

Thomas Reiter, Director of Human Spaceflight and Operations, European Space Agency

Thursday 8 May 2014

Plenary Panel: Commercial Space

Rebecca Spyke Keiser, NASA Deputy Associate Administrator for Strategy & Policy, NASA
Ken Davidian, Manager for the FAA Center of Excellence for Commercial Space Transportation

Friday 9 May 2014

Closing Session

Yongseung Kim, Executive Director of Satellite Information Research Laboratory, Korea Aerospace Research Institute (KARI)
Michael Moses, Vice President of Operations for Virgin Galactic

Technical Program

A strong technical program, featuring the industry leaders and original thinkers, will keep you at the cutting edge of new thinking, best practices, and stimulating idea exchanges. Program includes:

- Mission Design and Management
- Operations Concepts, Methods, Systems, and Automation
- Flight System Monitor and Control
- Planning and Scheduling
- Guidance, Navigation, and Control
- Human Systems and Operations
- Communications, Data Management and Processing
- Cross-Support, Interoperability, and Standards
- Launcher, Rocket, and Balloon Operations
- Small Satellite Operations
- Commercial Space Operations

Recognition

We are pleased to announce the following awards will be presented at the California Science Center during SpaceOps 2014:

International SpaceOps Exceptional Achievement Medal
Manfred Warhaut, (ESA Retired)
For always emphasizing the importance of operations in a project, ensuring that operations get the appropriate appreciation, and being a strong supporter of cross-support between space agencies.

International SpaceOps Award for Outstanding Achievement
The TerraSAR-X and TanDEM-X Mission Operations Team
For their outstanding and unique achievements during more than four years of operations.

International SpaceOps Distinguished Service Medal
Genevieve Campan (CNES)
In appreciation for involvement in the SpaceOps Organization and many valuable contributions to its activities in various functions for more than ten years.

Sponsorship and Exposition

In today's dynamic business environment, effective outreach and customer interface are vital to successfully capturing new partnership opportunities. AIAA's sponsorship and exhibits programs can help you achieve your objectives. Contact Merrie Scott, merries@aiaa.org to secure your sponsorship, and Christopher Grady at chrisg@aiaa.org to book your exhibit space today.

Hotel Information

AIAA has made arrangements for a block of rooms at the hotels listed below.

Sheraton Pasadena, 300 East Cordova Street, Pasadena, California 91101; Phone: +1.626.449.4000
Room rates are $185 per night for single or double occupancy. For reservations, please call +1.866.716.8106. Please identify yourself as being with the SpaceOps/AIAA conference. These rooms will be held until **18 April 2014** or until the block is full. After 18 April 2014, any unused rooms will be released to the general public. You are encouraged to book your hotel room early.
Government Employees—There are a limited number of sleeping rooms available at the government per diem. Government I.D. is required.

Hilton Pasadena, 168 South Los Robles Avenue, Pasadena, California 91101; Phone: +1.626.577.1000
Room rates are $162 per night for single or double occupancy. For reservations, please call +1.800.HILTONS. Please identify yourself as being with the SpaceOps/AIAA conference. These rooms will be held until **18 April 2014** or until the block is full. After 18 April 2014, any unused rooms will be released to the general public. You are encouraged to book your hotel room early.

Registration

Register at **www.SpaceOps2014.org**.

SCITECH 2015

5–9 JANUARY 2015 **KISSIMMEE, FLORIDA**

"This is the best place to come. You get to meet the who's who of aerospace."

- Arvind Mohan, SciTech 2014 attendee

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- 23rd AIAA/ASME/AHS Adaptive Structures Conference
- 53rd AIAA Aerospace Sciences Meeting
- AIAA Atmospheric Flight Mechanics Conference
- AIAA Guidance, Navigation, and Control Conference
- AIAA Infotech@Aerospace
- AIAA Modeling and Simulation Technologies Conference
- 17th AIAA Non-Deterministic Approaches Conference
- AIAA Spacecraft Structures Conference
- 56th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference
- 8th Symposium on Space Resource Utilization
- 33rd ASME Wind Energy Symposium

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AIAA

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Upcoming AIAA Continuing Education Courses

14–15 June 2014
Workshop and Courses at AIAA Aviation and Aeronautics Forum and Exposition 2014 (AIAA AVIATION 2014)
www.aiaa-aviation.org

Third AIAA Workshop on Benchmark Problems for Airframe Noise Computations (BANC-III)

The major emphasis of this workshop will be coordinated computational, modeling, and measurement efforts based on collaborative definition of a hierarchical set of benchmark configurations representing major sources of airframe noise; joint development of datasets that would eventually achieve benchmark quality.

Business Management for Engineers (Instructor: Alan Tribble)

This course is intended to provide an overview of basic business principles used to manage a company. In particular, this course will help individuals with a strong technical background in science or engineering prepare for the transition from a role as a technical contributor to a business leader.

Key topics
To develop an understanding of the basic principles of:

- Capitalism and free markets
- Business finance
- Business structure and functions
- The relationship between systems engineering and program management
- Communicating for business impact versus technical
- Globalization

Optimal Design in Multidisciplinary Systems (Instructors: Joaquim R. R. A. Martins & Jaroslaw Sobieski)

Design engineers and technical managers involved with preliminary or detailed design of aerospace, mechanical, and other multidisciplinary engineering systems will find this material applicable in their work environment. Advanced research students and research scholars in academia and in research laboratories will also benefit from the topics covered in this course. They would use this material as an entry point into possible areas of further research.

Key Topics

- Multidisciplinary design—components, challenges, and opportunities
- Optimization methods
- Sensitivity analysis
- Decomposition architectures in multidisciplinary design
- Surrogate modeling in design
- Soft computing methods in optimal design

31 July–1 August 2014
Workshop and Course at AIAA Propulsion and Energy Forum and Exposition 2014 (AIAA Propulsion and Energy 2014)
www.aiaa-propulsionenergy.org

2nd AIAA Propulsion Aerodynamics Workshop

This workshop is being held so that various groups from industry and academia can look at a given set of Propulsion Aerodynamic problems and come up with an agreed set of solutions to the problems.

Missile Propulsion Design, Technologies, and System Engineering (Instructor: Eugene L. Fleeman)

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

Key Topics

- Key drivers in the missile propulsion design and system engineering process
- Critical tradeoffs, methods,, and technologies in propulsion system sizing to meet flight performance and other requirements
- Launch platform-missile integration
- Sizing examples for missile propulsion
- Missile propulsion system and technology development process

3–4 August 2014
Course at AIAA Space and Astronautics Forum and Exposition 2014 (AIAA SPACE 2014)
www.aiaa-space.org

Decision Analysis (Instructor: John Hsu)
Decision analysis is an important part of system life cycle development throughout all phases and system hierarchical levels. This course presents the trade study process as part of the systems engineering process and introduces different decision analysis methods including the traditional trade study methods, trade space for Cost as Independent Variable (CAIV), Analytic Hierarchy Process (AHV) as part of the Analytic Network Process (ANP), Weighted Sum Model (WSM), Potentially All Pairwise Rankings of All Possible Alternatives (PAPRIKA), and Decision Analysis with Uncertain information/data. The highlights are: evaluation criteria weights assignment methods including objective determination via QFD methodology; how to down-select too many alternatives; various scoring methods for evaluation criteria; how to develop decision trees; mathematical eigenvector calculations to assist the AHP analysis; how to handle billions pairwise combinations and rankings for PAPRIKA; and five methods to reach decisions with uncertain information/data, and more. Several ways of writing credible and thorough trade study report are introduced.

Key Topics
- Understand the trade study process and role in the overall systems engineering process.
- Learn the traditional trade study methods: Defining selection criteria, Identifying weights, Identifying alternatives, Defining scoring criteria, Scoring alternatives, Calculating ratings for alternatives, and Performing sensitivity analysis.
- Learn how to develop decision trees as hierarchical guidance for different levels of trade studies.
- Learn the trade study role and contribution to Cost as Independent Variable (CAIV).
- Learn how to use and apply decision analysis methods including Analytic Hierarchy Process (AHV) as part of the Analytic Network Process (ANP), Weighted Sum Model (WSM), Potentially All Pairwise Rankings of All Possible Alternatives (PAPRIKA), and Decision Analysis with Uncertain information/data.
- Learn how to write a credible, organized, structured and thorough trade study report.

AIAA Progress in Astronautics and Aeronautics

AIAA's popular book series Progress in Astronautics and Aeronautics features books that present a particular, well-defined subject reflecting advances in the fields of aerospace science, engineering, and/or technology.

POPULAR TITLES

Tactical and Strategic Missile Guidance, Sixth Edition

Paul Zarchan
1026 pages

This best-selling title provides an in-depth look at tactical and strategic missile guidance using common language, notation, and perspective. The sixth edition includes six new chapters on topics related to improving missile guidance system performance and understanding key design concepts and tradeoffs.

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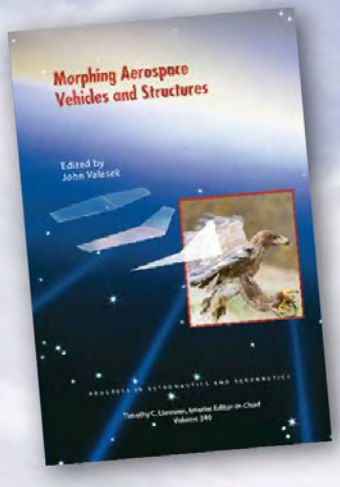

Morphing Aerospace Vehicles and Structures

John Valasek
286 pages

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