9 AEROSPACE AMERICA OCTOBER 2012

October 2012

AEROSPACE AMERICA

Curiosity on the move

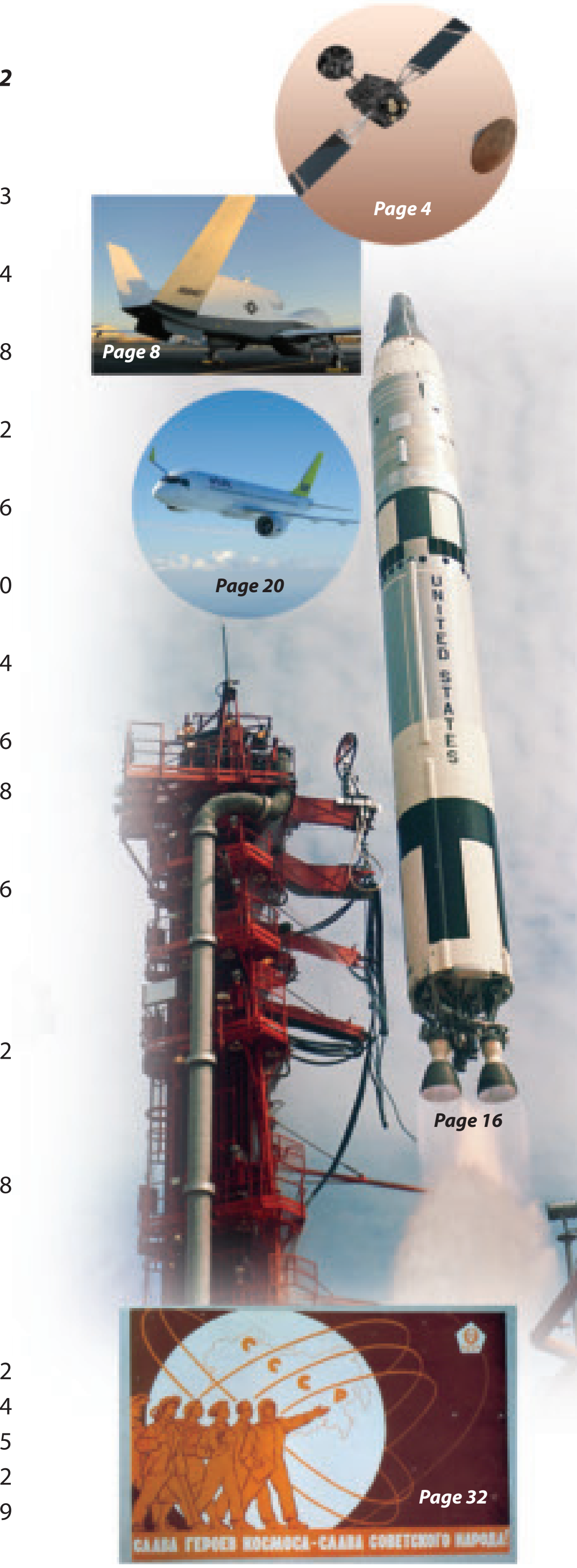
Declassifying the space race: Part 2

High stakes for human-rating spacecraft

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

AEROSPACE AMERICA

October 2012



DEPARTMENTS

FEATURES

BULLETIN

COVER

Two of Curiosity's left wheels were captured in two images taken by the rover's Mars hand lens imager. In the distance is the lower slope of Mount Sharp. Turn to page 26 to read all about the rover's arrival at Mars.

Aerospace America (ISSN 0740-722X) is published monthly, except August, by the American Institute of Aeronautics and Astronautics, Inc. at 1801 Alexander Bell Drive, Reston, Va. 20191-4344 [703/264-7500]. Subscription rate is 50% of dues for AIAA members (and is not deductible therefrom). Nonmember subscription price: U.S. and Canada, $163, foreign, $200. Single copies $20 each. **Postmaster: Send address changes and subscription orders to address above, attention AIAA Customer Service, 703/264-7500.** Periodical postage paid at Herndon, VA, and at additional mailing offices. Copyright © 2012 by the American Institute of Aeronautics and Astronautics, Inc., all rights reserved. The name Aerospace America is registered by the AIAA in the U.S. Patent and Trademark Office. 40,000 copies of this issue printed. This is Volume 50, No. 9.

®

is a publication of the American Institute of Aeronautics and Astronautics

Elaine J. Camhi
Editor-in-Chief
Patricia Jefferson
Associate Editor
Greg Wilson
Production Editor
Jerry Grey, *Editor-at-Large*
Christine Williams, *Editor AIAA Bulletin*

Correspondents
Robert F. Dorr, *Washington*
Philip Butterworth-Hayes, *Europe*
Michael Westlake, *Hong Kong*

Contributing Writers
Richard Aboulafia, James W. Canan, Marco Cáceres, Craig Covault, Leonard David, Philip Finnegan, Edward Goldstein, Tom Jones, James Oberg, David Rockwell, J.R. Wilson

Fitzgerald Art & Design
Art Direction and Design

Michael Griffin, *President*
Robert S. Dickman, *Publisher*
Craig Byl, *Manufacturing and Distribution*

Ross B. Garelick Bell *Business Manager*

Send materials to Craig Byl, AIAA, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344. Changes of address should be sent by e-mail at custserv@aiaa.org, or by fax at 703.264.7606.
Send correspondence to elainec@aiaa.org.

October 2012, Vol. 50, No. 9

American Institute of Aeronautics and Astronautics

Commentary

Funding the final frontier

Curiosity has landed. After eight years of development, NASA and JPL have pulled off something many thought impossible. Perhaps President Obama said it best: "And tonight's success reminds us that our preeminence—not just in space, but here on Earth—depends on continuing to invest wisely in the innovation, technology, and basic research that has always made our economy the envy of the world."

But against this backdrop is an FY13 budget submission that proposes a cut of $300 million, or 20%, to NASA's planetary program, with the Mars portion dropping 38%. This is in the face of a diverse and amazingly successful robotic space program and a fiscally responsible plan for continuing planetary science advances for the next decade.

In 1969, NASA received about 4% of the total federal budget. With that, the agency changed the world as Neil Armstrong landed on the Moon, launching humankind's dreams for decades. By the mid 1990s, with government investment dwindling, NASA's budget was down to about 1%. What did we get for that? We got the Hubble Space Telescope. We got the space shuttle, which flew 135 times and built the international space station. MESSENGER is currently orbiting Mercury, and Magellan mapped the surface of Venus. NEAR landed on an asteroid and Stardust brought samples home from a comet born at the beginning of the solar system. We sent Galileo to study Jupiter and its moons, and found the first extraterrestrial ocean beneath Europa's ice shell. Cassini is currently orbiting Saturn, observing the system's rings and Titan's lakes. New Horizons is on its way to Pluto, arrival set for 2015, and Voyager is leaving the solar system.

NASA now accounts for only 0.48% of the FY12 budget. We're doing much more with even less, but there are limits.

Carl Sagan once said, "Somewhere, something incredible is waiting to be known." Nowhere is this truer than in our cosmic backyard. Europa has more liquid water than Earth—could it harbor life? We haven't even begun to explore Uranus and Neptune, now thought to be the most common type of planet in the galaxy. Asteroids and comets are relics from the very beginnings of our solar system—what can they reveal about planet formation and how life arose? We know little about the Martian moons—could they be used as base camps for exploring the planet's surface? Without stable solar system exploration funding, and with growing investments in space programs in Europe, Russia, India, Japan, and China, we may be entering an era when the U.S. won't be making those discoveries.

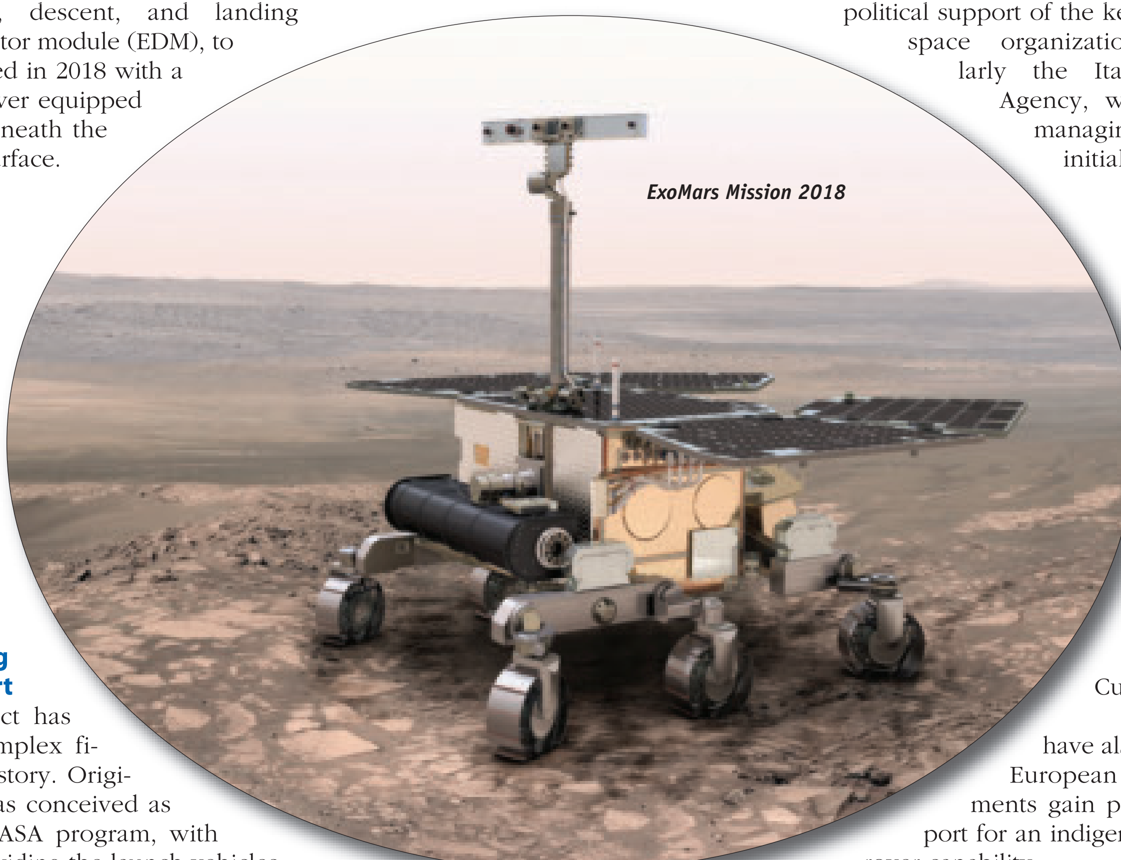
During times of fiscal austerity, some ask, "Why waste money up there?" But the dollars are not lost in space—they are spent on jobs and technological advancements, on innovation and the quest for excellence that is the hallmark of our space program. The return on the nation's investment is immense—not only in scientific discoveries, but in the inspiration and sense of wonder it gives our citizens.

We urge the administration and Congress to continue the nation's investment in solar system exploration. NASA's modest 0.48% of the budget buys windows into the wonders of the cosmos as well as U.S. dominance of critical science and technology, and leadership in space. Even in tight budget times, the return is well worth the price.

Dan Britt and Carey Lisse
Div. for Planetary Sciences, American Astronomical Society

ESA to break new ground with ExoMars

ESA GOVERNMENT MINISTERS ARE DUE to meet in late November to decide on the future of the ExoMars program, a two-mission project to search for evidence of life on Mars. The first mission, due for launch in 2016, comprises a trace-gas-sensing orbiter and an entry, descent, and landing demonstrator module (EDM), to be followed in 2018 with a robotic rover equipped to drill beneath the planet's surface.



ExoMars Mission 2018

Finding support

The project has had a complex financial history. Originally it was conceived as an ESA/NASA program, with NASA providing the launch vehicles for both missions and a share of the design and production work on the rover. But when NASA pulled out earlier this year because of budgetary problems, ESA negotiated with Russia's Roscomos for the use of two Proton launchers to replace the NASA-sponsored Atlas rockets and to supply instruments for the trace gas orbiter.

European space industry experts are quietly confident that the project will go ahead, despite the financial challenges.

According to ESA, "Final agreements to be developed with Russia in the coming months and final program configuration will be submitted to the ESA Council Meeting at Ministerial level in November to approve. Avenues to find some additional money that would be needed to complete the mission as envisaged have been investigated, mainly through redistribution of internal resources."

ESA has already committed substantial sums to the program. It originally budgeted around €1 billion for the project, but this was based on NASA partnering in the rover program and providing the launch vehicles.

With ESA now committed to developing the rover by itself—the first time it will have built a robotic rover—the bill for the mission is climbing. In June ESA announced a tranche of funds to support the program until the end of the year, and the project enjoys the political support of the key European space organizations—particularly the Italian Space Agency, which has a managing role. The initial successes e NASA Curiosity Mars rogram have also helped as European governments gain political support for an indigenous robotic rover capability.

ExoMars rover/ Curiosity comparisons

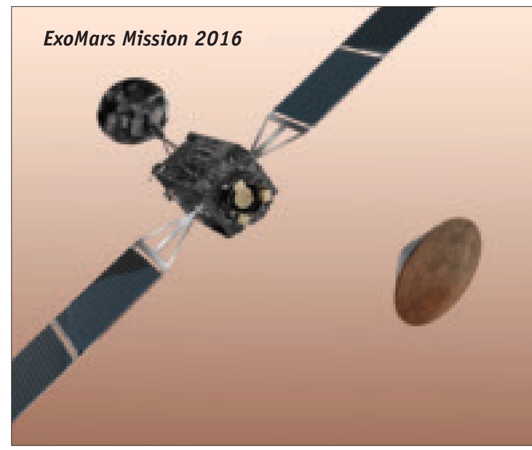
The early collaboration between ESA and NASA on the rover design has yielded some beneficial results. "The time spent working together was beneficial for both sides," according to Mark Roe, the rover vehicle project manager with Astrium U.K. "It has shown our U.S. colleagues that Europe does have unique technologies, and we have learnt from them some of the lessons of their real practical achievements."

But the European ExoMars rover will be a very different kind of vehicle from Curiosity.

"The U.S. rover is significantly bigger—which means in the European version we have to implement a greater level of equipment integration," says Roe. There are a number of design differences. "Within the locomotion system, we both have a six-wheel configuration; but in the European version these are driven through three bogies, which gives us the opportunity to 'wheel-walk,' to move the wheel ahead of the steering, which means that if you are stuck in soft sand it will allow the vehicle to crawl out more easily.

"Our navigation system features a higher level of soft control, which will allow us to perform obstacle guidance in a more intelligent way. And while NASA's Curiosity uses nuclear power, we will use solar arrays, so we have a different thermal challenge. We have to heat our rover with electrical power, and we are concerned with the challenge conserving heat; with Curiosity the challenge is power dissipation. And Curiosity doesn't have a drill—we are building our rover to get samples from beneath the surface with the aid of subsurface radar."

"I think the two rovers are complementary, not competitive," says Sue Horne, space exploration program manager with the U.K. Space Agency. "ExoMars will drill down 2 m below the surface to look for evidence of life, evidence which might have been destroyed by the ultraviolet radiation on the surface of the planet."



The U.K. is contributing the Mars X-ray diffractometer to identify mineral structures, the Raman spectroscope to measure seismic movements, and the life marker DHIP to detect organic molecules deriving from past or present life on Mars in samples collected by drilling.

Program aims and partnerships

The Exo (Exobiology) Mars program will search for signs of past and present life on Mars, examine how the water and geochemical environment varies, and investigate Martian atmospheric trace gases and their sources—especially whether the presence of methane in the atmosphere is a result of biological or chemical processes.

The 2016 mission includes a trace gas orbiter and an entry, descent, and landing demonstrator module (EDM). The orbiter will carry scientific instruments to detect and study atmospheric trace gases. Some of the EDM sensors will evaluate the lander's performance as it descends, and others will study the environment at the landing site. The 2018 mission includes the landing of a rover, equipped with a drill to collect rock samples from beneath the surface of the planet.

The mission will seek to validate a number of technologies for future sample return missions:

•Entry, descent, and landing (EDL) of a payload on the Martian surface.

•Surface mobility with a rover.

•Access to the subsurface to acquire samples.

•Sample acquisition, preparation, distribution, and analysis.

For the 2016 mission ESA will contribute the orbiter and the EDM as well as mission operation control for these elements. Russia will contribute the Proton launcher and other scientific experiments. This will enhance the 'science' value of the 2016 mission more than originally envisaged, according to ESA.

For the 2018 mission, ESA will contribute the carrier, elements of the Russian EDL module, the complete rover including various experiments and a drill, the mission operations, and the rover operations. Russia will provide a Proton launcher, some elements of the carrier, most of the EDL module, some scientific instruments, and experiment contributions to the ESA rover.

The ExoMars prime contractor is Thales Alenia Space-Italy, which is also responsible for the design of the EDM, the development of the analytical laboratory drawer—which includes the Pasteur Payload instruments—its integration on the rover, the onboard computer, and the EDM's radar altimeter. Thales Alenia Space France is responsible for the design and integration of the orbiter module, while Astrium U.K. is producing the rover.

According to the stakeholder meeting held in May, the program is proceeding on schedule for both missions, with the 2016 mission now in the design development phase, following a successful preliminary design review (PDR) in December 2010 and trace gas-orbiter PDR in December 2011. Deliveries for the 2016 mission will start with the engineering/functional models of the avionics test benches and the structural-thermal model of the EDM starting before the end of this year.

The 2018 mission is now in the 'feasibility' phase, to culminate in March 2013 with the system requirements review. The design of the rover is currently in a 'chilled' rather than strictly 'frozen' status, according to Astrium U.K.'s Mark Roe, with agency-level reviews next year to clarify the design baseline. Those will include how the rover will be deployed within the Russian-built carrier, which is to deliver it safely onto the Martian surface.

Mars exploration beyond NASA and ESA

India plans to launch its first Mars orbiter in November 2013, using Polar Satellite Launch Vehicle PSLV-XL, with a 25-kg scientific payload to measure climate, geology, and the possibilities of life. Other non-U.S. missions to the planet include MetNet, led by the Finnish Meteorological Institute (FMI) and comprising a consortium including FMI, Lavochkin Association, the Russian Space Research Institute, and Spain's Instituto Nacional de Técnica Aeroespacial to deploy several semi-hard-landing craft carrying "a versatile science payload focused on the atmospheric science of Mars." China's first Mars satellite, Yinghuo-1, was lost on the 2011 Russian Phobos-Grunt mission. Japan sent the orbiter Hope to Mars in 1998, but ground controllers were unable to direct it into Mars orbit.

International dimensions

The ExoMars project is different in other ways, too. It marks the start of a new era of international cooperation on Mars missions, with a focus on combining more small-scale national programs into a wider global effort. Nations such as China and India are developing their own Mars missions, which means the next sample return mission beyond ExoMars is likely to be a truly global event, with new design philosophies for rover activities. One of the key mission objectives of ExoMars is to demonstrate a number of essential flight and enabling technologies required for an international Mars sample return mission.

"The focus on Mars exploration will be increasingly international," says Horne. "We've looked at the results of several studies which have examined the benefits of operating with two or more smaller rovers, or risking everything by putting all your eggs in a single basket.

"Scientists always want more—and the balance of probabilities is that in the future you will see rovers working in cooperation, collecting a wide suite of samples and bringing them back to a base on the planet for further analysis, where many different studies will be possible," he says.

Beyond the U.S., small-scale national missions to the planet have had a mixed success rate at best. Some of the technologies being applied by Russia to the ExoMars program have their origins in the failed 2011 Phobos-Grunt mission, which was designed to return samples from Mars' larger moon, Phobos. The mission was also carrying China's first Mars satellite. However, the launcher failed to propel the payload beyond LEO, and it eventually crashed back to Earth.

ESA sent the Mars Express mission to the planet in 2003. It had two elements, an orbiter (for high-resolution imaging, mapping, and surface and subsurface structural analysis) and the Beagle 2 lander. While Beagle 2 failed to land intact on the planet's surface, the orbiter has been successfully performing scientific measurements since 2004. In August the orbiter supported NASA's Curiosity rover program by tracking signals during the entry and descent phase of the mission.

But the U.S. is the only nation to have successfully landed a rover and instruments on the Martian surface. If ExoMars does succeed in landing a rover on the planet, it will give Europe a new capability in planetary exploration, which until now has been the preserve of the U.S.

✈✈✈

The initial success of NASA's Curiosity rover program in the dramatic landing on the Martian surface has captured the imagination of Europe's public and, significantly, its politicians. "If we had not had the success of the U.S. rover program, and its achievements had not been visible for all, I don't think we would have got this far," says one of the European scientists involved in ExoMars.

Philip Butterworth-Hayes
Brighton, U.K.

Events Calendar

OCT. 1-5
Sixty-third International Astronautical Congress, Naples, Italy.
Contact: www.iafastro.org

OCT. 11-12
Aeroacoustic Installation Effects and Novel Aircraft Architectures, Braunschweig, Germany.
Contact: Cornelia Delfs, +49 531 295 2320; cornelia.delfs@dlr.de; www.win.tue.nl/ceas-asc

OCT. 14-18
Thirty-first Digital Avionics Systems Conference, Williamsburg, Virginia.
Contact: 703/264-7500

OCT. 17-18
International Symposium for Personal and Commercial Spaceflight, Las Cruces, New Mexico.
Contact: 703/264-7500

OCT. 22-25
International Telemetering Conference, San Diego, California.
Contact: Lena Moran, 575/415-5172; www.telemetry.org

NOV. 5-8
Twenty-seventh Space Simulation Conference, Annapolis, Maryland.
Contact: Harold Fox, 847/981-0100; info@spacesimcon.org; www.spacesimcon.org

NOV. 6-8
Seventh International Conference Supply on the Wings, Frankfurt, Germany.
Contact: Richard Degenhardt, +49 531 295 2232; Richard.degenhardt@dlr.de; www.airtec.aero

Uncertainties mount as election looms

WITH SUMMER CHANGING TO AUTUMN in an election year, Washington is in "political paralysis," wrote Damian Paletta and Sara Murray in the *Wall Street Journal* following a report issued on August 22 by the nonpartisan Congessional Budget Office (CBO). According to that report, the nation faces two stark alternatives:

- The U.S. economy will slide into a "significant recession," warns CBO, if Congress does not avert a "fiscal cliff" of tax increases and spending cuts scheduled to begin in January.
- If, on the other hand, Congress postpones these measures for at least a year, the U.S. will see its fifth straight year with a budget deficit greater than $1 trillion.

No action is expected on budget and fiscal issues until after the November 6 election. Even then, observers believe, Congress and the executive branch will do little more than enact a postponement of a future day of reckoning when the government and the people will finally have no choice but to change the way Washington collects and spends money.

Important leaders may be out of town and painful decisions off the calendar, but Washington continues to deal with issues, including aerospace issues, every day. Less than three weeks before the nation bade farewell to Neil Armstrong, the first man to set foot on the Moon and a true American hero, a vehicle of ingenious design made a precarious and ultimately perfect touchdown inside a canyon in unexplored terrain on Mars.

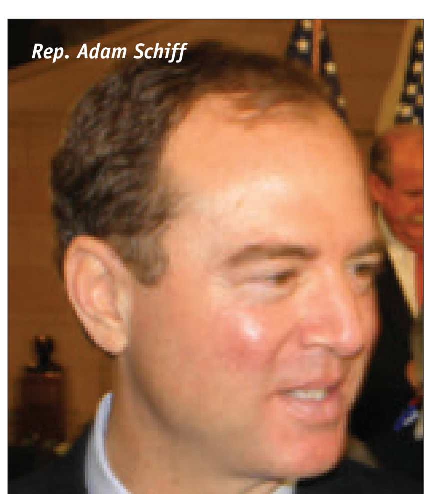
NASA developments

The August 6 landing of the rover Curiosity in Gale Crater on Mars was a triumph for NASA (see page 26). Scientists gave the location a new name, calling it Bradbury Landing after Ray Bradbury (1920-2012), author of *The Martian Chronicles* (1950), a fable that seized the imagination of almost everyone working in aerospace today.

The successful landing prompted celebrations at the Joint Propulsion Lab and around the country, and demonstrated that the nation has not completely lost interest in the exploration of space: NASA's servers were jammed with email messages from an enthusiastic public. One Capitol Hill lawmaker, who does not have a NASA facility in his district, reported receiving 200 congratulatory messages from constituents.

Although an extraordinarily complex technical success, Curiosity's arrival on Mars does not signal any change in NASA funding. No one knows what will happen to any part of the administration's FY13 budget proposal, including the NASA portion, but the document includes what Rep. Adam Schiff (D-Calif.) earlier this year called "disproportionate and devastating" cuts to planetary science.

The Mars effort—what Schiff called "the crown jewel of NASA's incredibly successful and popular planetary science program"—is taking extraordinary hits while total NASA spending remains unchanged from one year to the next. The current year's Mars exploration budget is $587 million, about the cost of two F-35 fighter planes. The administration's budget proposal plans call for trimming the total to $361 million in FY13, $228 million in 2014, and just $189 million in 2015. In a letter to the *New York Times*, Robert Zubrin, director of the Mars Society, called this "a level that would effectively put the nation out of the Mars exploration business."


Rep. Adam Schiff

Two weeks after Curiosity landed, NASA announced that it will launch a lander called InSight to Mars in 2016. However, more ambitious and costlier plans to bring Martian soil samples back to Earth have been set aside. Until recently, the agency was finalizing preparations for the first two such missions, scheduled for 2016 and 2018, to be undertaken in conjunction with the European Space Agency. But NASA canceled these missions this year, and the U.S. has backed out of its ExoMars exploration partnership with ESA (see page 4).

Past successes on the red planet are still producing results. NASA's golf-cart-sized Opportunity rover is still cruising around the Martian surface more than eight years after it landed with its twin, Spirit. And NASA has two orbiters—Mars Odyssey and the Mars Reconnaissance Orbiter—watching the planet from space. Speaking to reporters August 20, John Grunsfeld, associate administrator for NASA's Science Mission Directorate, denied that Mars is getting any favoritism from the U.S. government, pointing to missions with other purposes—for example, Juno, which is on its way to Jupiter, and Osiris-Rex, which is being prepared for its mission to an asteroid.

Some experts, including Capitol Hill's Schiff, say they do not know why planetary science has taken such heavy hits in budget planning. NASA Administrator Charles Bolden has not been a vocal presence in this debate, and though he has not said so in public, he has quietly acknowledged that he would like to stay on if President Barack Obama is reelected.

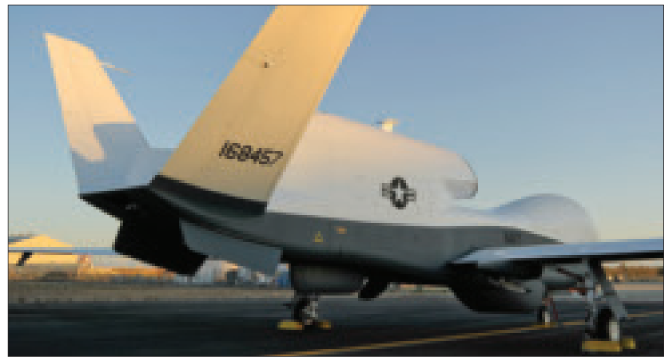
Spotlight on UAVs abroad…

Like UAVs, Washington too may be 'unmanned' in some sense, with the men and women of Capitol Hill now in their home districts and the president on the campaign trail. What one government worker calls 'us regular people' are still at work, though, and in many offices UAVs are receiving increasing attention.

No one disagrees that such aircraft are here to stay. New uses for them are being discovered daily, including law enforcement surveillance applications that have privacy activists concerned. But even if UAVs are a key part of our future, many in Washington now say that the high priority given to military versions is about to be taken down a notch.

"The use of UAVs will continue to expand," says Stephen Meyne, an analyst and historian. "But they're no longer the darlings of the Pentagon they once were." Winslow Wheeler, an analyst and frequent critic of UAV program costs, faulted the "burgeoning love affair of the U.S. defense community with drones" in a recent paper, and suggested the romance is beginning to cool.

Several reports circulating in the capital say that UAVs cost more than previously believed, that duplication abounds in military UAV acquisition, and that coordination among the military service branches on UAV operations needs to be improved.



The Navy is planning to spend $3 billion on the Northrop Grumman MQ-4C Triton. Photo by Alan Radecki.

A staff sergeant at Kandahar Airfield, Afghanistan, marshals an MQ-9 Reaper after its return from a mission. (USAF photo/Tech. Sgt. Chad Chisholm.)

A Government Accountability Office report to Congress blasts the Navy for planning to spend $3 billion on its version of the USAF Global Hawk, the MQ-4C Triton. The GAO wrote that the Navy has not justified a need for its unique modifications to the aircraft. Moreover, says the report, the Navy never conducted a cost analysis to determine how much money could be saved if it purchased the version already being used by the Air Force.

Separately, a Pentagon study two years ago concluded that $1.2 billion could have been saved if the Army and Air Force had worked together to develop sensors for UAVs designed to track ground communications.

More recently, the bipartisan, nonprofit American Security Project (ASP) issued a report asserting that military UAVs are only slightly less expensive than manned warplanes and are more prone to mishaps. The report, released in August, notes that unmanned combat planes offer advantages such as the ability to loiter over or monitor a target for longer periods than a crewed plane can. But the ASP report says that most military drones generally are only "slightly cheaper to both acquire and operate than conventional fighter jets."

The military embraced UAVs in a big way under Robert Gates, who was defense secretary from 2006 to 2011 and favored aerial systems suitable for a counterinsurgency war like the one in Afghanistan. When Air Force leaders wanted more F-22 Raptor superfighters and a new bomber, Gates rebuffed them and focused on remotely piloted aircraft like the MQ-1B Predator and MQ-9 Reaper.

Both vehicles were originally designed for surveillance, a mission they perform well with electrooptical and radar sensors. However, during Gates' tenure they became flying arsenals, able to launch a variety of missiles at ground targets while being controlled from afar.

Predator and Reaper are in use by the Air Force in Afghanistan and by the CIA in the tribal hinterlands of Pakistan. The role of these UAVs in 'targeted killings' has aroused some debate about the legality and morality of drone warfare, but no one expects it to abate. In August, the administration acknowledged a U.S. drone mission in Yemen, the newest major front in the struggle against al Qaeda.

For big-picture planning, however, the Pentagon's focus is shifting away from UAVs and small systems. The Obama administration is giving new emphasis to the Pacific and China. Most of the generals and admirals who served under Gates have retired, and their replacements are less interested in counterinsurgency than in being ready for a 'peer' war with a modern nation-state like Iran or North Korea. This new group of military leaders has been able to kick-start efforts to develop a new bomber and is focusing on the F-35 Lightning II as the weapon of the near future.

Another sign of changing priorities: The administration's FY13 budget proposal—whose own future, like that of the NASA proposal, is now unclear—would kill an important UAV program, the Air Force's RQ-4B Block 30 Global Hawk, which was once expected to replace the U-2 reconnaissance aircraft. The service will continue to buy the Block 40 version for inland, overground surveillance.

...and at home

If UAVs are getting less grease within the military, they are on the verge of becoming plentiful everywhere else in the nation's airways. Lawmakers and industry want to enable UAVs to operate in the 'national airspace,' or NAS—the unrestricted skies between 20,000 and 50,000 ft now used by airliners and general aviation aircraft. Two years ago Congress instructed the FAA to conduct tests with the goal of making it happen.


DHS Secretary Janet Napolitano

The FAA missed the congressionally mandated August 12 deadline for establishing six test ranges for UAVs, the first step toward full integration of manned and unmanned aircraft everywhere in our skies. The Association for Unmanned Vehicle Systems International wrote to FAA Administrator Michael Huerta emphasizing the importance of the test sites.

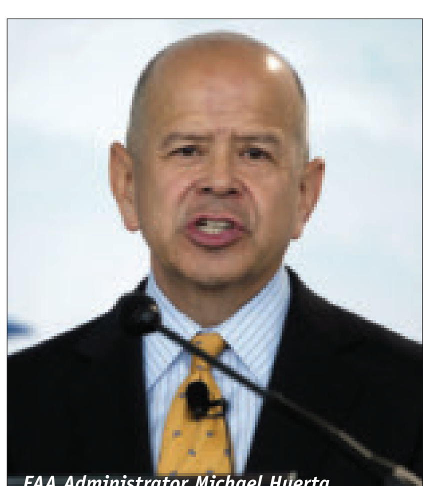
"This is a critical step in the process toward the safe and responsible integration of UAS [unmanned aircraft systems] into the national airspace by 2015," wrote association president Michael Toscano. The purpose of the ranges is to demonstrate that UAVs need not be limited, as they are today, to military ranges, restricted areas, and skies below 20,000 ft.

"There are operational issues that we need to address," Huerta told a trade group in August. He cited pilot training as an example, referring to the pilots of manned aircraft that would share the sky with UAVs. "We also need to make sure that unmanned aircraft see and avoid other aircraft and that they operate safely." Huerta did not explicitly mention the missed deadline, but other FAA officials say the range operations will begin soon.

As for the civil liberties issues raised by surveillance drones, DHS Secretary Janet Napolitano told a House of Representatives committee on July 25 that her department is preparing to expand the use of surveillance drones to ensure "public safety."

Customs and Border Protection, a component of the DHS, has been monitoring U.S. borders since 2005 with nine Predator Bs. These big aircraft, with a wingspan of 65 ft 7 in. and a gross weight of 10,000 lb, are also called Reapers; two are dubbed Guardians when modified for offshore maritime patrol duties. All carry synthetic aperture radar and electrooptical sensors in the latter role.

A critical report by the DHS inspector general questioned the performance of the two Guardians: During one recent period when the department's 14 ex-Navy P-3 Orion manned patrol aircraft helped intercept $11.1 billion worth of cocaine


FAA Administrator Michael Huerta


August marked the 50th anniversary of the Orion's entry into service.

weighing the equivalent of 40 school buses, "the high-tech drones did not contribute to any sea-based seizures during that time," said the report.

The American Civil Liberties Union has expressed concern about privacy issues raised by surveillance drones, and has found an unlikely ally. Asserting his second-amendment rights, Fox News commentator and retired Judge Andrew Napolitano—no relation to the DHS secretary—said on television in May, "The first American patriot that shoots down one of these drones that comes too close to his children in his back yard will be an American hero."

And speaking of the Orion...

The Navy just marked the 50th anniversary of its Orion aircraft's entry into service. This maritime reconnaissance, patrol, and antisubmarine aircraft was called the P3V-1 when the first example reached Patrol Squadron Eight at Patuxent River, Maryland, in August 1962. The P-8A Poseidon, a derivative of the Boeing 737-800 airliner, will soon begin replacing the Orion, known today as the P-3C. The Navy has a program aimed at extending the service life of its current 120 Orions (out of 757 built).

Although a handful of transport planes have had long service lives, it appears that only two other combat aircraft have served for a half-century or more—the B-52 Stratofortress and the Russian Tupolev Tu-95 'Bear.'

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

Robert F. Dorr's book Mission to Tokyo *was published September 1.*

Conversations with

Detlef Müller-Wiesner

What are the current priorities of the DGLR?

Our association celebrates its 100th anniversary this year. In April 1912 the roots of DGLR were established by an aeronautical association founded by Professor Ludwig Prandtl and Prince Heinrich. So 2012 is a year in which many events are dedicated to the achievements of great aerospace engineers and entrepreneurs.

This year is also an excellent opportunity to combine history with new technical opportunities for improved products in the aerospace market. Our Deutscher Luft- und Raumfahrt Kongress [German Aerospace Congress] was held in September this year in Berlin in parallel with the International Aerospace Exhibition, ILA. More than 500 participants there exchanged the latest results of aerospace research.

Following the DGLR slogan "Informing, Networking, Supporting," this year we are going to reshape information services for our members. We want to ensure that our students and younger engineers are more actively addressed by our messages. Working for—and with—younger people are top priorities for our association.

A further priority for our members is to enhance international cooperation with national, European, and global aeronautics and space organizations. On the global level we are members and contribute to the International Astronautical Federation and the International Council of the Aeronautical Sciences. On the European level we are members of the Council of European Aerospace Societies (CEAS). And on a national level we have many bilateral relationships in Europe and worldwide. There are, for example, regular exchanges with AIAA about potential common activities.

How would you characterize government and public perception of the aerospace sector in Germany?

This is difficult to answer because there are no detailed statistics known to me which could authoritatively support my personal perception, which is based on discussions with young students, researchers, engineers, politicians, and industrial leaders.

Government and public perceptions of the aerospace sector are, in my view, to a certain extent ambiguous. People like to travel by aircraft around the world more than ever. Ticket prices in comparison to income levels have continuously been decreasing since the middle of the last century. Emissions (noise, carbon dioxide, and nitrogen oxides) have also been continuously decreasing.

Germany is an exporting country, and its entire industry depends on air transport. This was clearly shown during the Iceland ash-cloud blockage of the air transport system, when after just a few days our automotive companies and others had to partially stop production because of the interruption of the air transport supply chain.

All this has been acknowledged by the government, but it has not really reached public opinion yet. I could give many examples of this. The latest is that people in Munich have voted against construction of a third runway at Munich Airport.

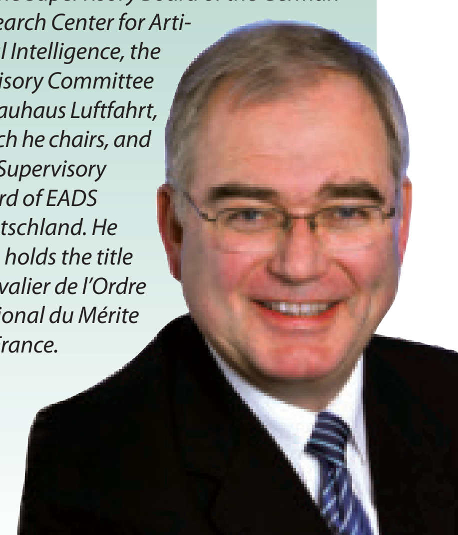
On the other hand, when it comes to the aerospace industry there is a positive public opinion that this industry—as original equipment manufacturers and suppliers—still creates new jobs in Germany for research, en-

Detlef Müller-Wiesner is president of the German Society for Aeronautics and Astronautics (DGLR). Since 2006 he has been EADS chief operating officer for innovation, and EADS deputy chief technical officer. In this capacity he has headed EADS Global Innovation Networks and chaired the EADS Research & Technology Council. The council is responsible for the joint planning and implementation of the R&T programs at the divisional and corporate levels. Müller-Wiesner is also senior vice president and head of external affairs, business, and transverse initiatives within EADS.

He studied mechanical engineering at Clausthal University of Technology and received a Ph.D. for his thesis on structural durability.

Since 1986, when he began his professional career at ERNO Raumfahrttechnik, he has worked for EADS or for companies that later became part of EADS. In the space technology field, he held positions of responsibility in the development, construction, service, and program departments. When the company was founded in 2000, he was tasked with heading, integrating, and developing its corporate research activities (now known as EADS Innovation Works).

Müller-Wiesner is a reserve officer of the German air force, president of the International Council of Aeronautical Sciences, and a member of the senate of the Helmholtz Association. He also serves on the Supervisory Board of the German Research Center for Artificial Intelligence, the Advisory Committee of Bauhaus Luftfahrt, which he chairs, and the Supervisory Board of EADS Deutschland. He also holds the title Chevalier de l'Ordre National du Mérite du France.



Interview by Philip Butterworth-Hayes

gineering production, and services, year after year. As a result of this success it is becoming more difficult for the industry to get the skilled workforce it needs.

We try within the DGLR as much as possible to contribute to solving this challenge through our members and networks, individually and through more combined measures, to convince young people about the challenges, opportunities, and excellent prospects for professional engineers in the aerospace, defense, and security sectors.

Are you happy with the level of aerospace research that is currently under way in Germany, and what can be done to more quickly move projects from the theoretical calculations to practical projects?

With respect to the aerospace research landscape in Germany, we do have an excellent and acknowledged network of research institutions, like the German Aerospace Center, universities, and industrial research and technology centers.

Many ongoing and planned projects are executed as part of international cooperative programs. The excellence of the researchers involved in these programs has been underlined by numerous awards they have received at international events and conferences. This excellence is not limited to Germany—in other European countries you will also find excellent researchers and engineers.

Under the leadership of the German Ministry of Education and Research, a high-level group of scientists, researchers, and industrial leaders is working on an update to the German High Technology Strategy. This strategy defines the main streams of the German research landscape, according to the identified future needs of society. Mobility and energy, for example, are areas that have been identified as aeronautical research needs for the future. The German Ministry of Economics is currently working on a future aeronautics strategy and has already published a long-lead Space Strategy for Germany. So we could say, in theory, that the need for aerospace research is for the moment acknowledged, and through this an excellent level of scientific competencies has been established.

"Technically there should be more challenging demonstrator projects started, so that right from the early phases of technology research systems, engineering design principles are applied."

In practice, as in other countries, there is always an ongoing political debate about where to best place budgets for research and technology to best fit societal needs. So aerospace stakeholders like the DGLR and its personal and corporate members are taking an active part in those discussions, to maintain and develop the level of aerospace in competition to other research areas.

Acceleration in innovation is indeed needed now more than ever. In my personal experience there are several measures being applied to move programs from theoretical calculation to practical projects. As knowledge goes with people, I am convinced that colocation of scientists, research engineers, and industrial design and production engineers provides the best environment for ideas and research results to move more quickly into products and processes. It is also important that high-level sponsors encourage those teams by their trust and personal support.

Technically there should be more challenging demonstrator projects started, so that right from the early phases of technology research systems, engineering design principles are applied.

Another measure is of course to identify, at an early stage of research opportunities within practical projects, how to best exchange research results and ideas through networks. Aerospace associations like the DGLR play an important role here by establishing the structures of those networks, providing stages for the exchange of information between experts, industrial leaders, and politicians.

Is there a danger that the current financial pressures in Europe might take the focus of those research establishments away from long-term work in areas such as space science and hypersonics?

Of course this danger exists, in principle, during times of tight public budgets. In Germany I do not see this danger for the moment, because under the current government the budget for science and education has been exempted from budget cuts. The level of support for space and aeronautics seems to be staying constant within other government departments for the near-term future. We will see after the federal elections in Germany next year what the position of the new government will be.

For other European countries the situation might be different, depending on the individual state of the economy in these countries. Today I do not expect major announcements of a withdrawal from basic research in other countries. Big European basic science projects like ITER (the International Thermonuclear Experimental Reactor) or CERN (the European Organization for Nuclear Research) are ongoing. The European Parliament and the European Commission are preparing the Horizon 2020 research agenda and program, where today a

"….research institutions and industry expect from their engineers some 'soft' skills, like being able to work within a team, intercultural working capabilities, and knowledge of the legal framework to which engineers are subject."

budget volume of €80 billion is under discussion. This program will cover all areas of research and includes aerospace topics.

In the space sector the European Space Agency is preparing a ministerial conference for later this year where topics and budgets for the future are going to be fixed by member states.

What new key skills will aeronautical engineers have to master in order to maintain the country's technical excellence levels?

If we focus on 'engineers working in aeronautics and space,' then this becomes part of the answer. The amount of work dedicated to research and development by engineers specialized in aerospace is decreasing, in my experience. Due to the complexity of today's flying systems, the demand for skills like electronics, communications, and other disciplines is increasing. So skills in systems engineering are vital for large complex programs to be successfully executed. Fortunately some European and German technical universities have realized the increasing demand for education in systems engineering and have integrated this into their curricula.

Hand-in-hand with systems engineering is the increasing demand for skills in the principles of successful project management. And last but not least, research institutions and industry expect from their engineers some 'soft' skills, like being able to work within a team, intercultural working capabilities, and knowledge of the legal framework to which engineers are subject.

Are there any problems in attracting people to the industry?

In general there is an increasing problem in Germany and Europe in finding the right number of highly skilled people with a technical background, or a background in natural sciences. That is the reason why politicians, industry, and scientific/technical organizations like the DGLR are working hand-in-hand on campaigns and sustainable measures to attract young people, starting at the kindergarten level, to become creative engineers or natural scientists.

For the aerospace sector the problem is probably less severe than for other industrial sectors, because building flying machines still has its specific fascination for technical people. Aerospace companies are among the 10 most preferred employers for engineering students in many European countries.

What are some of the DGLR's key pan-European and transatlantic areas of cooperation?

As I mentioned earlier, DGLR is a member of the Council of European Aerospace Societies, together with aerospace associations from other European countries. Every two years we organize the CEAS Congress, hosted by one of the national associations. CEAS publishes the *CEAS Journal* with scientific papers from the aeronautical and space branches of the council. The technical networks of DGLR have working relationships with many of the European national associations in organizing events covering specific technical areas.

We are also working closely with AIAA, for cohosted events and for exchanges of students, which is one of our current plans. Every year DGLR supports the International Air Cadet Exchange, which is organized together with NATO air forces.

What do you think should be the main priorities for Europe if it is to maintain technical and industrial competency in all aerospace areas?

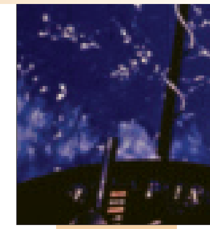
First, there could be an interesting debate around whether—in a globalized economy and with all existing means of information exchange—Europe really needs to maintain a technical and industrial competency in all aerospace areas.

I would like to focus my answer here on the need for further maintenance and enhancement of competencies in aerospace. Cooperation and integration in aerospace research and industry are now part of daily life in Europe for many engineers. I am personally convinced that keeping up this momentum of integration on one hand while ensuring the diversity of education and cultures on the other is one priority for the future success of aerospace in Europe.

The continuation of support for research, and especially for basic research, by industry and the public sector is of course another prerequisite to assure the sustainability of the recent success of the aerospace sector in Europe and among its global partners.

The European vision for aeronautics is laid down in *Flight Path 2050*, where high-level experts have defined targets and roadmaps to achieve future competitive aeronautical products. Many of the contributing experts are members of their national aerospace associations, like DGLR and CEAS. *Flight Path 2050* also acts as one of the strategic guidelines for the definition of European and national research programs for aeronautics.

"First, there could be an interesting debate around whether—in a globalized economy and with all existing means of information exchange—Europe really needs to maintain a technical and industrial competency in all aerospace areas."



Gemini: Blazing the trail to the Moon

A 10-STORY-TALL TITAN II BOOSTER certainly makes an impression on a 10-year-old Cub Scout. Touring the Martin Marietta factory in Middle River, Maryland, in the summer of 1965, I craned my neck to look up 100 ft at a pair of silver and black Titans in their vertical test cells. I was captivated. Here were the rockets that would carry Gemini 7 and 8, and they were being built right in my hometown. Someday, I hoped to learn enough to join my neighbors who were building the Titans; if my wildest dreams came true, someday I'd ride on a rocket like that.

Forty-seven summers later, I'm still impressed with the Martin Baltimore team that assembled and launched the Titans powering the Gemini crews to orbit. I'm more curious than ever about how they did it—how they pulled off a dozen successful launches in a row, and in paving the way to the Moon, captured the lead in spaceflight from the Soviet Union.

Martin's Baltimore plant in Middle River, Maryland, conducted assembly and checkout of the Titan IIs selected for Gemini. Gemini-Titan GT-2 (the second unmanned Gemini launch) stands in the test cell in D building in 1964. It flew on January 19, 1965. Courtesy: Glenn L. Martin Maryland Aviation Museum.

Preserving that legacy is the Glenn L. Martin Maryland Aviation Museum in Baltimore, located on the site of that factory that performed final assembly and test of the Gemini-Titans before they were shipped to the Cape for their rendezvous with their astronaut crews, and with history.

Last fall the museum hosted a daylong symposium on the Martin Gemini effort, and attendees met a number of space veterans from the 1962-1966 program. The experts discussed the historical importance of Gemini, the technical challenges of human-rating the Titan II and operating the spacecraft, and their personal reflections on blazing a trail to the Moon.

On the shoulders of Titans

The 10 piloted Gemini missions, said Smithsonian National Air and Space Museum historian Michael J. Neufeld, gave the U.S. the undisputed lead in the space race. Neufeld recounted Gemini's major achievements: orbital maneuvering (to include rendezvous, proximity operations, and docking); a demonstration of astronaut endurance and productivity on missions lasting up to two weeks; successful EVA techniques and space suits; and experience in complex space/ground mission operations. All these combined to give NASA the confidence and depth of experience necessary to attempt Apollo's lunar landing missions.

Martin engineer Harry E. Mettee recalled that the Baltimore plant, which during WW II had turned out thousands of B-26 Marauder medium bombers and Navy flying boats, later fell on hard times. By the early 1960s, most of the aircraft manufacturing work was gone, and the workforce had dwindled far below the wartime peak of 53,000.

Salvation came when NASA designated Titan II as the Gemini booster. Most Titan manufacturing was done at Martin's Denver plant, far removed from surprise bomber or missile attack; Baltimore built the tank domes, skirts, midsections, and other Titan components. But NASA didn't want its Gemini launcher playing second fiddle at Denver, which was busy turning out hundreds of Air Force Titan I and II ICBMs. So Baltimore got the job of assembling all Gemini-Titans, including 'man-rating' them for astronaut flight.

Mettee recalled that the first Titan stages shipped to Baltimore required more than 200 weld repairs. Bastian 'Buz' Hello, Martin's Gemini program director, soon had Baltimore sending its own people to Denver to select only the best Titan stages. Manufacturing responsibility in Baltimore was in the capable hands of Francis O. 'Fuzz' Furman, a Martin factory legend. The 'Buz and Fuzz show' ran a tight ship.

NASA constantly chided Martin about the rigorous quality standards needed to man-rate the Titan. Furman, who helped institute consistent high quality throughout Martin's WW II manufacturing operations, was lectured yet again by a young NASA executive, who stressed that "men will be riding on this rocket." Furman shot back, "Who the hell do you think has been riding in all those airplanes we built over the past 30 years—monkeys?"

In 1966, Martin Baltimore technicians hoist the second stage of the Gemini IX Titan II into position for test. A dozen of the Air Force ICBMs were modified for Gemini launch duties; the Middle River-assembled Titans had a perfect flight record. Courtesy GLMMAM.

Martin built a high bay for vertical testing in D building, once a seaplane assembly line. Plastic bubbles served as clean rooms for critical Titan subassemblies, and Furman religiously enforced standards. He told one group of workers, "Be sure you're clean when you come in here. Some of you might have to take a shower more than once a week."

After vertical assembly and checkout of the Titans, the two-stage, 109-ft boosters were destacked and shipped to Cape Canaveral in Air Force C-133, or Pregnant Guppy, transports. Martin's record was near-perfect: Although Gemini VI-A did suffer a last-second engine shutdown on Pad 19 in 1965, it later launched successfully, as did the other 11 Gemini-Titans.

Riding the Titan II

One astronaut particularly grateful for Martin's attention to quality was Gemini XI pilot (and later Apollo 12 crewmember) Dick Gordon. At the symposium, Gordon recalled the thrilling experience of his Titan II launch riding next to commander Pete Conrad.

The Titan II's central mission was to place a 9-megaton thermonuclear device on the most hardened strategic sites in the Soviet Union, using a high-thrust, high-acceleration ascent profile. The first stage fired its twin-nozzled Aerojet LR87 engine (430,000 lb of thrust) for 2.5 minutes, subjecting the crew to 6 *g*s of acceleration at burnout. Titan II's second-stage LR91 engine ignited while still attached to the first stage, a sequence aptly called 'fire in the hole.'

Gordon, who says that "nothing important in spaceflight happens without an explosion," remembers that staging vividly. "We went from 6 *g*s to

Gemini XI lifts off from Cape Canaveral's launch complex 19 on September 12, 1966. The Titan II shot astronauts Charles 'Pete' Conrad Jr. and Richard F. Gordon Jr. into their first-orbit rendezvous demonstration. Courtesy: NASA.

zero instantaneously. Then—CRASH!—the separation pyros fired, the second stage lit, and we accelerated away." Three more minutes at 100,000 lb of thrust pushed the 8,400-lb Gemini and its crew aggressively up to orbital speed. Plastered into his couch by more than 7 *g*s, a single question dominated Gordon's thoughts: "When is this mother going to quit?" Titan II took just five and a half minutes to reach orbit; by comparison, each of my space shuttle ascents lasted more than three minutes longer.

Proving rendezvous

A critical objective on Gemini XI was demonstrating a first-orbit rendezvous with the Agena target vehicle, which had launched earlier on the morning of September 12, 1966. Once blasted from the Moon, the Apollo lunar module ascent stage would have just nine hours of battery and consumables life. Conrad and Gordon had to prove they could catch an orbiting target well within that window. With a launch window only two seconds long, the Titan II thundered off Pad 19 just a half-second late.

Riding that fast break, Conrad and Gordon locked onto the Agena with their Westinghouse rendezvous radar, rippling off a rapid series of rendezvous burns. Their onboard radar and rendezvous charts worked accurately enough to dispense with the solutions from Houston's mainframes. In an impressive show of sighting, calculating, and precision flying, Gemini XI pulled up to the Agena just prior to the California coast, less than 94 minutes after launch. Another Gemini objective for Apollo was in the bag.

Westinghouse radar expert Ralph Strong recounted how Gemini XII's antenna electronics mysteriously failed, fortunately *after* the final Agena rendezvous. Telemetry revealed the cause to be electrical arcing, previously thought impossible in a vacuum. Engineers discovered there was just enough rarefied atmosphere in orbit to get electrons bouncing between conductors, cascading back and forth until a spark jumped the gap. His team verified and fixed the problem, but Strong says it confirmed his belief that "a random failure is simply one that you are unwilling to spend the energy on to understand."

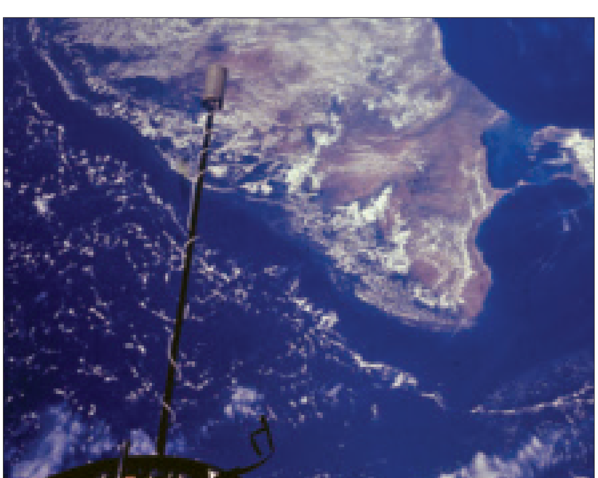
Secrets of spacewalking

One of the biggest challenges for Gemini was EVA, crucial to the Apollo program's plans for surface exploration and emergency spacecraft repairs. Gordon recounted how NASA came away from Ed White's Gemini IV spacewalk with unwarranted confidence. Few guessed the challenges posed by working (not just floating) outside while battling a semirigid suit in the free-fall, vacuum environment. Gene Cernan's exhausting EVA on Gemini IX had come close to disaster; and when Gemini X's Mike Collins again struggled with fatigue when tackling seemingly simple tasks, NASA finally heard the wake-up call.

Enter Sam Mattingly, who in the early 1960s ran the Baltimore engineering firm Environmental Research Associates (ERA). Sam and his partner Harry Loats had been evaluating early space station airlock and hatch designs for NASA Langley; they soon concluded that 1-*g* crew evaluations could never yield accurate results. Mattingly, Loats, and Langley's Otto Trout decided they should evaluate the hardware under water, wearing a pressure suit weighted to produce neutral buoyancy, thus mimicking the challenges of movement in free fall.

Borrowing a training suit from Norfolk NAS, Mattingly and his small team submerged the airlock mockup on the bottom of the swimming pool at the McDonogh School, just down the road from ERA's offices in northwest Baltimore. In July 1964, Mattingly donned a pressure suit and slipped beneath the surface, pouches of lead shot strapped to his limbs. Soon he and his colleagues were conducting extended simulations of various EVA tasks: hatch opening, airlock translation, and tool use.

ERA's neutral buoyancy tests on what later became the Skylab space station concept came to the attention of Gemini troubleshooter Dan Jacobs. He arranged an ERA demo of the Gemini X spacewalk tasks. "We ran that script under water and showed that some tasks weren't doable—unless you had three hands," says Mattingly. Collins' frustrating experiences in orbit confirmed the pool prediction—without handholds and anchors to free an astronaut's hands, even the simplest tasks outside proved daunting.

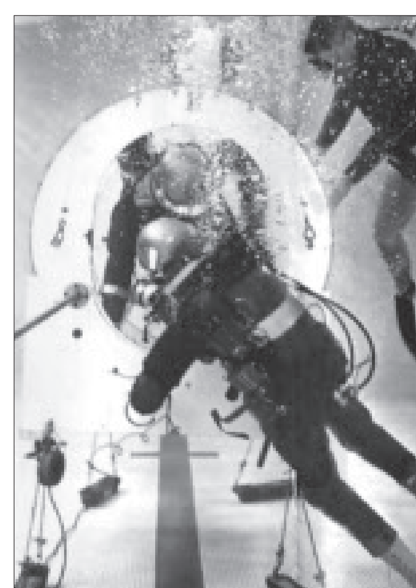


Gemini XI soared above the southern tip of India, with island of Sri Lanka, and the Arabian Sea and Bay of Bengal. The Agena docking vehicle antenna mast projects into image; Conrad and Gordon had fired the Agena's engine to soar to a then-record height of 1370 km.

Jacobs sent Mercury veteran Scott Carpenter up to McDonogh. Armed with a power tool, Carpenter tried his hand at releasing 57 hatch bolts from a Saturn third stage 'wet workshop.'

"In 30 minutes he got maybe one bolt off," says Mattingly. Stiff suit gloves and a constant struggle to hold body position defeated Carpenter's best efforts. Over the intercom, Mattingly heard him lament, "I can't bend my [expletive] finger anymore!"

Cernan also came up to Baltimore, trying to understand what factors had undermined his Gemini IX EVA. Mattingly and company were able to show him that doing those tasks while 'free floating' was simply beyond any astronaut's capabilities—no one could have succeeded. A relieved and grateful Cernan took time out at McDonogh to give a pep talk to a star-struck audience of students watching from the pool bleachers.



For early 1964 ERA neutral buoyancy studies, ERA cofounder Sam Mattingly was dressed in an Arrowhead pressure suit; he evaluated the problems involved with entering, traversing, and exiting a 4x6-ft airlock while 'weightless.' Success in these simulations enabled NASA to overcome Gemini's EVA challenges. Photo courtesy Sam Mattingly.

Gordon had used NASA's KC-135 aircraft to practice his Gemini XI EVA in brief, 25-sec bursts of free-fall, but "that was deceptive in that the airplane and helpers always gave you a stable starting point." ERA filmed their underwater simulation of the Gemini XI tasks, but Gordon's frenetic training pace kept him from seeing the movie before his September 1966 launch.

In orbit, Gordon was to rig a 30-m tether from the Agena to the Gemini docking bar, but could not stabilize his body over the Agena docking cone. The stiff suit prevented his legs from effectively straddling the Agena, and with one hand needed just to hold on, it was nearly impossible to connect the tether. His eyes stinging and nearly blinded from sweat coating his face, Gordon struggled to position his body.

He quickly realized that translating back to the Gemini adapter section for a power tool evaluation was out of the question. "I might have gotten there," he says, "but I would have killed myself in doing it." Just 30 minutes after Gordon left the cockpit, Conrad brought the exhausted astronaut back inside. "I knew it was going to be harder, but I had no idea of the magnitude," Gordon later reported.

Mattingly and his colleagues had seen it all coming. Soon another guest arrived at McDonogh: Gemini XII's Buzz Aldrin, intent on proving that EVA was doable. Training on a Gemini adapter section submerged in the McDonogh pool, Aldrin ran through a series of 2-hour exercises, working out how to use foot restraints, handrails, tethers, and simple tools. "He was a quick study," Mattingly recollects, "the smoothest of anyone who came in."

On November 13, 1966, Aldrin conducted a 2-hr, 6-min EVA, the second of the final Gemini flight. Using tethers, handholds, and the techniques developed in Baltimore, he retrieved a micrometeoroid detector, translated with ease to the rear adapter section, anchored himself in foot restraints, and proceeded to cut metal, torque bolts, and maneuver his suit with ease. Back at the Agena, he mated and demated electrical connectors and tested an Apollo torque wrench. He finished up by wiping down the outside of commander Jim Lovell's window, prompting Lovell to ask, "Hey, would you change the oil, too?"

Gemini XI astronaut Dick Gordon straddles the Agena spacecraft docking collar during his second EVA, on Sept. 13, 1966. Gordon struggled to complete his spacewalking tasks because of insufficient handholds and tethers outside, a problem finally resolved on Gemini XII. Courtesy: NASA.

At the museum, Gordon acknowledged Aldrin's achievements: "Failure may be your best teacher. My failures helped make Buzz's EVAs a success."

Gemini lessons

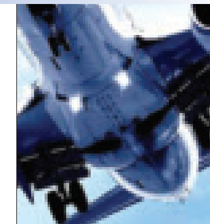
Looking back on the significance of Gemini, Gordon reflected that the fast pace of the program, with a launch every two months, reduced NASA's ability to learn the utmost from each flight. "We would have liked to stretch out the launch interval to properly apply those lessons." But Apollo—and the Soviets—wouldn't wait. Even so, Gordon says firmly, "Gemini made possible Apollo's success."

A year has passed since the U.S. gave up its ability to launch its own astronauts to LEO. May's SpaceX/Dragon success at ISS shows that the U.S. is making slow but sure progress in resurrecting that capability. What NASA did 50 years ago is still doable today: The agency inaugurated Gemini in January 1962, and just over three years later, in March 1965, launched the first crew, Gus Grissom and John Young, into orbit. A commitment today to matching that performance would honor Gemini's accomplishments and restore a vital national capacity we unwisely let slip away. In 2012, rocket technology is still important, but steady leadership on policy and budgetary matters is what makes success in space possible.

✈✈✈

With the untimely passing of Neil Armstrong on August 25, America lost not just an intrepid Gemini veteran, but its most brilliant link to the heroic exploits of Apollo, when we reached out confidently to touch the face of another world. Armstrong was our exemplar of piloting skill and unassuming modesty, universally admired by the astronaut family. His career reminds us of the talents called forth by Apollo, and the serious leadership and steady determination we will need to stride beyond the bootprints of Armstrong and his colleagues.

Thomas D. Jones
Skywalking1@gmail.com
www.AstronautTomJones.com



The enduring jetliner duopoly

This year's Farnborough Air Show saw a mix of predictable events. In terms of orders, it was Boeing's show. Its 737 MAX did well enough to close some of the gap with the Airbus A320neo and to remove any doubt that Boeing had made the right move with its 737 reengining decision. And the reasonably healthy flow of orders bore no relation to the broader world economy.

In addition to the large single-aisle order numbers, the stage was set for the next phase of the Airbus-Boeing market share war. Both companies are finalizing their next-generation twin-aisle products. In this segment, the onus is on Airbus to catch up with Boeing.

Battle of the single-aisle styles

For the first half of the year, Boeing's 737 MAX labored in the shadow of Airbus's A320neo family. Airbus led the way in reengining its single-aisle family (although this move itself was a reaction to the Bombardier CSeries). Boeing looked like a follower, saddled with an older, smaller jet that seemed less adaptable to the new generation of wider turbofans.

Until Farnborough, Boeing had secured just 451 MAX orders, against over 1,400 for the neo. But over the week of the show Boeing scored another 175 firm and 135 MOU (memorandum of understanding) orders, plus another 50 firm orders for current-model 737NGs. Airbus got just 29 neo MOUs, and another 56 MOUs for current-generation A320 series jets.

As the week ended, hundreds of additional MAX orders were rumored to be in the short-term pipeline. These orders represent a very strong endorsement of Boeing's defensive strategy. At the Paris show in 2011, Boeing looked as if it had been blindsided by the strength of Airbus's neo launch. Boeing did not appear to have a competitive response, aside from vague long-term plans for an all-new single-aisle product. By the end of the week, American, which had purchased only Boeing jets for several decades, looked set to defect and go with Airbus. But the rapid creation of MAX allowed Boeing to prevent all its other key 737 customers from defecting (so far) and even to capture half of American's single-aisle fleet orders.

737 MAX

But Boeing still has to execute on the MAX program, and make good on its ambitious performance promises. It is basically dependent on sole-source engine provider CFM (General Electric/Safran) coming through with an equally ambitious Leap-1B turbofan.

This Boeing/CFM performance challenge is complicated by the fact that parity is not enough. In the past decade, the 737 has been able to challenge the A320 with slightly lower fuel burn and slightly (3-4%) superior operating economics. This is because the A320 family offers better comfort and better range/payload, and because Airbus sells its aircraft with lower commercial margins. To enjoy the same production numbers and market share, Boeing must continue to offer a product that burns less fuel.

Meanwhile, Bombardier's CSeries, which played a key catalyst role in the Airbus/Boeing reengining war, remains stuck at 138 orders, where it has been for several years. The company was at least able to get a letter of intent for 10 CS300s from airBaltic at Farnborough; this prevented the ignominy of another air show shutout.

Clearly, with MAX and neo establishing strong but almost preordained market positions, the Airbus-Boeing single-aisle market share war matters less than it once did. In fact, production rate fluctuations now matter much more than market share changes, as evidenced by Airbus's decision to hold single-aisle rates at 42 per month (instead of moving on to 44, as planned).

Yet even if market shares look set to remain fixed for the next few years, this is a long-term industry. Product launch decisions made today will have a profound impact on company standings in the second half of the decade.

Filling the product gap

One of the more intriguing aspects of the competition between Airbus and Boeing is that a product gap has emerged between the A320neo/737 MAX and the new generation of twin-aisle jets. There is nothing in production, or in design, that can efficiently do the job of the 757, 767-200/300, and A300. The 321neo and 737-9 simply lack the range and payload of these models. The A350XWB and 787 are optimized for much longer ranges, and carry very large wings and other structures, making them less appealing for 3,000-4,000-n.mi. routes. The dedicated shorter ranged 787-3 was canceled in December 2010. In January 2010 the custom A350XWB-800 wing was also dropped, leaving the -800 with the larger -900/1000 wing.

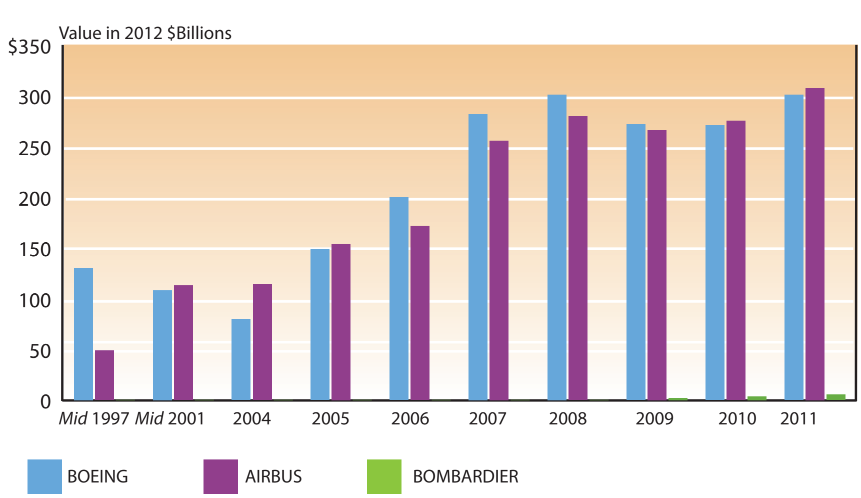
Total production of the 757, 767-200/300, and A300 exceeded 2,000 aircraft, and most are still in service. That indicates a substantial replacement market, even if the routes they serve are not growing as fast as the longer range routes. Either Airbus or Boeing may well move forward with a 180/230-seat medium-haul jet in the next few years. Boeing in particular can use this new product to avoid being criticized for launching its 737 MAX as a 'me-too jet.' Both companies will also want to use this launch opportunity to keep their new clean-sheet aircraft design engineering skills intact.

In terms of the timing of the new plane (or planes), a launch by either company is unlikely until current twin aisles and reengined singles have been brought to market. That means a 2016/2017 launch at the earliest, with a service entry in 2021/2022. But in terms of technical characteristics—twin aisle versus single aisle, composite versus metal primary structures—this aircraft is far from defined.

The virtues of up-gauging

In contrast to the defensive game it is playing with its single-aisle product line, Boeing's twin-aisle standing looks quite offensive, and there is an excellent chance the company will get even more aggressive in the next few years. The opportunity revolves around both companies' efforts to grow their existing midsize twin-aisle products.

COMPARATIVE BACKLOG VALUES



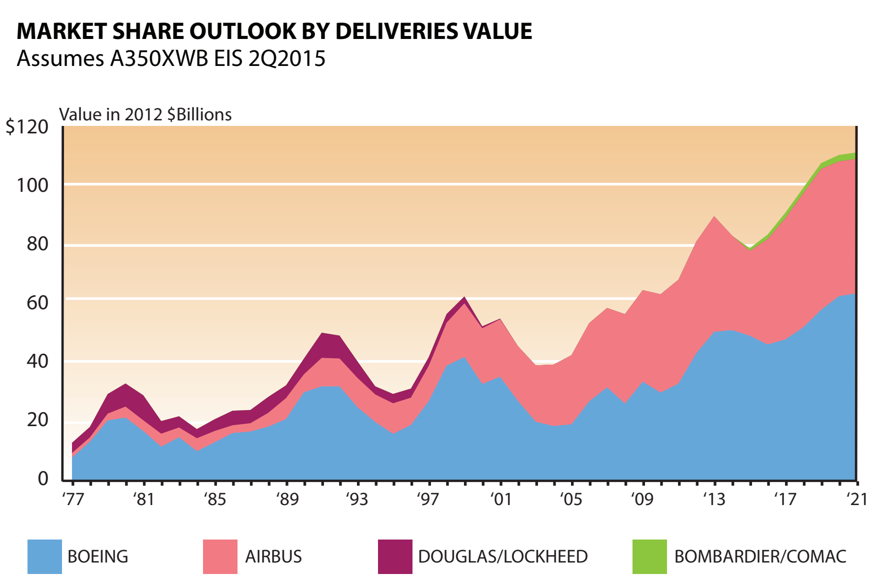
The planned upgrade to Boeing's 777 is the biggest potential new program in the jetliner business. First of all, it is a large aircraft that is set to enjoy a high level of commercial success, and it will almost certainly be launched in the next five years. Its very large new composite wings will have 10% more area than the -300ER's wings. The current 777 fuselage width is retained, but with a stretch, to 'upgauge' the plane. The systems will be mostly new, although a more electric design is not likely.

All three large engine manufacturers are competing for this platform, which requires 100,000-lbst (static thrust) class engines. The engine contract may be sole-source (as on the current 777-300ER/-200LR), or there may be a choice of two. Specific engine options include General Electric's GE9X, a large-scaled version of Pratt & Whitney's Geared TurboFan, and the Rolls-Royce RB3025.

Currently, Boeing is planning on three versions of the new 777 series:

- 777-8X—200/300ER replacement; 353 seats/8,000 n.mi.
- 777-9X—300ER/747 replacement; 407 seats/8,000 n.mi.
- 777-8LX—200LR replacement; 353 seats/9,500 n.mi.

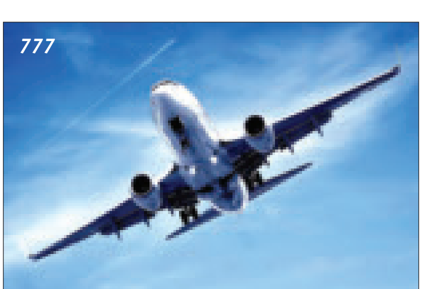
Boeing leadership has discussed asking its board for authorization to offer later this year, but 2013 is more likely. Right now, there is a debate in the company as to which should go first, this 777-X family, or the 787-10 stretch. There is also a chance that



Boeing will decide to pursue them simultaneously, a challenge the company has not undertaken since its parallel 757/767 development programs in the late 1970s and early 1980s. Assuming the 777-X is launched next year, service entry will be in 2018.

The stretched 787 will have 320 seats and a range of 6,800 n.mi. In terms of market segment, it will be aimed at Airbus's A330-300 and A350-XWB-900. Since there will be fewer major design changes than with the 777-X, the 787-10 will offer fewer opportunities for new business capture for the industry's subcontractors.

As with the 777-X, Teal Group believes there is a 100% chance that this product will be launched in the next five years. As noted, timing depends on the launch of the 777-X series, but as a much less ambitious derivative the 787-10 is more likely to happen on schedule. Then again, the 787-10 has been around as a concept since 2005.


777

The current 787-10 plan calls for a 2013 launch, with a 2017 entry into service. Lufthansa and Emirates are among prospective launch customers.

While Boeing is assessing options for what could be a powerful counterattack against the A350XWB, Airbus achieved a noteworthy victory at Farnborough when Cathay Pacific became the fifth customer for the -1000 variant. Cathay converted 16 -900 orders to -1000s, and exercised options for an additional 10 -1000s. These were the first new -1000 orders in three years. Since the design changes announced at the June 2011 Paris Air Show, there had been doubts about the type's competitiveness.

Change at the top

Perhaps the most intriguing aspect of this order concerns Boeing itself. Just before the show, Boeing Commercial president Jim Albaugh resigned and was replaced by Ray Conner, who had been head of sales. Since Albaugh was a noted advocate of the new 777-X series, and since Boeing seemed to indicate at the show that it might hold off on announcing the new project, it is possible that Cathay was indicating a preference for a new model rather than the existing 777-300ER. If that is the case, and if British Airways and other key customers really do want a new 350-seat design, Boeing will need to accelerate 777-X plans.


ARJ21

Yet there are still valid reasons for Boeing to prioritize the 787-10 over the 777-X. The latter plane would go after the A350XWB-1000, which still looks like an uncertain performer against the current 777-300ER. By contrast, the 787-10 would go after the A350XWB-900, which enjoys a much stronger market position than the -1000 (about 360 orders versus about 80). And Boeing has no direct competitor to the -900.

Meanwhile, Airbus continues to announce A330 improvements, and it is clear that the type may remain in production longer than expected. Boeing at Farnborough dubbed the 787-10 an "A330 killer," but this raised the question of why the 787-8 and -9 were not good enough to do the job themselves. After all, the all new technology 787 is supposed to be revolutionary, and the A330 is a 25-year-old design. On the other hand, the A330's steady stream of product improvements also hurts the A350XWB-800's chances of survival.

A successful rivalry

While the two big jet makers battle on two fronts, new emerging producers continue to look for opportunities to break into the market. Since this industry is worth over $70 billion annually, was largely insulated from the global economic meltdown, and still looks set for more growth, that is hardly surprising. But breaking into the industry remains quite difficult.

The Chinese and Russian single-aisle offerings (COMAC's C919 and Irkut's MS-21) are undermined by one crucial weakness: Both are being designed, built, sold, and supported by government-owned companies. Historically, government-owned aerospace companies do an extremely poor job of meeting market needs.

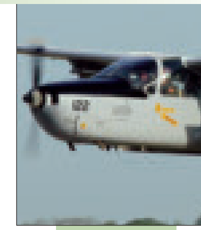
Nominally, the C919 had 165 firm orders as of July 1, with the MS-21 holding about 200 (excluding the more completely fictitious ones). But coercing domestic carriers into placing orders for state-built aircraft is completely different from actually getting them to take delivery of these planes.

The best illustration of this is the COMAC ARJ21 regional jet. In theory, the 'firm' order book consists of 290 aircraft. Yet most likely none will be delivered. Even with service entry delayed by six years (from 2007 to late 2013), in terms of anticipated performance the plane looks like a miserable failure. While it may be used by the company as a stepping stone to learn certification requirements for its C919, COMAC is taking the same industrial approach on the C919 that it took on the ARJ21. This probably dooms it to failure too.

Excluding jets offered by these state-owned producers leaves Bombardier as the only emerging large jetliner provider. The company's 110/130-seat CSeries provides the best illustration of how hard it is to break into Airbus and Boeing's turf. The CSeries is in the very unusual position of being just one year away (in theory) from entering service with an unknown carrier. Despite the recent letters of intent, there are just 138 firm orders, with the order book stuck at about that level for several years.

In short, the long-running and at times vicious battle between Airbus and Boeing masks the fact that it is one of the world's most successful duopolies. It is a fierce competition, but that rivalry has also served to hone both companies' competitive skills, particularly when it comes to new product development. That competitive edge appears to be powerful enough to keep out newcomers.

Richard Aboulafia
Teal Group
raboulafia@tealgroup.com



Fighting friction, smoothing flow

For aerospace manufacturers, particularly those in the business of building transports, the Holy Grail of their continuing quest is to reduce the drag-creating effects of friction on the skins of their aircraft.

Friction accounts for half the total drag on a modern jet transport; the rest comes from pressure—induced and wave drag. An aircraft's need to generate lift in order to stay in the air creates these latter three forces, so not a great deal can be done to minimize their effects. Wing fences or winglets can shave only a few percentage points off an aircraft's induced drag budget, and only if the plane remains cruising long enough.

However, if skin friction can be reduced appreciably, an aircraft will achieve a proportional saving in the amount of fuel it burns, conferring benefits on range and operating cost. This is the reason for the industry's fascination with laminar flow control. If greater amounts of boundary-layer air can be made to flow over an aircraft's wing, fuselage, and empennage without becoming turbulent, the plane will burn proportionally less fuel.

About half the total skin friction experienced by an aircraft is on its fuselage and empennage, and about half is on its wings, says William Saric, a professor at Texas A&M University's Dept. of Aerospace Engineering and the director of its Flight Research Laboratory. Recently, companies have experimented successfully with riblets—raised rib-like protuberances applied along fuselages and empennages in areas where aircraft have turbulent boundary-layer air—to reduce skin friction (and fuel burn) by 2-5%.

Fuel savings from laminar flow

According to Saric, achieving wing laminar flow would complement the use of riblets elsewhere on an aircraft and would yield additional fuel savings. He estimates that wing laminar flow control potentially offers fuel-burn savings of 10% to 12%—roughly equal to the savings a new generation of turbofan engines offers compared with the preceding generation.

The calculation is simple: Skin friction accounts for half the drag on an aircraft, and the wings account for half of that skin friction—hence they represent a quarter of the total friction drag. But not all skin friction on the wings can be nullified: Saric notes there is a limit to the degree of wing laminar flow that can be achieved.

Laminar flow breaks down as a result of disturbances within boundary-layer air. As these disturbances grow and become more unstable, they create turbulence. The boundary layer can remain laminar as the flow accelerates to its minimum pressure at about 60% of chord. However, the air must decelerate efficiently to atmospheric pressure by the time it reaches the wing's trailing edge; this ensures that boundary-layer disturbances create turbulence in the pressure recovery region over the control surfaces.

Since laminar flow is only possible over about 60% of the wing, total wing friction can potentially be reduced by only 60% at most—or about one-eighth of total skin friction on the aircraft. Saric says laminar flow over the wing's upper surface would produce about 60% of the wing friction reduction benefit, and laminar flow over the lower surface about 40%.

Saric's team at Texas A&M University's Flight Research Laboratory use a Cessna 0-2 Skymaster to carry a 30-deg-swept-wing airfoil section perpendicularly under its left wing to flight-test laminar flow techniques for transonic wings.

Tried and tested techniques

Various approaches have sought to achieve laminar flow control, and some have seen fair success. Creating a 2D airfoil (a very thin airfoil with a sharp leading edge), and ensuring the wing leading edge and surface are highly polished, is the best known way to achieve natural laminar flow.

Saric says it is also much easier to achieve it on a wing with no sweep angle, or only a small one, than on a transonic or supersonic swept wing.

Another option is to use weak suction at the surface. Boeing used this technique successfully in the 1990s in an experiment with a 757. This approach combined natural laminar flow control—using an accelerating pressure gradient in the swept-wing airfoil—with tiny holes in the leading edge of the wing. Suction applied through those holes helped control leading-edge airflow contamination and crossflow instabilities.

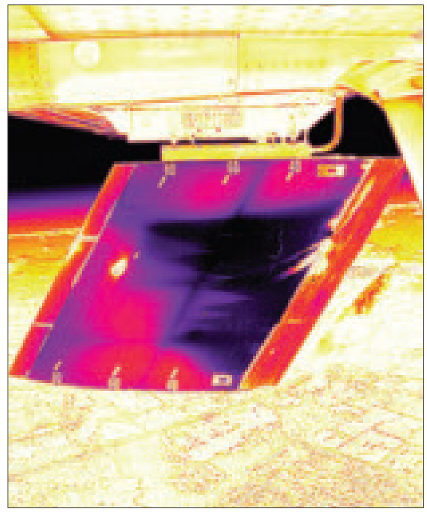
But in a swept wing that carries fuel and features high-lift leading-edge devices, installing the ducting needed to produce leading-edge suction presents engineering problems that may not be solved easily (or cheaply) in a production aircraft. Saric's team at Texas A&M is pursuing a different approach that, while still at the technology demonstration stage, might eventually offer a simpler way to produce laminar-flow control benefits.

Controlling crossflow instabilities

Swept wings create an imbalance between the centripetal acceleration and pressure gradient experienced by air in the layer above the boundary layer, compared with the air within the boundary layer. This imbalance creates a secondary crossflow of air in the boundary layer, which runs in waves along the wingspan, perpendicularly to the air streaming over the chord. In attempts to achieve laminar flow, these crossflow waves are particularly difficult to control.

In two separate research initiatives—one a NASA Environmentally Responsible Aviation (ERA) project and the other an AFRL-funded effort with Lockheed Martin and Texas A&M—Saric's team has experimented to suppress the most unstable crossflow wavelengths in different flight and wing conditions.

Their approach has been to interfere with those unstable waves by inducing waves of other wavelengths along the span using two different techniques. The team's experiments have used wind tunnels and the laboratory's own Cessna O-2 testbed, fitted to carry a 30-deg swept airfoil section perpendicularly under its wing. The initial results have been promising.



In this in-flight freestream turbulence measurement, the dark color indicates cold temperature and laminar flow,light blue indicates turbulent region. There are no DREs. Speed was 175 kt (indicated), altitude 7,000 ft.

Discrete roughness elements

One technique, funded under NASA's ERA project, has been to use periodic discrete roughness elements (DREs) placed spanwise at regular intervals within the first 1% of the chord of the wing, to create interference waves. These DREs are tiny bumps, no more than 10-12 µm high and no more than 1 or 1.5 mm in diameter. They are spaced so the distances between their centers are from one-half to two-thirds of the wavelength of the most unstable crossflow wave, to create the maximum of interference with it.

In flight testing of the swept-wing airfoil—carried under the Cessna O-2 and painted to simulate a typical operational aircraft surface—the Texas A&M researchers found that the DREs suppressed the most unstable wave enough to move the transition point between laminar and turbulent airflow from 30% of chord to 60%.

Saric says the wavelength of the most unstable crossflow wave on a particular wing depends on the airfoil of the wing, the radius of its leading edge, the aircraft's speed, and its condition of flight. (For instance, the most unstable wavelength might change with the aircraft's angle of attack.)

In wind tunnel testing, Saric's team found that the most unstable crossflow wavelength for their swept-wing airfoil model was 12 mm. However, in a wing-glove test on a Gulfstream 3 flying at Mach 0.75, the most unstable crossflow wavelength may be 7 mm;

(Continued on page 45)

The area where the wing glove was placed on NASA Dryden's Gulfstream GIII is outlined in green. Image credit: NASA/Tony Landis.

Curiosity on the red planet

Mars is ours!

by **Leonard David**
Contributing writer

It was nothing short of an engineering tour de force: NASA's Mars Science Laboratory (MSL) and its 1-ton Curiosity rover successfully touched down on the red planet's Gale Crater on August 5, after a 36-week sojourn from Earth.

The on-target, wheels-down landing of the nuclear-powered Curiosity meant that the largest rover ever sent to another planet had settled into place and was on task to start a multiyear science study of enigmatic Mars. But getting the $2.5-billion mission up and running, as well as down and dirty on the Martian surface, was preceded by a terrorizing, seven-minute, death-defying dive through the planet's atmosphere.

What made the touchdown traumatic was the need for several cutting-edge technologies to work perfectly. All were part of an intense entry, descent, and landing (EDL) phase relying on a sequence of 76 pyrotechnic blasts, a guided entry, supersonic parachute deployment, and the use of a descent-stage 'rocket backpack' teamed with a Doppler radar system built especially for the mission. Called the Sky Crane, this hovering platform—which had never been field tested—was used to enable a 'soft-landing' on the Martian surface.

Engineers at JPL celebrate the landing of Curiosity. The rover touched down on Mars the evening of August 5. Image credit: NASA/JPL-Caltech.

Curiosity's assignment is clear cut: To survey its surroundings and investigate whether or not environmental conditions on Mars have favored development of microbial life on that faraway world.

Following the landing, President Barack Obama saluted the achievement: "The successful landing of Curiosity—the most sophisticated roving laboratory ever to land on another planet—marks an unprecedented feat of technology that will stand as a point of national pride far into the future. It proves that even the longest of odds are no match for our unique blend of ingenuity and determination."

"If anybody has been harboring doubts about the status of U.S. leadership in space," said John Holdren, the president's science adviser, at a postlanding JPL news conference, "well, there's a 1-ton automobile-size piece of American ingenuity…and it's sitting on the surface of Mars right now."

The euphoria of the moment brought flag-waving and tears of triumph for hundreds of scientists and engineers gathered at JPL, where Curiosity was designed, developed, and assembled. It is also the rover's mission control site. Buoyed by the feat, more than one voice was heard to declare: "Mars is ours!"

Heartbeat tones

"It was a great day on Mars," says JPL's Alan Chen, operations lead for EDL. "We had an incredibly clean ride…we traveled over 350 million miles on the way to Mars, and we missed our entry target by only about a mile."

Triumphant shouts erupted at mission control on August 5 as images began arriving from the Martian surface—confirmation that NASA's Mars Science Laboratory and its Curiosity rover had touched down on the planet safely. A landing tour de force and an automobile sized rover with a suite of advanced instruments are ushering in a new era in planetary exploration, experts say.

A network of orbiters—NASA's Odyssey and Mars Reconnaissance Orbiter, and ESA's Mars Express—plus several ground stations back on Earth, supported the MSL landing. Heartbeat and informational tones from MSL during EDL enabled an early reconstruction of how things transpired.

Entering Mars' atmosphere at about Mach 24, then slowing down to just under Mach 2, MSL/Curiosity pulled a little over 11 Earth *g*s, says Gavin Mendeck, an EDL team member from NASA Johnson. "If you were a human riding onboard it would be a little bit of a rough ride. Fortunately, Curiosity is made of some pretty sturdy stuff, and she handled that just fine," he says.

The spacecraft executed three bank reversals in the Martian atmosphere to target itself to the desired landing spot, although a tail wind may, in part, have contributed to a downrange misdistance of 1.5 miles, says Mendeck.

Parachute deployment decelerated MSL from roughly Mach 1.7 to subsonic speeds, gauged to be Mach 0.7, notes JPL's Devin Kipp, a member of the EDL team focused on the parachute descent. "Not a lot of exciting things happened, because everything was right down the pipe of what we expected—but that's how we want it," he says.

Powered descent and maneuvers made by Sky Crane to spot-land Curiosity onto Mars went according to script, says JPL's Steve Sell, who was in charge of powered flight within the EDL group. "From data received so far, we flew this right down the middle. It's absolutely incredible to have worked on a plan for so many years and then just see everything happen exactly according to plan," says Sell. One by one, the shedding of all the contingency plans as the data came in "was like weights being lifted off our shoulders."

Parking lot landing

Using eight throttleable engines, the Sky Crane gently lowered Curiosity to a final stop. The crane's bridle system, made of nylon cords, spooled out the rover to the ground. The rover's wheels and suspension system served as the landing gear. When Curiosity sensed touchdown, the connecting cords between rover and Sky Crane were cut. Still carrying a large reservoir of fuel, more than projected, the descent stage performed a flyaway maneuver, crashing at 100 mph some 600 m away from Curiosity's landing spot, Sell says.

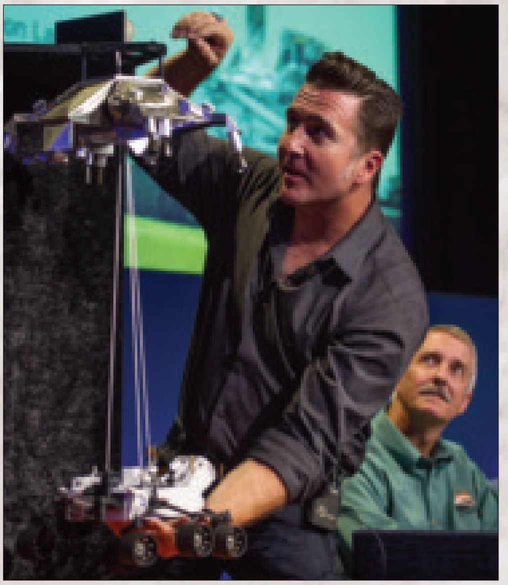
A best estimate of the rover's speed at touchdown puts it at 0.75 m/sec (1.7 mph) vertical and 0.04 m/sec (0.09 mph) horizontal, as reported by the flight software. In other words, Curiosity's wheels first met Mars at a slow walking speed.

The rover's safe and sound touchdown benefited from scientists' having chosen a place with a nice flat landing pad right next to it, Sell concludes. "The science store they wanted to go to had a parking lot."

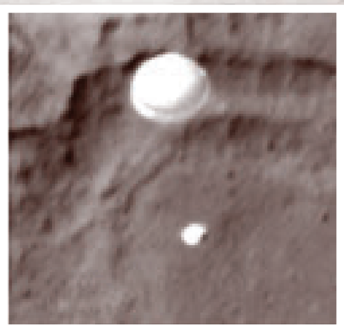
In a masterpiece of sharpshooting camera work, NASA's

This is a portion of the first color 360° panorama from Curiosity. The mission's destination, a mountain at the center of Gale Crater called Mount Sharp, can be seen in the distance, to the left, beginning to rise up. Blast marks from the rover's descent stage are in the foreground. Credit: NASA/JPL-Caltech/MSSS.

Adam Steltzner, JPL's Mars Science Laboratory EDL phase lead, demonstrates how the spacecraft lands the rover during a pretouchdown briefing. Credit: NASA/ Bill Ingalls.



Mars Reconnaissance Orbiter (MRO) spotted Curiosity descending under its parachute. MRO's High-Resolution Imaging Science Experiment (HiRISE) camera captured the image while the orbiter was listening to transmissions from Curiosity. The feat was a repeat performance for MRO, which in 2008 had captured a much similar view of NASA's Phoenix lander enroute to its Mars touchdown.



Curiosity underneath its parachute was photographed by the MRO's HiRISE camera. Image credit: NASA/JPL/University of Arizona.

"The MSL parachute image turned out just as I had hoped," says Alfred McEwen, University of Arizona in Tucson, HiRISE principal investigator. "The brightness levels of both the parachute and Mars surface were also very close to our predictions, and we had no saturation," he says.

The image shows the supersonic parachute fully inflated and performing perfectly. Details such as the band gap at the chute's edges, and the central hole, are also clearly visible.

McEwen tells *Aerospace America* that the odds of capturing the shot were a little lower for MSL's skydive than for Phoenix—a 60% rather than 80% chance, according to the known errors—although the chances of a mistake were lower because he and his team had done this kind of camera work before.

"I also wasn't surprised at the detail," he says, "because I had ground-test images of the parachute that I reduced to the expected HiRISE scale, and the real thing looked very similar. I had hoped we would be extremely lucky and capture it in our narrow color swath. But that didn't happen, because MSL landed east of the center of their predict by more than 600 m…the half-width of our color swath."

That MRO picture, likely taken 40-50 sec after parachute deployment, speaks volumes, notes JPL's Kipp. "It tells a whole lot about how the parachute performed. It's got its inflated shape perfectly. You can see the dark area at the top of the parachute, which is the vent that lets some air escape through the top. The shape is exactly what we expected to see. You don't see any apparent damage…we see a perfectly functioning parachute that looks exactly like we thought," he says. "That's good news."

Jitters at JPL

Before MSL began its nose-dive into the Martian atmosphere, the EDL jitters at JPL were palpable.

"We definitely did all we could, says Richard Kornfeld, deputy EDL phase lead for validation, during a prelanding interview. "We took all the problems and decomposed them. Obviously, this is a more complex mission than in the past."

Curiosity was the fourth Mars lander mission for Kornfeld, a veteran of the Spirit and Opportunity touchdowns as well as Phoenix and now MSL. "What impressed me more about this one is its complexity…and with that comes a complex test program, along with the complexity of the team to understand all the aspects of everything," he says.

"We pushed the envelope, and the team has set new standards. That builds confidence, but no guarantee for the future. We continue to perfect the tools. The flight test data you get from previous missions, well, they are worth gold," Kornfeld says.

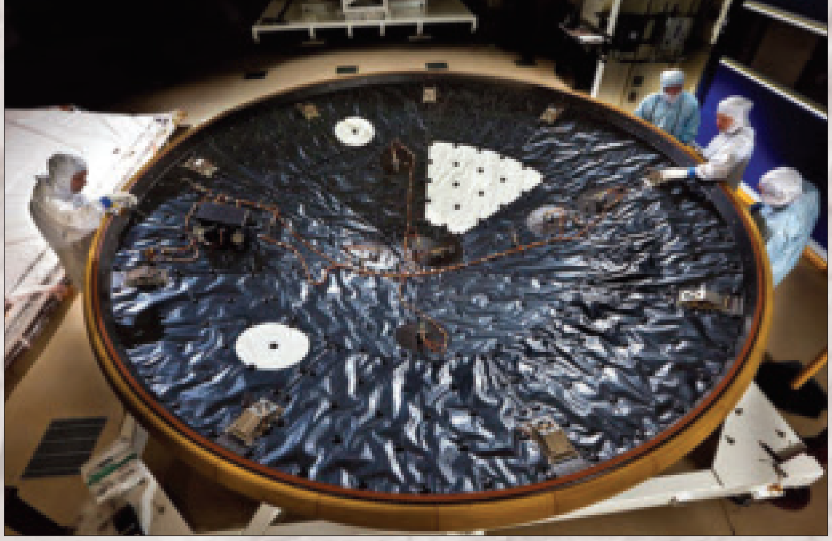
Personally for Kornfeld, the entire EDL sequence did equate to seven minutes of nail-biting terror. More specifically, he felt great anxiety about the powered descent of the Sky Crane, because of "its novelty and its first-time use," he says.

Sky Crane evolved over many years, says Rob Manning, MSL's chief engineer at JPL. But bringing the 'rover on a rope' idea to fulfillment did not come easy.

"I've always been a fan of the whole closed-loop control architecture. Early on there were a few of us who realized that we could control the horizontal velocity as well as the vertical velocity with this simple two-body control system," Manning tells *Aerospace America.* "Architecturally, it all made so much sense to some of us, because there's a natural evolution from Viking, Mars Pathfinder, Mars Exploration Rovers, and to some extent Phoenix. They are not different architectures; they are all interconnected. So it was a natural synergy in the ideas and the equations of motion. The physics, the things that we're trying to protect ourselves from, they all converged to make this architecture come true."

Sky Crane meant "putting your propulsion system on your roof, and just flipping it around so the payload is below," Manning says. "I think it was one of the most innovative parts of MSL. It certainly is the most revolutionary architectural transformation."

Concerning Curiosity itself, Manning says one of the challenges is that the rover flew the entire MSL configuration on its own. "So what is Curiosity's specialty? Is it a pilot? Is it a hypersonic entry vehicle? Is it an interplanetary navigator spacecraft? Is it an all-terrain vehicle…what the heck is it? That transformation…that overloading of functionality has been the bane of my life," he admits. "A lot of that has made me very nervous over the years, to get all these functions to work on the same computers, the same input/output, and especially to get the resources to test it all."



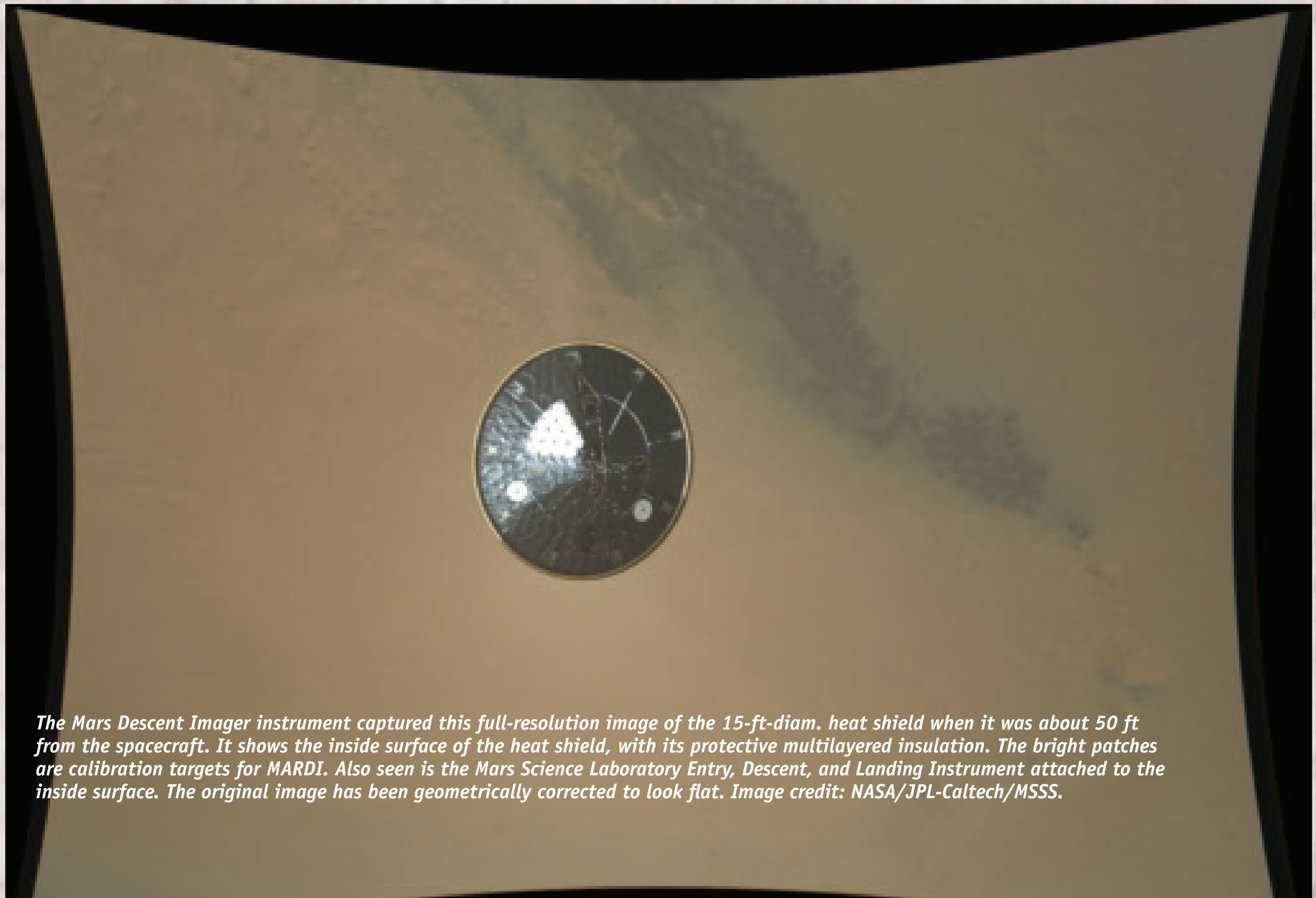
The heat shield for MSL was the largest ever built for a planetary mission. Credit: NASA/JPL-Caltech/Lockheed Martin.

Miracle of engineering

With each Curiosity image received, the call to get moving is perceptible. Despite the rover's first-rate health, a lengthy, step-by-step commissioning of the mobile robot has taken priority. "Be patient with us, please," says MSL project manager Pete Theisinger, "because we will be patient with Curiosity."

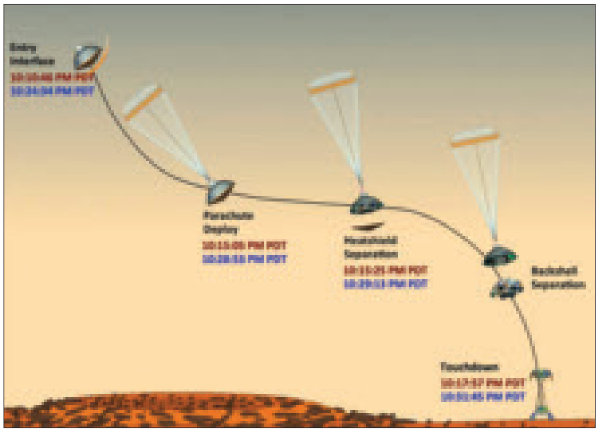
Caltech's John Grotzinger, MSL chief scientist, is leading some 400 researchers on the mission that now must interact with Mars, and 300 or more engineers who will operate Curiosity over the years ahead.

Shortly after the landing, Grotzinger first pointed to an area excavated by the blast of MSL's descent-stage rockets. With the loose debris blown away by the rockets, details of



The Mars Descent Imager instrument captured this full-resolution image of the 15-ft-diam. heat shield when it was about 50 ft from the spacecraft. It shows the inside surface of the heat shield, with its protective multilayered insulation. The bright patches are calibration targets for MARDI. Also seen is the Mars Science Laboratory Entry, Descent, and Landing Instrument attached to the inside surface. The original image has been geometrically corrected to look flat. Image credit: NASA/JPL-Caltech/MSSS.

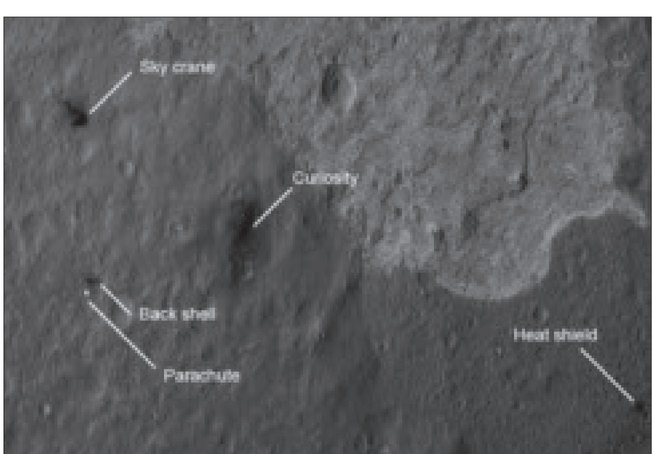
This graphic shows the times at which NASA's Curiosity rover hit its milestones during its entry, descent, and landing on Mars. The times at which the events actually occurred are in red; the times at which Earth received confirmation that they occurred are in blue. All times are listed in Pacific Daylight Time. Credit: NASA/JPL-Caltech.



the underlying material can be seen. Of particular note is a well-defined topmost layer that contains fragments of rock embedded in a matrix of finer material.

Catching Grotzinger's eye in the larger panorama of landscape relayed from Curiosity is how Earthlike the scene appears. "You would really be forgiven for thinking that NASA was trying to pull a fast one on you…and [that] we actually put a rover out in the Mojave Desert and took a picture.

"I think for us at this point as scientists we haven't even scratched the surface," he says. "It is a miracle to us. We have chosen this place as a result of scientific deliberation. This EDL system for the first time in the history of landed missions allowed the science community to choose between four [landing site] options."



The four main pieces of hardware that arrived on Mars with Curiosity were spotted by MRO's HiRISE camera, which captured this overhead image about 24 hr after the landing. The heat shield was the first piece to hit the ground, followed by the back shell attached to the parachute, then the rover itself, and finally, after cables were cut, the Sky Crane flew away to the northwest and crashed. Relatively dark areas in all four spots are from disturbances of the bright dust on Mars, revealing the darker material beneath. Curiosity is approximately 4,900 ft away from the heat shield, about 2,020 ft away from the parachute and back shell, and roughly 2,100 ft away from the discoloration consistent with the impact of the Sky Crane. Credit: NASA/JPL-Caltech/University of Arizona.

Grotzinger reflected on the first images of Curiosity's wheels firmly on the ground. "You know you've landed on Mars. No semaphore tones, no people jumping up and down; you actually see a picture of the surface of the planet with a spacecraft on it. And that is a miracle of engineering."

During its fifth day on Mars, Curiosity underwent a planned 'brain transplant'—that is, transitioning to a new version of flight software on both of the rover's redundant main computers. "We're wiping away all of the cruise and entry, descent, and landing software and making room for the software needed to perform the exciting portions of the surface mission ahead," reported Jessica Samuels of the MSL engineering operations team. The new software, she said, is better suited for Mars surface operations such as driving, or using Curiosity's robotic arm and drill. It also includes advanced image processing to check for obstacles as the rover motors about on Mars.

Mobile analytical laboratory

"In my view, the historic landing of the MSL mission's Curiosity rover was beyond transformational," says James Garvin, chief scientist at NASA Goddard. A member of the MSL science team, Garvin has a long association with the project, as the first MSL program scientist, as one of the mission's founding fathers starting in January 2001, and as a participant in MSL's payload definition and selection.

"This remarkable and unprecedented feat of spaceflight engineering was significant in that it culminated the implementation stage of a science-guided Mars Exploration Program that was forged from the ashes of NASA's failed Mars '98 missions and put into place in fall of 2000," Garvin tells *Aerospace America.*

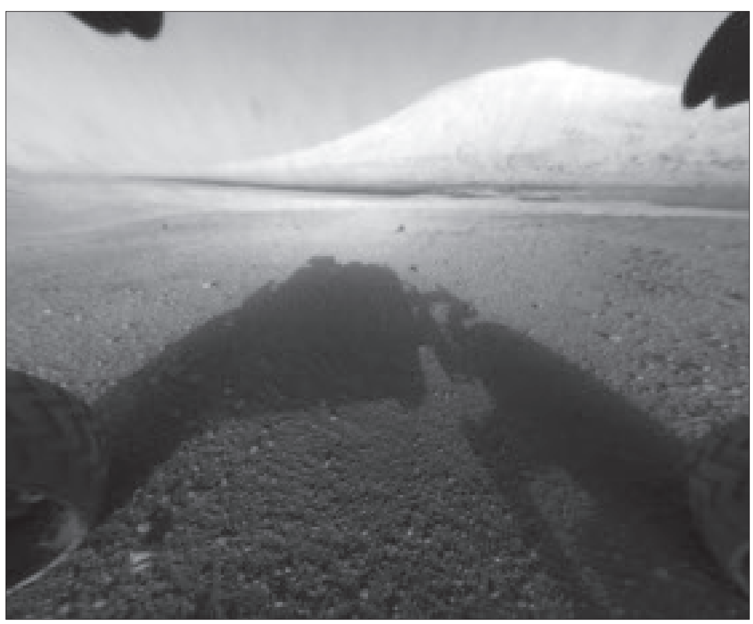
By serving as a "surface observatory," MSL has ushered in a new era, Garvin declares. "Having a mobile analytical laboratory, with field science instruments that far exceed what traditional field geologists here on Earth would carry, is truly transformational," he says. For example, Curiosity's CheMin (chemistry and mineralogy) and SAM (sample analysis at Mars) instruments provide capabilities that typically require Earth laboratories far away from field exploration, "and yet on Mars we have them 'on our back' ready to go," he notes.

Furthermore, Curiosity carries specialized 'eyes' and compositional sensors that are better than the hand-lens and rock ham-

A chapter of the layered geological history of Mars is laid bare in this postcard from Curiosity, where we see the layers at the base of Mount Sharp, the rover's eventual science destination. Image credit: NASA/ JPL-Caltech/MSSS.

mers used on Earth by geologists. Engineers at JPL worked with rover instrument developers across the U.S., Canada, Russia, France, Germany, Spain, and Finland.

"We are finally beyond the era of the classic robotic field scientist, and now, on the surface of another world, we have a capability better than what we routinely use to explore the Earth! All of this in less than a decade of Mars program evolution and execution," Garvin exclaims.



This image, taken by Curiosity, shows what lies ahead for the rover—its main science target, informally called Mt. Sharp. The rover's shadow can be seen in the foreground, and the dark bands beyond are dunes. Rising up in the distance, Mt. Sharp, the highest peak, at a height of about 3.4 mi., is taller than Mt. Whitney in California. The Curiosity team hopes to drive the rover to the mountain to investigate its lower layers, which scientists believe hold clues to past environmental change. Image credit: NASA/JPL-Caltech.

MSL has opened another new era, he adds: that of accessing locations where the 'science pull' is remarkably rich. Curiosity is factory loaded with gear to study the history of past environments on Mars, and of the preservation potential (or lack of potential) for chemical or compositional indicators of ancient habitats.

"We have *never* been able to access any places as exciting as the Gale Crater region," says Garvin. It is an amazing location, rich in known scientific targets worthy of intensive exploration, he believes. He says this is the first time since the 1972 Apollo 17 Moon landing that "we know we are in one of the best places in the solar system to conduct pathfinding new science!"

✈✈✈

In many ways, the Mars Science Laboratory can be viewed as a down payment on the day when humans set foot on Mars.

Says Garvin, "MSL could be the stepping stone to give us confidence that people can get to Mars, and to showcase for everyone that the U.S. space program is up to the task. I can only imagine the day when women and men land on Mars equipped with MSL-like robotic 'assistants' to explore other compelling sites on the red planet. Like the first ships arriving on the shores of North America, Curiosity's landing on Mars will catalyze human exploration of a new world."

Declassifying the

Part 2:

Monitoring the Soviet space program

Recently released documents from the National Security Agency and other intelligence organizations reveal the surprising extent of U.S. knowledge about Soviet space programs during the Cold War era. As activities in this arena advanced in the USSR, increasingly potent U.S. surveillance capabilities provided unprecedented levels of detail via remote observations of Soviet efforts and assets.

Soviet space poster from 1963 reads: "Glory to space heroes—Glory to the Soviet people!" The CCCP emblem connotes the Soviet achievement of first lunar impact in September 1959.

by Peter Pesavento
Contributing writer

As information about the formerly classified GAMBIT and HEXAGON programs (discussed in Part 1, September, page 32) first came to light, material about another satellite observation system with a hitherto unknown connection to the U.S.-Soviet Moon race was released by the USAF National Air and Space Intelligence Center (NASIC).

According to one NASIC document (originally classified 'Secret; Special Access Required') a U.S. 'Project 647' satellite witnessed the June 26, 1971, launch—and subsequent crash back onto the steppe—of the Soviet SL-X, the Soviet counterpart to the U.S. Saturn V. Nearly 19,300 n.mi. out in space, and off-angle to the Tyuratam launch site by 58 deg, the U.S. spy satellite recorded the event for the entire 165 seconds that it lasted. The 647, more commonly called the DSP, or Defense Support Program satellite, probably provided some of the very first emission signature data collected from the launch attempt, the third in that Soviet series.

The November 11, 1971, report discloses that the infrared "…sensor was saturated after the first 30 seconds and remained at that level for 110 seconds.…

Initial detection probably occurred shortly after ignition while the missile was still on the launch pad. The derived ignition time was 2351:05Z [Zulu, or Universal Time]…. The launch point was determined by converting the azimuth and elevation of the first data point to latitude and longitude using the target-satellite-earth geometry. The derived launch point…position is within Tyuratam Space Launch Site J1/J2."

The DSP satellite event report provides details of the vehicle's ascent and subsequent breakup, as well the various large stage pieces crashing back on the steppe.

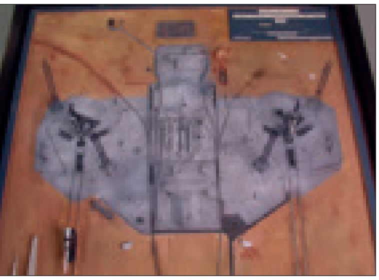
PDBs: Keeping the president informed

Another family of newly disclosed documents is called "The President's Daily Briefs." These multipage reports provided the president with coverage of world events as they were happening. Akin to the *New York Times* on steroids, the PDBs showcased classified facts, trends, scoops, and other secret information that would keep America's top policymaker accurately informed. They were provided by the nation's far-flung intelligence-gathering network around the world.

The original classification ranking of these daily chronicles during President Lyndon Johnson's term of office was 'Top Secret—Contains SIGINT [signals intelligence] and Keyhole [satellite photoreconnaissance] Materials.' Most of the news entries in the series were a few sentences to a paragraph long, although sometimes—depending on the nature of the events—they could encompass several paragraphs.

Overall, the Soviet space mission coverage in the newly released PDBs appears to focus on important factors connected with manned spaceflights and interplanetary missions. This perhaps reflects the keen interest that Johnson had in Soviet space activities. These include, for example, the Venusian missions launched in January 1969. The entry for January 6 of that year states, "The first Soviet interplanetary probe toward Venus during this current favorable launching period is apparently designed to descend gently onto the planet in mid-May. Unlike Venus-4, which in October 1967 was the first Soviet shot to hit the planet, this probe probably has improved instruments to insure transmission of Venusian atmospheric data during its descent."

A DSP satellite, also known as Project 647, undergoes testing on the manufacturer's premises in southern California. The long telescope tube contained the infrared sensor that tracked, as well as registered, rocket and missile launches from Tyuratam and elsewhere. This photograph depicts Flight 1, the vehicle that recorded the entire June 1971 SL-X launch failure from Tyuratam—from the rocket's launch to its crashing back on the steppe. The telescope tube pointed down at the Earth. At the base of the satellite are solar panel arrays that helped to power the spacecraft. Courtesy USAF.



A diorama in the CIA museum shows the Area J launch complexes. Built in 1969 by the National Photographic Interpretation Center's model shop as an aid for overhead satellite intelligence analysis, in this scale, 1 in.=80 ft. The model shows the two Area J launch pads, 1,640 ft apart. Between them are propellant storage, and pumping facilities. A rotatable service gantry tower 455 ft high can be seen at each pad, as well as lightning arrestor towers roughly 600 ft tall. In the lower left-hand corner, for scale comparison, are the Washington monument and Saturn V rocket. Image courtesy Scott Koch, CIA.

The January 1969 PDBs provided nearly daily coverage of the Soyuz 4 and 5 flights, which culminated in the docking and spacewalk transfer of two cosmonauts in the middle of the month.

These PDBs also present previously undisclosed information on what the U.S. intelligence community knew about key Soviet space missions, including certain aspects of what information reached the president. The new material features the first disclosed mention of the SL-X. The January 3, 1969, entry mentions that recent satellite photography had captured the Russian rocket on its Area J launch pad at Tyuratam: "The booster, which has been photographed on its pad several times [since December 1967], was returned to the nearby checkout building….Assuming the checkout turned up no major difficulties, the first flight test could occur within the next few months."

Perhaps the most dramatic reportage declassified so far concerns the Soyuz 1 tragedy, which ended in the death of cosmonaut Vladimir Komarov. Five of the PDBs contain coverage of the mission, preparations in the days preceding it, events during the launch, and Soviet activities in the aftermath of the crash. The April 24, 1967, entry (provided to the president while the mission was still in space) is among the longest PDB excerpts so far made public, covering three paragraphs, and shows the confluence of SIGINT (signals intelligence) communications intercepts, and RADINT (radar intelligence) data:

Rare Soviet poster commemorating the Soyuz 1 mission, which—due to equipment breakdowns on orbit—lasted only one day. Soyuz 1 ended tragically in the death of cosmonaut Vladimir Komarov. This poster was issued following the event. The caption reads: "First flight test of the spacecraft Soyuz 1. 23-24 April, 1967." The signatures included some of Komarov's closest friends: Yuri Gagarin, Gherman Titov, Boris Yegorov, and Konstantin Feoktistov. This poster was originally from the collection of the late Vasiliy Savinykh, first deputy of the Moscow-region-based Association of Cosmonautics. Image courtesy Peter Pesavento.

"Soyuz-1, the new Soviet manned spacecraft launched on Saturday, has been having serious difficulties. The cosmonaut tried to bring the spacecraft down at 8:00 PM EST on Sunday, but failed. He tried on the next orbit, and may have succeeded. If not, he will have two or possibly three more chances, at ninety-minute intervals, to come down in the USSR Sunday night. Failing these, he must wait until Monday night….

"The difficulty in deorbiting may be a result of the troubles the spacecraft has been having with stabilization, communications, and power supplies. These are more serious than the Soviets have experienced with any of their previous manned craft....

"Soyuz-1 carried only one man, but had room for three. It was the first manned test of a new spacecraft the Soviets have been developing, most likely for a circumlunar flight. The Soviets may have originally intended a more complex mission for this spacecraft, such as orbiting a second spacecraft and transferring crew members, but scrapped these plans when troubles developed."

The PDBs demonstrate that the Soyuz 1 coverage was apparently standard for key missions selected for the president's notice, and was applied to many manned-related missions. The discussions involve launch windows, deployment of space tracking and support ships in the Atlantic, Indian,

A keen eyewitness

The DSP satellite provided remarkably detailed data about launch and subsequent failure of the Soviet SL-X rocket in June 1971:

"The vehicle followed a fairly smooth trajectory and was heading northeast for about 55 seconds. Between 55 and 65 seconds after ignition, the vehicle appeared to veer rapidly to the east, although it continued to gain altitude. Intensity data collected at 55 seconds after ignition also indicate anomalous activity. The peak intensity was significantly higher than at any other time, while many adjacent detectors responded at high intensity levels. One secondary object…was observed above and slightly behind the primary target. This object may have been one of the upper stages of the vehicle. The anomalous activity was still in evidence at 65 seconds after ignition with large numbers of detectors responding. The launch vehicle reached a peak altitude of approximately 9 n.mi. at 75 seconds after ignition. At 95 seconds almost all of the responses from detectors other than those measuring emissions from the primary target had disappeared. However, a large group of detectors responded ten seconds later, indicating that perhaps another anomalous event was taking place. During this time, the vehicle itself was steadily losing altitude. It apparently impacted 135 seconds after ignition, because the azimuth and elevation did not change after this time. The impact position…is about 9.3 nautical miles northeast of the derived launch point….The target appeared to continue burning for at least 20 seconds after impact. At 165 seconds after ignition, infrared emissions from the target were no longer observed. There were no background returns from the launch area either before or after the event."

This HEXAGON panoramic image of the Area J facilities at Tyuratam was taken in August 1984. These two launch pads with their distinctive blast pit deflectors were part of Russia's buildup to send cosmonauts to the lunar surface competitively with Apollo. Four launch attempts between 1969 and 1972 failed. Courtesy NRO.

and Pacific Oceans, and the increased aircraft traffic arriving at the airport located inside Tyuratam, indicating that a space shot was imminent. Indeed, it appears from the PDBs that unmanned circumlunar mission events—whether successful, unsuccessful, or postponed—were given special mention along with description details.

For example, the July 24, 1968, entry says, "The Soviets apparently are postponing their latest attempt to get off an unmanned circumlunar flight. It had looked as if the launch would come this week, but several of the support ships are now moving off their stations in the Atlantic and Indian Oceans. The ships are not headed home, however. We do not know just what caused the delay. The Russians may try again in August."

A significant portion of the material read by Johnson came from the collection efforts of the National Security Agency (NSA). Based on newly declassified reports, the cumulative effect of the electronic intelligence (ELINT, a subset of SIGINT) data acquired via NSA listening posts provides a sense that the agency was able to attain blanket coverage of all USSR-sourced SIGINT. The ELINT included intercepted telemetry from rocketry launches at Kapustin Yar and Tyuratam, as well as Soviet spacecraft operating on orbit. Some of the NSA signals-monitoring locations that aided in the surveillance included Sinop in Turkey, Asmara in Ethiopia, and Chitose in Japan.

NSA ELINT on Soviet Moon exploits

For the first time, the NSA has released over 200 analysis documents from its voluminous archives on the Soviet space program. Unlike the more general information previously declassified and released from other federal agencies, this new NSA material lifts the veil on the 'nuts and bolts' of ELINT, such as how much information was gathered and how well the accumulated telemetry intercepts were interpreted.

The new documents' original security

Event	Time (seconds from launch) LUNA 20
SCI timer start	Ø327:58.682
Folded scale velocity meter (FSVM) start: 232 MHz	minus 178
240 MHz	minus 173
192 MHz	minus 173
Start of ignition sequence	minus 2.09
Ignition (first pressure rise)	minus Ø.99
Half thrust level achieved	minus Ø.64
Full thrust and liftoff (FSVM slope change)	minus Ø.26
Velocity program start	minus Ø.Ø8
Timer start	Ø.Ø
Roll maneuver start	9.81
Pitch program start	15.28
Roll maneuver end	18.66
Roll maneuver start	8Ø.22
Pitch program end	123.Ø6
Second-stage ignition	123.78
First-stage MECO	126.37
First-stage velocity program end	126.61

(b) (1)
(b) (3)-50 USC 403
(b) (3)-P.L. 86-36

7.

TOP SECRET ZARF UMBRA

(b) (1)
(b) (3)
(b) (3)

TCS-42698-72

Event	Time (seconds from launch) LUNA 20
Second-stage full thrust	126.75
Second-stage velocity program start	127.19
Pitch program start	136.35
Pitch program end	146.6Ø
Separation event	199.7Ø
Pitch program start	277.65
Pitch program end	292.Ø1
Third-stage vernier ignition	336.29
Second-stage MECO	338.32
Second-stage retrorocket ignition	338.94
Second-stage velocity program end	339.Ø
Third-stage ignition	345.43
Third-stage full thrust	346.27
Pitch program start	349.33
Third-stage velocity program start	35Ø.3Ø
Pitch program end	4ØØ.55
Pitch program start	51Ø.18
Pitch program end	549.Ø3
Third-stage MECO	579.Ø9
Third-stage velocity program end	585.95
Third-stage VECO/retrorocket ignition/third- and fourth-stage separation	588.81
Start propellant settling	639.Ø5
Fourth-stage ignition for parking orbit insertion burn	838.28
Fourth-stage MECO	956.7Ø
Start propellant settling	399Ø.9
Fourth-stage ignition for translunar injection burn	4191.Ø
Fourth-stage MECO/payload separation	4661.4

8. Analysis provided a launch-vehicle altitude of about 27 n.m. at first-stage MECO, 43 n.m. at fairing separation, 66 n.m. at second-stage MECO, and 81 n.m. at launch plus 446 seconds

These NSA Luna 20 launch report excerpts, parts 1 and 2, are from an NSA report on the Luna 20 lunar landing mission. The data show in bold relief the awesome capabilities of electronic signal interception of Soviet space launches, as well as precision analysis of the resulting data by U.S. intelligence analysts. It shows that signals could be picked up (in high fidelity) at the Tyuratam launch pad (beginning prior to liftoff). MECO is an acronym for Main Engine Cut Off. Courtesy NSA.

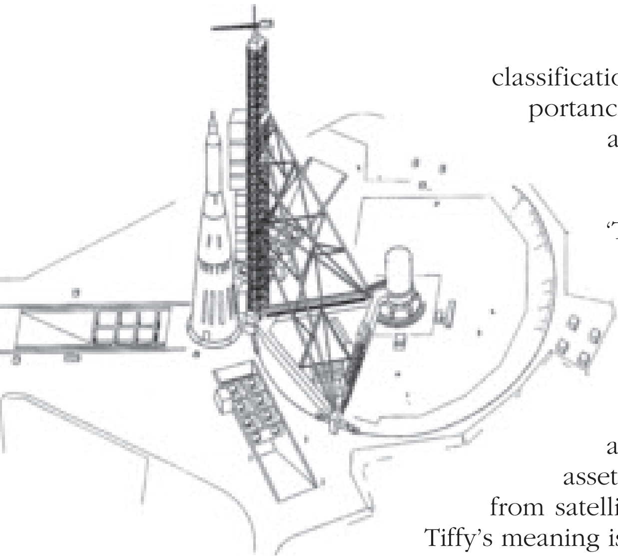


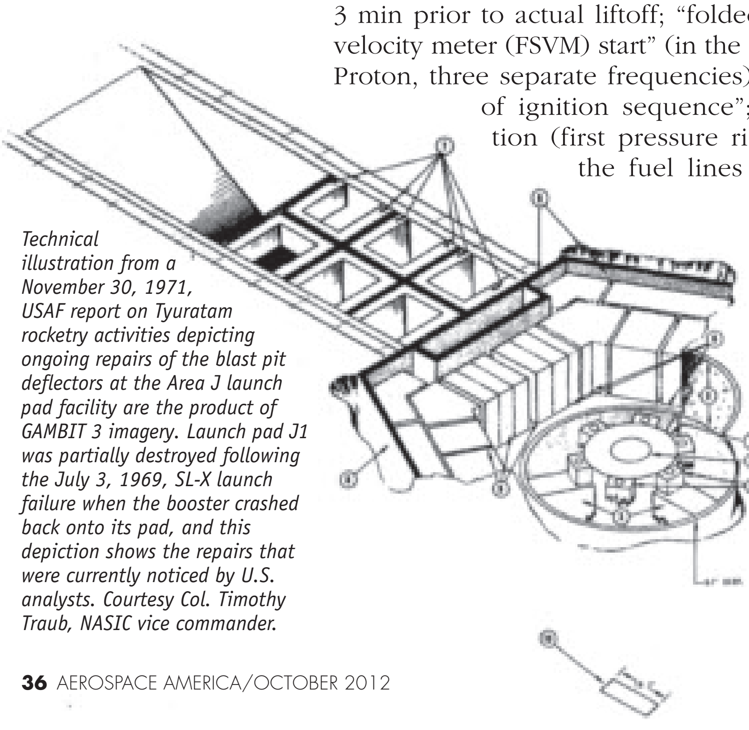
Illustration from a February 1969 "Basic Imagery Interpretation Report" recently released by NASIC, that is the product of GAMBIT 3 imagery. The drawing depicts the SL-X and its "Complex J" launch pad environs, which included a service tower over 470 ft tall. Of additional special note are the depicted exterior fuel line fairings on the first stage, as well as the second, of the vehicle. Courtesy Col. Timothy Traub, NASIC vice commander.

classification levels reflect the importance of the NSA's intercept activities to the entire U.S. intelligence community. These levels range from 'Top Secret Umbra' (Umbra is the codeword for SIGINT garnered from ground-based equipment) to 'Top Secret Tiffy Ruff Zarf Umbra.' (Zarf is code for SIGINT acquired via space-based assets; Ruff is for information from satellite photoreconnaissance; Tiffy's meaning is currently unknown.)

These reports disclose a breathtaking range of previously classified ELINT capabilities. Most of the documentation amply demonstrates how well the NSA was able to capture and identify Soviet launch activities with a hitherto unknown thoroughness. The meticulous technical detail includes the entire sequence leading to the liftoff of an interplanetary version of the Proton rocket. The data collection apparently began several minutes before launch and continued all the way through attainment of Earth orbit. The released details also reveal how exceptionally well U.S. analysts understood the inner workings of Soviet rockets, including their guidance and control systems.

A case in point is reportage dealing with the Luna 20 mission, Russia's second successful retrieval of lunar soil samples. The benchmark launch-sequence events for this space shot include "binary coded decimal timer start," begun approximately 3 min prior to actual liftoff; "folded scale velocity meter (FSVM) start" (in the case of Proton, three separate frequencies); "start of ignition sequence"; "ignition (first pressure rise)" of the fuel lines to the motors; "half thrust level achieved"; "full thrust and liftoff (FSVM slope change)"; "velocity program start [computer program to control ascent]"; "timer start [at the moment of liftoff]"; and six further telemetry benchmarks recorded prior to "first-stage MECO [main engine cutoff]". Subsequently, an additional 27 data points were chronicled, up through "fourth-stage MECO/payload separation." The timing of each step in the chronicled launch sequence is accurate to hundredths of a second.

A further wrinkle discovered in the NSA documents was that the Russians would regularly engage in the practice of "on-pad simulations" for lunar launches (which took place during the week or two prior to the actual liftoff), going through the entire set of mission milestones electronically, sometimes multiple times. It is worth noting that the NSA analysts could recognize the difference between the simulation and an actual mission event. In the case of Luna 20, the on-pad electronic simulation was conducted up through the fourth-stage separation and took place on February 2, 1971, 12 days before actual launch.



Technical illustration from a November 30, 1971, USAF report on Tyuratam rocketry activities depicting ongoing repairs of the blast pit deflectors at the Area J launch pad facility are the product of GAMBIT 3 imagery. Launch pad J1 was partially destroyed following the July 3, 1969, SL-X launch failure when the booster crashed back onto its pad, and this depiction shows the repairs that were currently noticed by U.S. analysts. Courtesy Col. Timothy Traub, NASIC vice commander.

Scrupulous precision

Declassified NSA documentation further accentuates the high precision and scrupulousness of ELINT monitoring, which continued all the way through a lunar mission to the flight's intended end point (for example, the Moon). Benchmark events such as enroute course-correction burns and burns in lunar space are recorded to the second; velocity changes are recorded to the fourth decimal place. Orbital parameters (apolune and perilune) are recorded to a tenth of a kilometer.

NSA capabilities were especially showcased when a Soviet craft failed to achieve its objectives. When that happened, a near-complete dearth of subsequent information releases by official Soviet media outlets was usually the norm. One NSA report series concerns the Luna 18, a lunar soil sample return attempt that crashed on the Moon in September 1971. This report highlights how extensive NSA's capabilities were in the face of a Soviet information vacuum.

In one document, in a section entitled "Orbital Adjustments," there are indications that NSA analysts had been applying a site-specific computer algorithm that allowed precise tracking of the Luna 18 spacecraft, apparently with numbers 'plugged in' from the Russian telemetry data. It also allowed for the possibility that NSA listening posts could communicate directly with the spacecraft itself:

"The first of two orbital adjustment maneuvers was made on 9 September during the 27th lunar revolution. The spacecraft was occulted during the maneuver, precluding determination of the exact burn time, but vehicle programming indicates that it occurred at about 0323Z. This adjustment increased the orbital period approximately 3 ½ minutes in order to align the final lunar orbit with the selected landing site. The burn was simulated by applying an instantaneous thrust acceleration of 16.76 meters/second….

"The second orbital maneuver, also occulted, was made during revolution 40 on 10 September. Although vehicle programming indicated that the maneuver burn may have occurred at 0736Z, optimum analytic results were achieved by using a simulation burn time of 0748Z. The purpose of this maneuver was to lower the perilune to the point where it occurred coincident with the intended landing time and site. This decreased the magnitude of the final landing burn and possibly increased its accuracy. Making the adjustment approximately 24 hours before landing allowed time to compute accurate final-orbit parameters and to program the landing. The second orbital adjustment burn was simulated by applying an instantaneous thrust deceleration of 30.66456 meters/second at 0748Z. The resultant orbital parameters were: apolune 104.2 km; perilune, 33.5 km; and period 114.9 minutes."

Furthermore, even though it is now commonly known that Luna 18 crashed in its landing attempt, the NSA contemporaneously knew what happened, and how it happened. New information was disclosed by the NSA report on the spacecraft's final moments:

"Luna 18 began its descent to the Moon's surface on 11 September during lunar revolution 53….Although the second ignition occurred unusually early and shortened the normal coast period, this in itself should not have caused a crash. The coast period was sufficiently long to have allowed the automatic-landing system to supersede the earlier programmed phase. Luna 18 crashed approximately 6 seconds after second ignition, while still under full thrust…. The crash location was in a 'terrae' region of the Moon, an area rougher than the 'mare' landing site of Luna 16. Therefore, an unexpected topographical feature was most probably the cause of the crash."

In a subsequent report issued in 1972 about the Luna series landing sites on the Moon, new information about the location of the impact point of Luna 18's attempted soft landing was revealed: "The landing site of Luna 20 is very near that of Luna 18 which crashed to the surface at 03-43N, 056-30E on 11 September 1971. Luna 18, which probably had a soil sample return mission, was the first Soviet spacecraft to attempt a landing in mountainous lurain, but was apparently unable to cope with rapidly changing elevations of the lunar surface."

However, this newly disclosed NSA-sourced crash point clashes with the coordinates previously released—by both Russian space officials and NPO Lavochkin, manufacturer of the spacecraft—as 03-34N, 056-30E. To date, amateur astronomers using the official Russian location data have been unable to find Luna 18's crash site via NASA's photographic archives from its Lunar Reconnaissance Orbiter program.

High-level interest

Declassified documentation also reveals that the unmanned Luna series at times caught the attention of top U.S. policymakers, including the president. Especially noteworthy is a July 21, 1969, memorandum about Luna 15, a space shot the Russians now admit was the first attempt to acquire a lunar soil sample. At the time of this memo (originally classified 'Secret—Sensitive'), the Apollo 11 manned Moon-landing flight was in progress. In this brief communication, National Security Advisor Henry Kissinger tells President Richard Nixon, "SIGINT has revealed that the attempted soft landing of Luna 15 this morning was a failure. Signals from the spacecraft ceased just prior to touchdown indicating a hard landing. Attempts to activate the craft failed."

Of great interest to space historians are the revelations that the U.S. intelligence community knew contemporaneously that Luna 15 was planned to soft-land, as well as the previously undisclosed fact that the Soviets later attempted, more than once, to revive the crashed craft. Such facts constitute additional evidence of how well, and to what extent, U.S. intelligence community assets were employed to provide accurate, up-to-the-minute coverage of Soviet space activities that interested U.S. policymakers during the space race.

High stakes

Crewmembers of the ISS and the 135th space shuttle mission form a circle in the station's Kibo laboratory.

for human-rating spacecraft

In turning to private industry for human spaceflight systems, NASA faces a critical challenge: Devise flexible human-rating requirements for the commercial rockets that will launch astronauts into LEO and for the crew capsules that will carry them to the ISS and back to Earth. Certification standards for human spaceflight must be stiff enough to ensure the safety of the astronauts throughout their missions—notably flights to the ISS—while giving contractors enough leeway to control costs and to be creative in designing their spacecraft.

The future of commercial space may well be at stake. As NASA inspector general Paul K. Martin told Congress late last year, how NASA responds to the challenge "will to a large degree determine whether the nascent commercial space transportation industry evolves into a viable commercial enterprise that meets NASA's crew transportation needs."

The viability of the commercial spaceflight industry depends on ensuring the safety of human crews on privately developed launch vehicles and crew capsules. The challenge for NASA will be to develop stringent enough requirements for human-rating these spacecraft while still allowing sufficient freedom for innovative and economical vehicle designs. Successful cooperation between the agency and its contractors will be a delicate balancing act.

Critical choices

NASA developed human-rating requirements years ago for the contractor-built space vehicles it owned. Those standards are the result of more than a half-century of experience with manned spacecraft, from Mercury to the space shuttle. Now the agency is working with companies in the second phase of its Commercial Crew Development program (CCDev2) to determine, on a case-by-case basis, which of its basic human-rating requirements can be eased or otherwise modified to accommodate the entrepreneurial imperatives of its contractors.

NASA will leave nothing to chance, its officials insist. William Gerstenmaier, associate administrator for human exploration and operations, told Congress late last year that his agency will give its contractors "more freedom to pursue cost effectiveness," but will maintain "stringent safety requirements and standards."

"We are establishing the performance and safety requirements, and we are telling the companies they can make their own design choices; but they have to meet those requirements," declares Brent W. Jett, deputy program manager of the agency's commercial crew program at NASA Johnson. "We are allowing [the companies] to come in with standards they have used or are currently using. We will review them and decide whether to substitute their standards in place of ours."

NASA's standards are specified in its basic human-rating document, most recently updated in 2011 as NPR 8705.2B. "A human-rated system accommodates human needs, effectively utilizes human capabilities, controls hazards with sufficient certainty to be considered safe for human operations, and provides, to the maximum extent practical, the capability to recover the crew from hazardous situations," it states.

Firm but not rigid

NASA and industry officials note that the fundamental technologies of launch vehicles and capsules are well understood. "Developing crew transportation systems to achieve LEO does not require any significant technological breakthroughs," Gerstenmaier testified. This is a key factor in NASA's approach to oversight of the companies' programs, he said.

Human rating is defined by NASA as "the process of designing, evaluating, and assuring that the total system can safely conduct the required human missions."

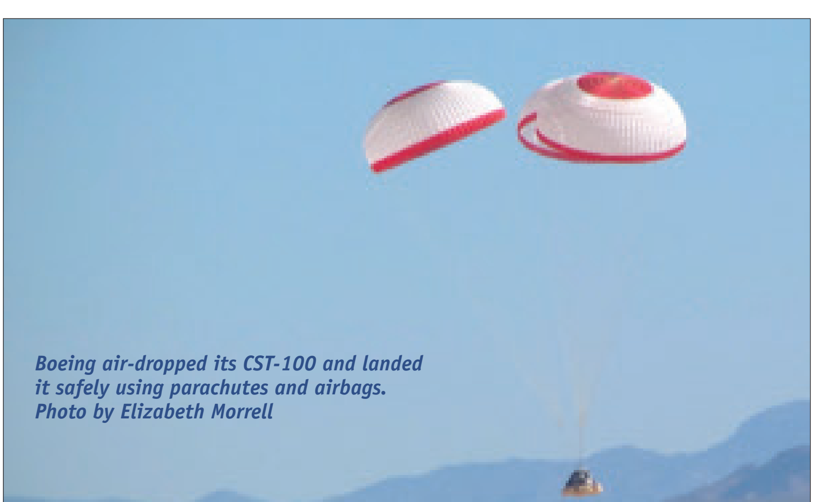
by James W. Canan
Contributing writer

Sierra Nevada flew its winged Dream Chaser capsule for the first time in a captive-carry test earlier this year. Photo by Eric Cain.

This includes incorporating design features and capabilities that accommodate human interaction with the system to make it safe and its mission a success, and to enable safe recovery of the crew from perilous situations. Moreover, human rating is "an integral part of all program activities throughout the life cycle of the system," which includes design and development, test and verification, program management and control, flight readiness certification, and mission operations, the NASA document notes.

Companies taking part in the CCDev program must meet these fundamental requirements but do not always have to toe the line. Jett says the traditional, accepted ways of designing and building spacecraft "are not the only ways to get to a system that is safe and reliable." He says some of the commercial spaceflight companies "are pushing those accepted practices a little bit, but that doesn't mean what they are doing is wrong; it only means that we have to be sure that we understand how to handle it."

Last year, NASA issued its CCT (Commercial Crew Transportation)-1100 series of documents, including some 300 technical and other requirements for its competing CCDev2 companies. All conceivable aspects of crew safety are covered, "from ground processing and providing a crew with optimal breathing air and life support systems to ensuring the reliability of a spacecraft's windows and computer circuit boards," a NASA paper explains. It also notes that because each commercial design is so different from the others, NASA "could not possibly have developed a set of requirements that detailed every nut and bolt like the thousands of requirements for the shuttle."



Boeing air-dropped its CST-100 and landed it safely using parachutes and airbags. Photo by Elizabeth Morrell

Blue Origin, Boeing, Sierra Nevada, and SpaceX were being funded under Space Act Agreements (SAA) to develop commercial crew vehicles. Alliant Techsystems (ATK), United Launch Alliance (ULA), and Excalibur Almaz were also involved in the CCDev program under SAAs, but without NASA funding.

On August 3, NASA announced new SAAs with Boeing, SpaceX, and Sierra Nevada to move forward in designing and developing spacecraft for LEO missions to the ISS in the next five years. The agreements are part of the CCiCAP (Commercial Crew Integrated Capability) initiative under the agency's Commercial Crew Program (CCP). These companies will continue with the development, testing, and maturation of their space systems until May 31, 2014, in preparation for launching crewed demonstration missions to LEO by the middle of this decade, NASA said.

Coping and complying

By all accounts, NASA and its contractors believe that compliance with the human-rating standards will not pose any insurmountable problems. The companies say they are harmonizing with NASA. SpaceX, for example, says its Dragon crew capsule and Falcon 9 launch vehicle were designed from the start with NASA human-rating requirements in mind.

Sierra Nevada has worked closely for more than five years with NASA Langley in developing the company's Dream Chaser crewed transportation system, which is derived from the HL-20 crewed system that NASA developed years ago. Earlier this year, the company flew its winged Dream Chaser capsule for the first time in a captive-carry test, prelude to a future drop test from a heavy-lift helicopter.

Also this year, Boeing, in partnership with Bigelow Aerospace, air-dropped from a helicopter its CST-100 capsule, resembling but slightly wider than the Apollo capsule, and landed it safely on a lake bed using parachutes and airbags. The capsule's ablative heat shield, the attitude control engines that maneuver the vehicle in space, and the Bantam launch-abort engine also passed key tests.

Bantam, built by Pratt & Whitney Rocketdyne, is designed to separate the CST-100 from the main rocket, much like an aircraft ejection seat, in the event of an emergency during launch. Bantam achieved full thrust while validating its performance in key operating conditions during engine startup and shutdown, says Rocketdyne.

John Elbon, director of Boeing's civil space programs, told Congress late last year that the company designed its system to be "as uncomplicated as practical to improve reliability and safety and to enable low operations costs." It also incorporates as much off-the-shelf, proven technology as possible to lower risks, keep operational costs down, and stay on schedule, he says.

Last spring Blue Origin reported the successful completion of high-speed wind tunnel testing that validated the aerodynamic design of its space vehicle. The craft has a unique biconic shape resembling two cones joined at the base. The company was slated to begin testing the pusher-type launch abort system late this summer, with emphasis on controlling the flight path of a subscale crew capsule by means of a thrust-vectoring propulsion system.

In July, ATK marked the final milestone in development of its Liberty system for transporting crews to the ISS: completion of a program status review. This covered all system requirements as well as system safety review, software status, flight test plan, ground processing certification plan, and schedule for initial operation capability. ATK describes its Liberty as "a complete commercial crew space system that includes a composite spacecraft, abort system, launch vehicle, and ground and mission operations, all of which were designed from inception to meet NASA's human-rating requirements."

The first stage of the two-stage Liberty is a five-segment solid-rocket booster derived from the shuttle and Constellation programs. The second stage has achieved 46 consecutive launches since 2003 as the core of ESA's Ariane V launch vehicle, said ATK's program manager Charlie Precourt when he testified before Congress last year.

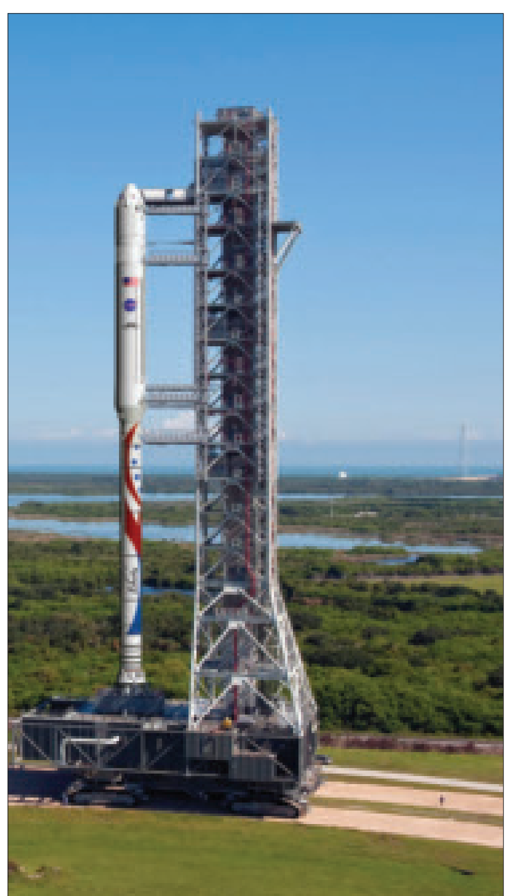
Dragon's progress

The most dramatic development thus far falls to SpaceX. Last May, in a widely acclaimed accomplishment for the commercial space program, SpaceX launched a cargo-carrying Dragon capsule to the ISS on the company's Falcon 9 rocket, berthed it at the station for six days, and brought it safely back to splashdown in the Pacific using drogue parachutes. This completed the demonstration phase of the company's commercial orbital transportation services agreement with NASA. That Dragon spacecraft was designed primarily to transport cargo to the space station, which it did, and reportedly met at least 80% of NASA's human rating requirements, including windows and enough of an ecosystem to let astronauts enter and move around while transferring cargo to the ISS.

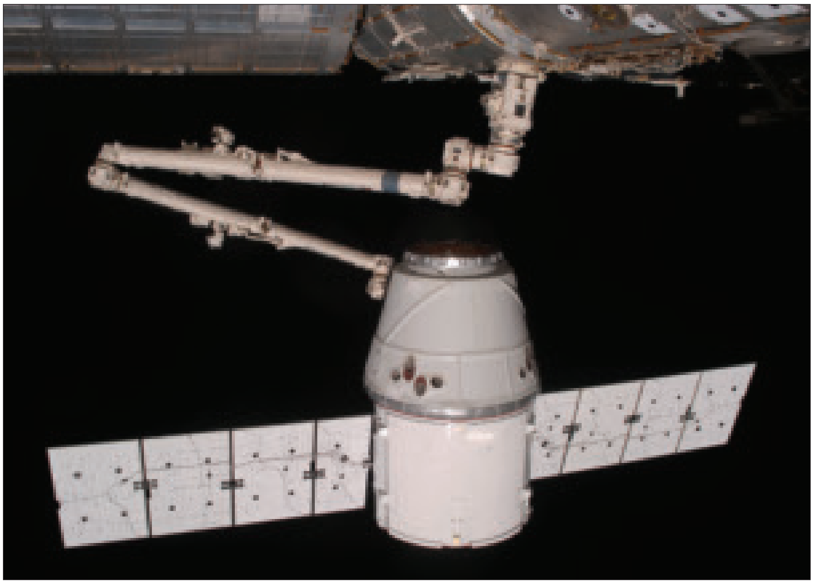
But Dragon will have to be modified in several important respects to carry astronauts. Among other things, it needs seats, a control panel, and enhanced environmental controls, says a company spokesman. It must also be equipped with an automated crew abort-and-escape system that works from the launch pad all the way to orbit. The crew-carrying Falcon 9 rocket must ascend on a 'soft' trajectory slanted enough to enable the crew to survive an abort, and to merit NASA human-rating certification.

Early this year, SpaceX successfully test-fired its SuperDraco, an advanced ver-

Blue Origins' crew capsule is a composite structure.



The first stage of ATK's two-stage Liberty is derived from the shuttle program; the second stage has achieved 46 consecutive launches as the core of the Ariane V.



Last May, Dragon berthed at the ISS for six days before safely splashing down in the Pacific Ocean.

sion of the Draco engines currently powering Dragon. Eight SuperDraco engines built into the side walls of Dragon will give the crewed capsule enough axial thrust to free itself from the launch vehicle and fly safely back into the atmosphere and down to Earth. This contrasts with traditional abort systems featuring solid-rocket escape towers jettisoned from crew capsules.

At the end of July, SpaceX announced completion of safety and operational design review requirements set forth in its CCDev2 agreement with NASA, and said it had fulfilled nine of 10 NASA requirements for its launch abort system. This prompted Ed Mango, manager of NASA's commercial crew program, to note that "SpaceX has made significant progress on its crew transportation capabilities."

Setting high standards

By and large, the companies in CCDev2 claim to have set high human-rating standards for themselves in conjunction with those of NASA. Last March, Col. Jim Voss, Sierra Nevada's director of advanced programs, and Garrett Reisman, CCDev2 project manager for SpaceX, jointly reassured members of Congress in writing that the commercial space industry is at pains "to ensure that the vehicles we are developing in cooperation with NASA will be the safest ever to fly." Their engineering teams feature members with "many years of experience in developing safe and reliable vehicles, at NASA and in the private sector. Tapping that experience, we have established stringent internal controls to ensure we meet both NASA's safety requirements and our own," they wrote.

"We believe that immediate development of safe and reliable access to the Space Station is a national priority and an important safety issue, as we are currently reliant on the Russian Soyuz, a single point of failure that puts the Space Station at risk," Voss and Reisman wrote.

Jett emphasizes that human-rating of a space system is pegged to its particular mission. For example, launch vehicles must have enough thrust in all stages to boost astronauts into the specific orbit or on the specific trajectory that the mission demands without compromising their safety and well-being aboard. This is why the Falcon 9 and the Atlas V and Delta IV EELVs can be modified to carry astronauts to the ISS, but would not suffice for manned missions into deep space, a task requiring a so-called heavy-lift vehicle of the kind that NASA and SpaceX have in mind.

Reviews and modifications

Human-rating requirements focus largely on rocket and capsule structures, including fuel tank walls, pressure vessel walls, and pressurized lines, on redundancy of power systems and control systems, on abort systems, and on mission-related measures such as constraining and accommodating the *g* forces of the ascent and reentry trajectories. Abort systems claim major attention in the human rating process.

SpaceX will launch its Dragon crew capsule atop a Falcon 9 rocket, which was designed to ascend on a slanted trajectory. This will enable Dragon to reenter the atmosphere more or less gradually should its astronauts have to abort. As of now, Blue Origin, Sierra Nevada, and Boeing plan to vault their crew capsules into space atop ULA's Atlas V rocket and on trajectories

Earlier this year, SpaceX successfully test-fired its SuperDraco engine.

conducive to safe aborts on ascent. Those three companies and ATK are developing systems for orbital missions; the others are designing systems for suborbital flights. Boeing's capsule will also be compatible with the SpaceX Falcon 9.

Atlas V has long been a NASA mainstay in launching satellites and spacecraft for robotic missions, including the Curiosity Mars rover and the Juno probe to Jupiter. To meet NASA human-rating standards for Atlas V, the three-stage rocket's launch pad must be modified to enable astronauts to board the spacecraft, its upper stage must be powered by two Centaur engines instead of one, and its flight computers must be programmed to take it on a trajectory that will induce *g* forces the crew can tolerate. The rocket also needs additional sensors to detect emergency situations for the crew, NASA says.

Last July, ULA completed a systems requirements review of Atlas V in partnership with NASA and with Blue Origin, Boeing, and Sierra Nevada, whose capsules the rocket may carry. The purpose was to determine which human-rating requirements the Atlas V already meets and "to define what we need to do from here to certify the rocket for human spaceflight," says George Sowers, ULA's vice president for human launch services.

"Our partnership with ULA during this round of development has really been focused on understanding the core design of the launch vehicle," NASA's Mango explains. "In these reviews, we were able to see how ULA plans to modify the vehicle for human spaceflight."

NASA's basic human-rating requirements document notes that in the past, three crewed launch vehicles—the shuttle and two Soyuz spacecraft—suffered catastrophic failures during launch or on the launch pad, and that both Soyuz crews survived their failures "due to a robust ascent abort system." The private sector space systems must therefore enable crews to abort anytime and anywhere, from the launch pad to Earth-orbit insertion, if their spacecraft loses thrust or flight-path control. Crews must also be equipped to monitor launch vehicle performance at all times and to automatically initiate an abort in the event of catastrophic failure. Moreover, "the space system shall provide the capability for the ground control to initiate the Earth ascent abort sequence," the document says.

Manual options

A key section of the NASA human-rating document asserts that a crewed space system "shall provide the capability for the crew to manually control the flight path and attitude of their spacecraft," except during ascent through the atmosphere "when structural and thermal margins…negate the benefits of manual control."

Enabling the crew to control the spacecraft's flight path "is a fundamental element of crew survival," the NASA paper says. "Manual control means that the crew can bypass the automated guidance of the vehicle to interface directly with the flight control system" in order to choose any flight path within the system's capability, it says.

The document also specifies that "the crewed space system shall provide the capability for unassisted crew emergency egress after Earth landing" and "a safe-haven capability for the crew inside the spacecraft after Earth landing until the arrival of the landing recovery team or rescue forces." Crew safety is a function of emergency systems and equipment, such as fire suppression systems, fire extinguishers, emergency breathing masks, and launch-and-entry pressure suits, the paper points out.

Falcon 9 is the launch vehicle for both the the cargo and crew capsules.

Surviving varied environments

In the human-rating process, "there is a lot of attention paid to the launch and to getting safely into orbit," Jett explains. "We have quite a bit of experience in launching

FAA safety oversight

In keeping with National Space Policy, NASA and the FAA "have complementary and interdependent interests in ensuring that commercially developed human-rated systems and vehicles for LEO are effective and safe," both agencies noted in a joint memorandum of understanding (MOU) issued last June. The MOU supports their mutual oversight of commercial space transportation of government and non-government passengers to LEO "in a manner that avoids conflicting [safety] requirements and multiple sets of standards."

The FAA is responsible for regulatory oversight and licensing of private companies and individuals involved in commercial space transportation. An FAA license is required for any launch or reentry, or for the operation of any launch or reentry site, by U.S. citizens anywhere in the world.

The MOU's statement of intent also says: "NASA intends that all launches supporting ISS crew transportation services will be licensed by the FAA for public safety and wishes to work with FAA to reach a common understanding and approach for meeting that objective."

NASA is responsible for certifying the safety of the launch vehicles and capsules that carry its crews. The FAA is responsible for judging whether all public safety requirements are met in the launch and reentry of the commercial space systems and their passage through the National Airspace System. An FAA license is not required for government-only space activities such as those carried out by NASA and DOD.

The FAA is expected to begin proposing safety regulations for commercial spaceflight by the end of this year. The FAA and NASA are colocating personnel at NASA headquarters, FAA field offices, and the Johnson and Kennedy Space Centers to facilitate their cooperative oversight of commercial spaceflight safety.

Blue Origin, Sierra Nevada, and Boeing plan to use the Atlas V, although the CST-100 will also be compatible with the Falcon 9.

spacecraft. We don't have as much experience in bringing people and things back through the atmosphere at the end of a mission, especially a long mission in which the vehicle is on orbit for 180 days, exposed to micrometeorites, and goes through the thermal cycles in the vacuum of space. I'm concerned just as much, if not more, about the entry part of the mission. We understand what has to be done on entry, but we just don't have as much experience with it as we do with launching."

Jett notes that a key element in NASA certification of crewed spacecraft is determining the full range of environments in which they will fly. For example, he says, if a crew capsule stays on station in space for six months, it will experience a wide range of thermal conditions in varying degrees of exposure to sunlight. NASA must conclude that the vehicle can withstand all possible thermal exposures before certifying it for human occupancy.

The agency must also make sure that commercial crewed capsules will be capable of docking directly with the station, in contrast to the ISS captive-arm docking technique used by the Dragon. The crewed capsules must be capable of closing straight-on and most carefully with the ISS before docking, a technique that makes greater demands on flight control software.

Integration and testing

Withal, the overall objective of the human-rating process is to arrive at the safest practical design to accomplish a mission, the NASA document emphasizes. "Since space system development will always have mass, volume, schedule, and cost constraints, choosing where and how to apply failure tolerance requires integrated analysis at the system level to assess safety and mission risks," says the paper.

Failure tolerance is a term frequently used to describe minimum acceptable redundancy, it says, and "since redundancy does not, by itself, make a system safe, it is the responsibility of the engineering and safety teams to determine the design that optimizes safety given the mission requirements and constraints."

NASA's human-rating-cum-certification process in CCDev2 is pegged in large part to the results of ground and flight tests of the space vehicles involved. The testing regime features such vital elements as abort systems, docking systems, ecosystems, and, finally, the vehicles themselves.

Flight test programs are used "to validate the integrated performance of the space system hardware, software, and, for crewed test flights, the human in the operational fight environment," NASA's basic human-rating document explains. Flight tests also are aimed at validating the analytical models that are used "to confidently predict the performance of the space systems at the edges of the operational envelopes, and to predict the margins of the critical design parameters."

To minimize risk to flight-test crews, "it is preferred that an unmanned flight test be conducted prior to a manned flight," but this "may not be feasible for all phases of flight and may not be necessary for some systems," NASA notes.

Cooperation and balance

NASA and its contractors are committed to working together in deciding what is necessary and what is feasible. Effective government/industry cooperation is the key to deciding this. It is also the key to the success of the commercial spaceflight enterprise at large.

As Gerstenmaier told Congress, the challenge lies in "balancing the need for NASA involvement in order to obtain a safe and reliable system, and allowing the providers the freedom to seek innovative and cost-effective solutions. Striking the right balance will be the key to successful and timely delivery of the crew transportation systems."

(Continued from page 25)

on the flight test model carried on the Cessna O-2 testbed the most unstable wavelength is 4.5 mm. Testing at Mach 1.85 with an F-15B had a 4-mm most unstable wave.

"My guess, if we had to make a transport wing, is that the most unstable wave would be in the 6-8-mm range," says Saric. The 'magic number' of the wave needed to interfere with the most unstable wave would be from half to two-thirds of the most unstable wavelength, so the distance between the centers of the DREs would be from 3.5 mm to 4 mm.

Different kinds of DREs

To date the only DRE shape tested has been a circle. However, Saric says Russian research has suggested a rectangular shape with rounded corners might be even more effective, the DRE extending in the direction of the airstream over the wing and its diameter being from one-quarter to one-third of the most unstable crossflow wavelength.

For some experiments, the Texas A&M researchers have used DREs stuck on the airfoil surface as an appliqué from a specially printed transfer sheet. In other tests, they experimented with pneumatic roughness elements, stretching membranes over tiny holes in the airfoil and applying pneumatic pressure from within. One advantage of using pneumatic elements was that the scientists could easily vary the height of the elements to determine the best height for disrupting the unstable interference wave.

The team also applied vacuum to create dimples in the membranes over the holes, producing a surface that looked rather like that of a golf ball. They found that the two other approaches "seemed to work as well as the appliqué," says Saric. On production aircraft, anodized aluminum DREs might be the most practical solution, he believes.

One disadvantage of DREs is that their positions are fixed, and a given DRE spacing is designed for a particular flight condition. As Saric notes, a widebody aircraft on a long-haul flight will start off fully loaded and flying at a particular altitude and angle of attack. However, as it burns off fuel, it has to bleed off lift by changing altitude or changing its angle of attack, so its flight condition changes. In changing flight conditions, DREs can be of only limited use.

DBDP jets

In respose to this, the Flight Research Laboratory is building on work initially performed in 2001-2002 with tiny solid-state dielectric barrier discharge plasma (DBDP) elements mounted in or near the wing leading edge. Each DBDP sends current between its conductor and dielectric element to create jets of air parallel or perpendicular to the direction of travel, to mimic DREs.

Together with Lockheed Martin, Saric's team is working to develop and test plasma actuators that can be set in an array along a wing. Different actuators in the array could be activated during different flight conditions, so that the spacing of active DBDPs could be changed in order to suppress crossflow interference waves of different wavelengths.

During DBDP development, the team used a technique called microparticle image velocimetry to trace the trajectories of the particles within each jet and thus derive a velocity vector for it. This technique produced "some really interesting results" that "gave us an idea for a different design for the plasma actuators," Saric says.

The Flight Research Laboratory plans to continue its joint research with Lockheed Martin on using DBDPs to achieve laminar flow control, says Saric, "probably beginning this fall," and, he hopes, with AFRL backing. The work "would encompass wind tunnel tests, flight tests, and detailed lab measurements and computations of what these things are doing."

NASA ERA-supported work continues with a laminar flow wing glove, using an appliqué, on a Gulfstream III. In this way, flow parameters approaching transport conditions will be achieved and the technical readiness level of the DREs will be raised. These flights are scheduled for 2014.

Chris Kjelgaard
cjkjelgaard@gmail.com

Out of the

25 Years Ago, October 1987

Oct. 30 President Ronald Reagan signs into law a bill that provides NASA with funding of $9.6 billion for the ISS. *Astronautics and Aeronautics, 1986-1990*, p. 135.

50 Years Ago, October 1962

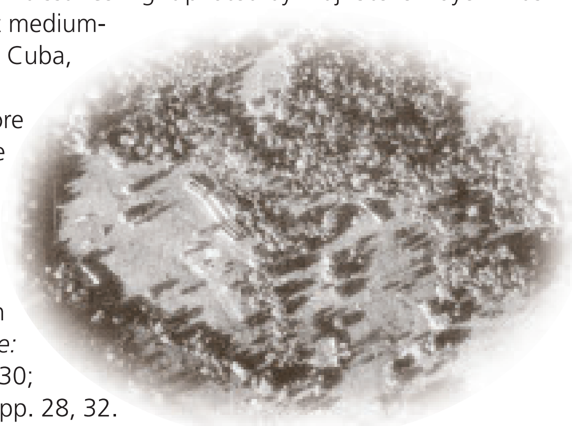
Oct. 2 A Thor-Delta rocket successfully launches the 89-lb octagonal Explorer 13, designed to investigate energetic particles in space and gather information on the profile of Earth's magnetic field. This is also the first launch of the uprated 168,000-lb-thrust DM-21 engine for the Delta. *Aviation Week*, Oct. 8, 1962, p. 32; *Astronautics*, November 1962, p. 175.

Oct. 3 Navy Cmdr. Walter M. Schirra is launched into orbit in his Mercury Sigma 7 space capsule by a Mercury-Atlas (MA-8) rocket from Cape Canaveral, Fla. After achieving nearly six orbits he lands safely in the Pacific 275 mi. northeast of Midway Island. He is recovered by helicopter crews and his capsule is hoisted aboard the USS Kearsarge. *United States Naval Aviation 1910-1980*, p. 247; *Aviation Week*, Oct. 8, 1962, pp. 26-30, and Oct. 15, 1962, pp. 28-29.

Oct. 5 NASA awards a contract to United Aircraft's Hamilton Standard Division and International Latex to develop the Apollo spacesuit. Latex will fabricate the suit while Hamilton Standard heads the overall program and develops the backpack or life-support system that the astronauts will wear during lunar explorations. *Aviation Week*, Oct. 22, 1962, p. 33.

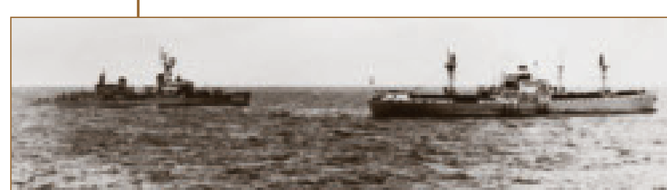
Oct. 5 The first full-flight-duration static test firing of S-IV stage engines is made at the Sacramento, Calif., test facility of Douglas Aircraft. S-IV in its present configuration consists of six Pratt & Whitney RL-10 engines, which fired for a full 7 min. *Missiles and Rockets*, Oct. 15, 1962, p. 11.

Oct. 14 An Air Force U-2 reconnaissance flight piloted by Maj. Steve Hoyer finds indisputable evidence of Soviet medium-range ballistic missiles based in Cuba, marking the beginning of the Cuban missile crisis. Several more U-2 missions are flown over the island nation to monitor the missiles' movements. Other U.S. aircraft find Soviet Ilyushin IL-28 Beagle bombers and additional planes at Cuban airfields. D. Daso, *U.S. Air Force: A Complete History*, pp. 429-430; *Aviation Week*, Oct. 29, 1962, pp. 28, 32.



Oct. 18 An Atlas Agena B launches the Ranger 5 lunar spacecraft from the Atlantic Missile Range at Cape Canaveral, Fla. However, a malfunction in the solar cell battery power loop causes the power to be depleted about 8 hr into the launch. The craft subsequently passes the Moon at an altitude of 450 mi., then goes into a solar orbit. The Ranger was to have deployed a seismometer on the surface of the Moon. *Aviation Week*, Oct. 29, 1962, pp. 38-39.

Oct. 24 U.S. ships of the blockading force are in position at sea in accordance with President John F. Kennedy's Oct. 22 order to quarantine Cuba as a result of the missile crisis. The force includes the attack carriers Enterprise and Independence, the antisubmarine carriers Essex and Randolph, and shore-based aircraft carriers that are to conduct air patrols in their assigned sectors. Strategic Air



Command forces and U.S. missile sites are also placed on high alert, while reconnaissance bombers and tankers join the Navy in their search for incoming shipping to Cuba. *United States Naval Aviation 1910-1980*, p. 247; D. Daso, *U.S. Air Force: A Complete History*, p. 430.

Oct. 27 Maj. Rudolph A. Anderson Jr. is fatally shot down as he pilots a U-2 over Cuba. For his mission he is posthumously awarded the Air Force Cross. D. Daso, *U.S. Air Force: A Complete History*, p. 430.

Oct. 28 The USSR agrees to remove its missiles from Cuba; the U.S. will move its own missiles stationed in Turkey. On the following day, USAF

Past

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

reconnaissance Voodoo aircraft confirm the Soviets' dismantling of their missiles. D. Daso, *U.S. Air Force: A Complete History*, p. 430.

And During October 1962

—Trans World Airlines conducts the first flight using Doppler radar rather than a professional navigator to maintain a course. The Boeing 707-320 carries 115 passengers and 11 crewmembers on the New York-to-London flight. *Aviation Week*, Oct. 8, 1962, p. 45.

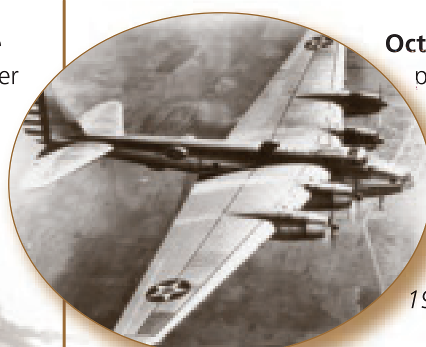
—The Boeing Vertol CH-46A Sea Knight medium assault helicopter makes its first official flight at Philadelphia. The helicopter is made for the Marine Corps. *Aviation Week*, Oct. 22, 1962, p. 30.

75 Years Ago, October 1937

Oct. 2 The Second International Aeronautical Exposition opens in Milan, attracting 422 exhibitors from 16 countries. This is the first time Germans participate in a foreign aeronautical show officially, under the auspices of the German air ministry. *Aero Digest*, December 1937, p. 108.

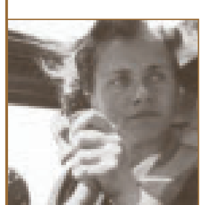
Oct. 3 Maj. B.F.S. Baden-Powell, the British aviation pioneer, dies at 77. A member of the Royal Aeronautical Society since 1880, he was later elected as its president. Baden-Powell joined the army in 1882 and in 1894 was attached to the army's balloon company at Aldershot. He retired from the army in 1904 and devoted himself to promoting aeronautics. *The Aeroplane*, Oct. 13, 1937, p. 438.

Oct. 8 Spenser Douglas Adair Grey, one of Britain's naval aviation pioneers, dies. Grey learned to fly on a Farman biplane and received Aerial Certificate No. 117 in 1911. He then bought a Blackburn monoplane and flew it around the country, a practice considered too 'spectacular to be proper for an officer and gentleman of the King's Navy.' He helped introduce Sopwith biplanes into the Naval Wing and pioneered the use of amphibian biplanes in England. Grey also flew with Winston Churchill when, as First Lord of the Admiralty, Churchill officially formed the Royal Naval Air Service in 1914. In 1916 Grey commanded a Naval Air Wing at Dunkirk and later was lent to the U.S. Naval Air Service. *The Aeroplane*, Oct. 20, 1937, pp. 469-470.



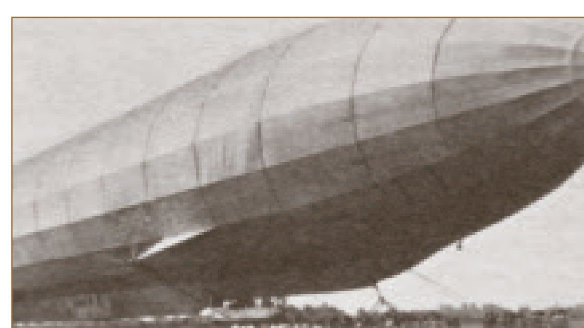
Oct. 15 The Boeing Model 294 (XB-15) heavy bomber prototype makes its maiden flight. Although only one is built, it contributes to the development of the B-29 Superfortress. Although not accepted for production, XB-15 does provide the wing for the Boeing 314 flying boat, which will open the first scheduled passenger service across the Atlantic in 1939. P. Bowers, *Boeing Aircraft Since 1916*, pp. 228-230.

Oct. 24 Jean Batten sets a new Australia-to-England solo flight record, clipping 14 hr 10 min from the previous mark. She flies her Percival Gull (Gipsy Six Series I engine) from Darwin, Australia, to England in 5 days 18 hr 15 min. *Aero Digest*, December 1937, p. 111.



Oct. 25 Well-known German aviatrix Hanna Reitsch flies a Focke-Wulf Fw 61 to a new world distance record for helicopters, 67.71 mi., between Bremen and Berlin. J. Smith and A. Kay, *German Aircraft of the Second World War*, p. 597.

100 Years Ago, October 1912



Oct. 7 In Germany, the Zeppelin LZ 14 is officially launched. The first rigid airship built for the Imperial German Navy, it is designated the L.1 as it enters service. A. van Hoorebeeck, *La Conquete de L'Air*, p. 97.

Oct. 24 Flying a Sopwith biplane, Harry Hawker wins the British Empire Michelin trophy by staying aloft for 8 hr 23 min. A. van Hoorebeeck, *La Conquete de L'Air*, p. 97.

THE AIAA SUGGESTION PROGRAM

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

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

AIAA

AIAA Bulletin

The Lockheed Martin tour group at the 48th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit.

OCTOBER 2012

AIAA Directory

AIAA HEADQUARTERS
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
www.aiaa.org

To join AIAA; to submit address changes, member inquiries, or renewals; to request journal fulfillment; or to register for an AIAA conference.
Customer Service: 800/639-AIAA†

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

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

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

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

Meeting Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
2012				
1–5 Oct	**63rd International Astronautical Congress**	Naples, Italy (Contact: www. iafastro.org)		
11–12 Oct†	**Aeroacoustic Installation Effects and Novel Aircraft Architectures**	Braunschweig, Germany (Contact: Cornelia Delfs, +49 531 295 2320, cornelia.delfs@dlr.de, www.win.tue.nl/ceas-asc)		
14–18 Oct†	**31st Digital Avionics Systems Conference**	Williamsburg, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)		
22–25 Oct†	**International Telemetering Conference**	San Diego, CA (Contact: Lena Moran, information@ telemetry.org, 575.415.5172, www.telemetry.org)		
5–8 Nov†	**27th Space Simulation Conference**	Annapolis, MD (Contact: Harold Fox, 847.981.0100, info@spacesimcon.org, www.spacesimcon.org)		
6–8 Nov†	**7th International Conference Supply on the Wings**	Frankfurt, Germany (Contact: Richard Degenhardt, +49 531 295 2232, Richard.degenhardt@dlr.de, www.airtec.aero)		
2013				
7–10 Jan	**51st AIAA Aerospace Sciences Meeting** **Including the New Horizons Forum and Aerospace Exposition** (Oct)	Dallas/Ft. Worth, TX	*Jan 12*	**5 Jun 12**
21–25 Jan†	**Annual Reliability and Maintainability Symposium (RAMS)**	Orlando, FL (Contact: Patrick M. Dallosta, 703.805.3119, Patrick.dallosta@dau.mil, www.rams.org)		
10–14 Feb†	**23rd AAS/AIAA Space Flight Mechanics Meeting**	Kauai, HI	*May 12*	**1 Oct 12**
2–9 Mar†	**2013 IEEE Aerospace Conference**	Big Sky, MT (Contact: David Woerner, 626.497.8451; dwoerner@ieee.org; www.aeroconf.org)		
19–20 Mar	**Congressional Visits Day**	Washington, DC (Contact Duane Hyland, duaneh@aiaa.org)		
25–28 Mar	**22nd AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar** **AIAA Balloon Systems Conference** **20th AIAA Lighter-Than-Air Systems Technology Conference**	Daytona Beach, FL	*May 12*	**5 Sep 12**
8–11 Apr	**54th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **21st AIAA/ASME/AHS Adaptive Structures Conference** **15th AIAA Non-Deterministic Approaches Conference** **14th AIAA Dynamic Specialist Conference** **14th AIAA Gossamer Systems Forum** **9th AIAA Multidisciplinary Design Optimization Conference**	Boston, MA	*Apr 12*	**5 Sep 12**
12–14 Apr†	**EuroGNC 2013, 2nd CEAS Specialist Conference on Guidance, Navigation and Control**	Delft, The Netherlands (Contact: Daniel Choukroun, d.choukroun@tudelft.nl, www.lr.tudelft.nl/EuroGNC2013)		
23–25 Apr†	**Integrated Communications Navigation and Surveillance 2013**	Herndon, VA (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.i-cns.org)		
27–29 May	**19th AIAA/CEAS Aeroacoustics Conference (34th AIAA Aeroacoustics Conference)**	Berlin, Germany	*Jul/Aug 12*	**31 Oct 12**
27–29 May†	**20th St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia (Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru)		
29–31 May†	**Requirements for UTC and Civil Timekeeping on Earth: A Colloquium Addressing a Continuous Time Standard**	Charlottesville, VA (Contact: Rob Seaman, 520.318.8248, info@futureofutc.org, http://futureofutc.org)		
6 Jun	**Aerospace Today ... and Tomorrow: Disruptive Innovation, A Value Proposition**	Williamsburg, VA (Contact: Merrie Scott: merries@aiaa.org)		
17–19 Jun†	**2013 American Control Conference**	Washington, DC (Contact: Santosh Devasia,devasia@ u.washington.edu,http://a2c2.org/conferences/acc2013)		
24–27 Jun	**43rd AIAA Fluid Dynamics Conference and Exhibit** **44th AIAA Plasmadynamics and Lasers Conference** **44th AIAA Thermophysics Conference** **31st AIAA Applied Aerodynamics Conference** **21st AIAA Computational Fluid Dynamics Conference** **5th AIAA Atmospheric and Space Environments Conference** **AIAA Ground Testing Conference**	San Diego, CA	*Jun 12*	**20 Nov 12**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
14–17 Jul	**49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit** **11th International Energy Conversion Engineering Conference (IECEC)**	San Jose, CA	*Jul/Aug 12*	**21 Nov 12**
14–18 Jul	**43rd International Conference on Environmental Systems (ICES)**	Vail, CO	*Jul/Aug 12*	**1 Nov 12**
11–15 Aug†	**AAS/AIAA Astrodynamics Specialist Conference**	Hilton Head Island, SC (Contact: Kathleen Howell, 765.494.5786, howell@purdue.edu, www.space-flight.org/docs/2013_astro/2013_astro.html)		
12–14 Aug	**AIAA Aviation 2013: Charting the Future of Flight Continuing the Legacy of the AIAA Aviation Technology, Integration, and Operations (ATIO) Conference and Featuring the 2013 International Powered Lift Conference (IPLC) and the 2013 Complex Aerospace Systems Exchange (CASE)**	Los Angeles, CA	*Oct 12*	**28 Feb 13**
19–22 Aug	**AIAA Guidance, Navigation, and Control Conference** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Modeling and Simulation Technologies Conference** **AIAA Infotech@Aerospace Conference**	Boston, MA	*Jul/Aug 12*	**31 Jan 13**
10–12 Sep	**AIAA SPACE 2013 Conference & Exposition**	San Diego, CA	*Sep 12*	**31 Jan 13**
6–10 Oct†	**32nd Digital Avionics Systems Conference**	Syracuse, NY (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)		

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

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

AIAA Courses and Training Program

DATE	COURSE	VENUE	LOCATION
2012			
3 Oct	**Space Radiation Environment**	Webinar	
10–11 Oct	**Introduction to Communication Satellite and their Subsystems**	Webinar	
17 Oct	**Overview of Missile Design and System Engineering**	Webinar	
7 Nov	**Flight Dynamics and Einstein's Covariance Principle**	Webinar	
14 Nov	**Risk Analysis and Management**	Webinar	
6 Dec	**Advanced Composite Materials and Structures**	Webinar	
5–6 Jan	**Specialist's Course on Flow Control**	ASM Conference	Grapevine, TX
5–6 Jan	**Six Degrees of Freedom Modeling of Missile and Aircraft Simulations**	ASM Conference	Grapevine, TX
5–6 Jan	**Systems Engineering Verification and Validation**	ASM Conference	Grapevine, TX

**Courses subject to change*

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

From the **Corner** Office

THE LESSONS OF *CURIOSITY*

Michael Griffin, AIAA President

The topic for this month's column is motivated by the hugely successful landing of the *Curiosity* rover on Mars in what appears to be perfect condition, at least as this is written.

This was a really hard thing to do. With our present level of technology, doing things in space is hard. Mars in particular is a really, really hard place at which to work effectively. To deliver a spacecraft to an atmospheric entry corridor at Mars requires the navigation engineers to work to a precision of better than one part in ten million, a tolerance found in very few fields of practice. Once there, entry is complicated by the fact that the Martian atmosphere is just thick enough to demand aggressive thermal protection measures, but not thick enough to be really effective in slowing the spacecraft to an easily accommodated touchdown velocity, as is possible on Earth. Once down, there is enough solar energy to complicate the thermal management of the rover, but not enough to provide a really useful amount of energy. The thin Mars wind blows fine-grained dust into every juncture of every moving part on the vehicle, and hugely alters the thermal properties of surface materials, again complicating the thermal management task. And, as we saw with *Curiosity's* predecessors, *Spirit* and *Opportunity*, it is easily possible to get stuck in the sand, thus demanding the cleverest possible mobility system design.

So, Mars is hard. Space is hard. In fact, most of the things we aerospace professionals do are hard. Even after more than a century of flight, building a new airplane to carry more people over greater distances more efficiently, cheaply, and safely than they have ever been carried before, is hard. Building a missile that can shoot down an incoming reentry vehicle, distinguishing it from a cloud of debris and potential decoys with only a few minutes of warning is terribly hard. Building a new telescope that can literally see back almost to the dawn of time is excruciatingly hard. Almost everything we do in aerospace is, in reality, just barely possible. We aerospace professionals have from the first been in the vanguard of those who have, in President Theodore Roosevelt's famous words about "the man in the arena", chosen a life of "striving valiantly" and risking failure "while daring greatly".

So what can we learn from the success of *Curiosity* that might merit deeper reflection, especially on those days—well known to many of us—when we are having to explain why a new idea or a new development didn't work out quite as well as we had hoped? A few thoughts come to mind.

I will first note that many who worked on the Mars Science Laboratory program were involved with it for a decade. To go beyond the successes of *Spirit* and *Opportunity*, to do more and better, required a new approach. It had to be conceived, studied, refined, improved, built and—most importantly of all—continually sold, to multiple administrations and Congresses. These features are common to most aerospace projects. The aerospace profession is simply not a place for those seeking instant gratification, or even the professional utility and satisfaction of working in an industry where the product life cycle is eighteen months or two years, as is the case for our engineering cousins in the incredibly dynamic consumer electronics industry. Aerospace projects, especially those which truly break new ground, require a constancy of purpose that seems particularly challenging for a pluralistic democracy. We as a profession have not yet figured out how to communicate this need to national policy makers in an effective manner.

Secondly, *Curiosity* shows us that, sometimes, size does matter. What we wanted from this mission cannot be done effectively or efficiently merely by deploying more copies of smaller systems like *Spirit* and *Opportunity*, as incredibly productive as they have been. What we want from the *James Webb Space Telescope* cannot be obtained by orbiting multiple copies of the *Spitzer* infrared space telescope, as good as it was. With all due respect to the value of smaller, cheaper missions executed by nimbler teams on shorter time scales, sometimes less is less and more is more. Sometimes, to do what needs to be done requires us to risk national treasure in amounts that will surely get our attention. Sometime we really do need a "flagship" mission. To me, one measure of the greatness of our nation and its stature in the world is our ability to tackle the biggest challenges. When the United States can no longer take on the challenge of an Apollo Program, a *Hubble* or *Webb* Space Telescope, or a Mars Science Lab, we will simply no longer be great—no matter how our economy is ranked in the world.

Curiosity demonstrates, if such demonstration were needed, the value of making the difficult choice. When in 2009 it was determined, for a host of individually small but collectively significant reasons, to be necessary to delay the planned launch of the mission until 2011, the detractors rose up in full voice—too much money, too much time, too much risk—arguing for cancellation. Despite the furor of that time, JPL, NASA, and the Congress determined to stay the course, and now we have a chance to reap the rewards of that persistence. But my hat is off to the individual managers and engineers, far down the chain of command as viewed from the White House or Capitol Hill, who had the courage to acknowledge and insist that we were not ready to go in 2009, knowing that they could expect, at best, years of abuse prior to a hoped-for eventual success. In the end, this kind of behavior shows what it truly means to be an ethical professional, to do the right thing, when the easy thing offers a much readier path.

In the end, we hope to gain an enormous amount of new knowledge about Mars from *Curiosity*. But even today, a study of this mission can offer for many of us considerable knowledge about ourselves and the nature of our profession—even if it isn't really new.

NEIL ARMSTRONG SCHOLARSHIP FUND

At the request of the family of Neil A. Armstrong, the AIAA Foundation has established the Neil A. Armstrong Scholarship Endowment Fund to support the dreams of future generations. The Fund information is now live on our website: **https://www.aiaa.org/SecondaryLanding.aspx?id=13514**.

"We are honored to have been selected by the Armstrong family as one of three recipients of gifts made in memory of Neil Armstrong," said Robert S. Dickman, executive director of AIAA. "Donations will fund the Neil A. Armstrong Scholarship Fund, to help ensure that the students of today have the opportunity to pursue the education that will be necessary for them to follow in Neil's footsteps as the aerospace leaders of tomorrow."

AIAA ANNOUNCES CANDIDATES FOR 2013 BOARD OF DIRECTORS ELECTION

AIAA is pleased to announce that its 2013 Nominating Committee has selected candidates for next year's openings on the AIAA Board of Directors. The Committee's chairman, AIAA Past President Brian D. Dailey, confirmed the names of the officer and director candidates who will appear on the ballot. They are as follows:

President-Elect
James Albaugh, The Boeing Company (retired)

VP-Elect, Technical Activities
Thomas Duerr, The Aerospace Corporation
David Riley, The Boeing Company

VP-Elect, Member Services
Joseph Morano, The Boeing Company
Annalisa Weigel, Massachusetts Institute of Technology

Director–At-Large
Neal Barlow, United States Air Force Academy
Steve Trejo, The Boeing Company
Mark Whorton, Teledyne Brown Engineering

Director–At-Large, International
David Finkleman, Analytical Graphics Inc.
Shamim Rahman, NASA Johnson Space Center
Karl Rein-Weston, The Boeing Company

Director–Technical, Information Systems Group
Sanjay Garg, NASA Glenn Research Center
James Rankin, University of Arkansas

Director–Technical, Propulsion and Energy Group
Jeff Hamstra, Lockheed Martin Corporation
Christopher Pestak, Battelle Memorial Institute

Director–Region 4
Jayant Ramakrishnan, ARES Corporation

Director–Region 5
Laura Richard, United Launch Alliance

Director–Region 7
Luisella Giulicchi, European Space Agency
Essam Khalil, Cairo University, Egypt

Voting members of the Institute will be able to cast their ballot beginning in February 2013.

OPPORTUNITY FOR PETITION CANDIDATES FOR 2013 BOARD OF DIRECTORS ELECTION

Any AIAA member who wishes to propose a candidate for the 2013 Board of Directors election through the petition process must submit a written petition, signed by at least 300 voting members, to the AIAA Secretary. To allow for verification of signatures by the cutoff date established in the bylaws, completed petition packets must be received by the AIAA Secretary by **Monday, 3 December 2012**. Each petition must be accompanied by the petition candidate's written acceptance, biographical data, campaign statement, and a color head and shoulders photograph.

Open positions for the 2013 election are the following:

- President-Elect
- VP-Elect, Member Services
- VP-Elect, Technical Activities
- Director–at-Large
- Director–at-Large, International
- Director–Technical, Information Systems Group
- Director–Technical, Propulsion and Energy Group
- Director–Region 4
- Director–Region 5
- Director–Region 7

Members intending to follow this process are asked to contact the AIAA Secretary, Klaus Dannenberg, at 703.264.7655 or klausd@aiaa.org, as soon as possible before the 3 December 2012 deadline for more specific instructions and coordination. Completed petition packets, containing at least 300 signed petitions, should be sent to:

Klaus Dannenberg
AIAA Secretary
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191

REDA RECOGNIZED BY NASA

AIAA Fellow **Dr. Daniel C. Reda** of NASA Ames Research Center was recently awarded NASA's highest civilian honor, The Distinguished Service Medal. This award was given for his "pioneering research on boundary layer transition for hypersonic flows over ablative thermal protection system materials and the advancement of ballistic ranges for this purpose".

HISTORIC SITES PROGRAM

The AIAA Historic Aerospace Sites committee chose four sites this year to be designated. The **Bell Aircraft Plant**, in Wheatfield, NY, produced many aircraft fighters during World War II, but is best known for the design and manufacture of the XS-1, the first plane to break the sound barrier. This plant also produced the Bell 47, the first commercially certified helicopter; and the Lunar Module ascent engine.

Lunken Field, also known as the Cincinnati Municipal Lunken Airport, played an important part in the early years of commercial and civil aviation. The Lunken family started the Aeronautical Corporation of America, or Aeronca, and built the affordable C-2, which helped kickstart the civil aviation industry. Lunken also served as a hub of activity for the Embry Riddle Company, which was awarded one of the first U.S. airmail contracts, and who formed the Aviation Company in 1928 as a holding company to acquire other airlines. In 1930, the holding company was renamed American Airlines. Lunken Field's old control tower is the oldest standing control tower in the United States.

Pearson Field, in Vancouver, WA, is one of the oldest continuously operating airfields in the United States. In 1905, a dirigible from the nearby Lewis and Clark Centennial Exhibition flew across the Columbia River and landed at what was then called Vancouver Barracks. Since then, the field, now the only active airport located completely within a U.S. National Historic Reserve, has continuously played a part in the development of U.S. air power.

On 18 December 1928, Arthur Rawson, followed by Harold F. Pitcairn, flew a Cierva C.8W Autogiro at Willow Grove, Pennsylvania, also called **Pitcairn Field**. This was the first successful rotary wing aircraft to fly in America and ushered in a new age of aeronautical development. Pitcairn Field – Willow Grove became the center of American Autogiro development and manufacture.

Ceremonies for Pearson Field and Bell Aircraft were held in September and October 2012. As part of an ongoing evaluation of AIAA activities, the AIAA Board of Directors voted at their August meeting to suspend the Historic Sites budget. Sites that were already chosen will have a plaque and ceremony through the end of FY13, but no new sites will be chosen for the year, and there is no budget for FY14. The program's budget will be re-evaluated for FY15.

REUBEN H. FLEET SCHOLARSHIPS AWARDED BY THE SAN DIEGO SECTION IN MAY

At the AIAA San Diego Section Honors and Awards Banquet on 23 May 2012, the AIAA San Diego Section Reuben H. Fleet Scholarships were awarded. Since 1983, 149 students have received the scholarship, which is made possible by the Reuben H. Fleet Foundation at The San Diego Foundation.

2012 Reuben H. Fleet Scholarship recipients (left to right): Greg Marien (Scholarship Coordinator, AIAA San Diego), Himanshu Waidya (SDSU), Daniel Nelson (SDSU), Alexander Weiss (SDSU), Sean Davis (SDSU), Alex Fleet (grandson of Reuben H. Fleet).

STEM OUTREACH SUCCESS IN THE NATIONAL CAPITAL SECTION

Michele McMurrer, Administrator, AIAA National Capital Section


2012 NCS Science Fair Winners, with NCS Chair Bruce Milam and Science Fair Committee Chair Dr. Natalia Sizov.

The National Capital Section (NCS), AIAA's largest with nearly 3,000 members, undertakes a multifaceted effort to recognize outstanding STEM educators and students across the Washington metropolitan area. Each year, the NCS funds 8 regional science fairs for middle and high school students in Maryland, Washington, DC, and Virginia with support from AIAA corporate member sponsors, and recruits 26 volunteer judges from NCS membership. Winning aerospace-related projects are recognized with certificates and free student membership in AIAA, monetary awards for second and third place winners, and first place winners receive a full scholarship to a week-long stay at Space Camp. Space Camp, located in Huntsville, AL, offers students a stimulating hands-on approach to study not available in the typical classroom setting. Corporate partners in the 2012 science fair scholarship program were Lockheed Martin and Honeywell International.

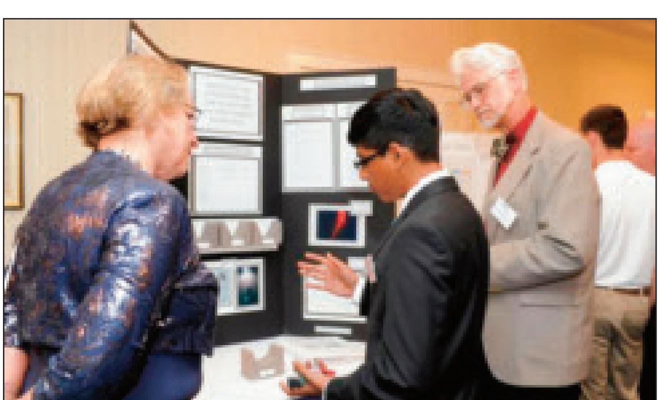
The impact of the NCS science fair programs on students can't be overstated, setting many young people on a course of study in aerospace that can last a lifetime. Among the many thank you letters received by the NCS from students are these words from 2012 first-place honoree Rachel Vogler, an 11th grade student from Loudoun County, VA, "I would like to express my gratitude for the Space Camp scholarship that your association awarded me…I attended the camp last week and I can honestly say that it was one of the best experiences of my life. Space Camp opened up the world of aerospace to me, and had it not been for your scholarship, I would not be compelled to study it more deeply.… thank you for the life changing opportunity."

Students are not the only participants to come away inspired. NCS member and volunteer judge Dr. Thomas Snitch remarked, "I was a judge at the Washington DC fair. We had participation by students who were living under difficult circumstances and, despite the challenges, these young people were able to construct scientifically respectable projects. While these students may have lacked financial resources, they were able to use ingenuity, help from great teachers and sheer willpower to examine tough issues. These students are absolutely inspiring."

The NCS also sponsors the AIAA NCS Educator of the Year Awards, recognizing three outstanding STEM educators who currently teach at the elementary, middle, and high school levels within the jurisdiction of the Section. This year's honorees were Charles Sabatier of Mount Vernon High School in Virginia, Elizabeth Butler of Martin Luther King Jr. Middle School in Maryland, and Kareen Lazarre, of J.C. Nalle Elementary in Washington, DC.

The annual NCS Honors and Awards Banquet, held each June, is the centerpiece of many months of dedicated education outreach efforts undertaken by the Section, and the highlight of the year for the NCS Council, who take great pride in nurturing and inspiring the talented educators, students, and young professionals who will light the way forward for the aerospace industry. The students' winning projects are shared during a pre-dinner reception and the student and eductor honorees receive their awards. Also numbered among this year's honorees were the Hal Andrews Young Engineer of the Year (Dr. Moble Benedict of the University of Maryland) and the NCS Engineer/Scientist of the year (Kai Harth of Aurora Flight Sciences). This awards program is headed up by Professor Norman Wereley, NCS Honors and Awards Committee Chair. The keynote speaker was Dr. Kathryn Sullivan, Assistant Secretary of Commerce for Environmental Observation and Prediction and Deputy Administrator for NOAA. Dr. Sullivan, who also currently serves as NOAA's acting chief scientist, a renowned astronaut and intrepid explorer, held the audience in rapt attention as she shared the motivating influences, trials, and inspirations of her professional journey from her youngest years onward.

If you would like to help support the 2012–2013 NCS Science Fairs, please contact Michele McMurrer at aiaancs1@aol.com.


Third place winner Shubham Patil, a freshman at Stone Bridge High School, discusses his work with longtime NCS Science Fair team member Dr. Nils Jespersen and his wife Beth Jespersen at the 2012 Honors and Awards Banquet.


Kareen Lazarre (left), teacher of mathematics at JC Nalle Elementary School, Washington, DC, one of the 2012 NCS Educators of the Year. Shown with JC Nalle principal Kim Burke and NCS Education Outreach Chair Michel Santos.

AIAA FOUNDATION ANNOUNCES GRADUATE AWARD WINNERS

The AIAA Foundation is pleased to announce the recipients of the AIAA Foundation's six Graduate Awards for the 2012–2013 academic year. The winning graduate students will receive a total of $17,500 in awards.

Each year the AIAA Foundation presents Orville and Wilbur Wright Graduate Awards. These $5,000 awards, given in memory of the Wright brothers' contributions to the evolution of flight, are presented to students completing master's degree or doctoral thesis work. The 2012–2013 winners are:

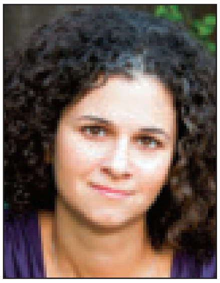
- **Paul Anderson**, University of Colorado–Boulder, Boulder, CO
- **Rachel Ellman**, Massachusetts Institute of Technology, Cambridge, MA

The AIAA Foundation also annually presents a series of $2,500 awards. The 2012–2013 winners are:

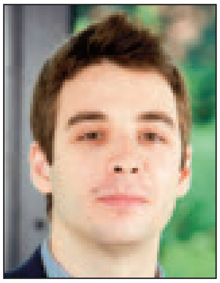
- **Noel Bakhtian**, Stanford University, Palo Alto, CA, who is the recipient of the *John Leland Atwood Graduate Award*. The Leland Award, sponsored by endowments from Rockwell and Boeing North America, Inc., and named in memory of John Leland "Lee" Atwood, former chief executive officer of Rockwell, North American, is presented to a student actively engaged in research areas covered by the technical committees of AIAA.
- **Ved Chirayath**, Stanford University, Palo Alto, CA, who is the recipient of the *Guidance Navigation and Control Award*. The Guidance, Navigation, and Control Technical Committee presents this award to a student engaged in work relating to the committee's subject areas.
- **Vlad Popescu,** Georgia Institute of Technology, Atlanta, GA, who is the recipient of the *William T. Piper Graduate Award*. The William T. Piper Award, sponsored by endowments W.T. Piper, Sr. Foundation, in the name of William T. Piper, Sr., the founder, eponym, and first president of Piper Aircraft Corporation. The award is also supported by AIAA's General Aviation Systems Technical Committee and the AIAA Foundation, and is presented to a student actively participating in research endeavors in General Aviation as part of their graduate studies


Anderson


Ellman


Bakhtian


Chirayath


Popescu

For more information on the AIAA Graduate Awards program, please contact Rachel Andino at 703.264.7577 or rachela@aiaa.org.

AIAA FOUNDATION PRESENTS ELEVEN UNDERGRADUATE SCHOLARSHIPS

AIAA and the AIAA Foundation have awarded eleven AIAA Foundation undergraduate scholarships for the 2012–2013 academic year. The Foundation has presented the *David and Catherine Thompson Space Technology Scholarship*, named for, and endowed by, former AIAA President David Thompson, chairman, chief executive officer and president, of Orbital Science Corporation, Dulles, VA, to **Alexander Young**, North Carolina State University, Raleigh, NC.

The AIAA Foundation has presented two undergraduate scholarships named for individuals who have contributed greatly to the field of aerospace science. The winners are:

- *Dr. James Rankin Digital Avionics Scholarship*: **Christopher Nie**, University of Colorado, Boulder, CO
- *Leatrice Gregory Pendray Scholarship*: **Emily Boster**, Texas A&M University, College Station, TX. This scholarship is presented to the Foundation's top female scholarship applicant.

Five AIAA Foundation undergraduate scholarships are presented by AIAA Technical Committees:

Space Transportation Technical Committee presented a $2,500 scholarship
- **Matthew Marcus**, University of Maryland, College Park, MD

Digital Avionics Technical Committee presented three scholarships of $2,500 each.
- **Amber Kaderbek**, The University of Alabama, Tuscaloosa, AL (Dr. Amy R. Pritchett Digital Avionics Scholarship)
- **James Lewis**, The Ohio State University, Columbus, OH (Ellis F. Hitt Digital Avionics Scholarship)
- **Ya Yu Hew**, The University of Texas, Arlington, TX (Cary Spitzer Digital Avionics Scholarship)

Liquid Propulsion Technical Committee
- **Byron Patterson**, West Virginia University, Morgantown, WV

The AIAA Foundation presented $2,500 scholarships to three students in their senior, junior, and sophomore year of college.

- **Daniel Libin**, Embry-Riddle Aeronautical University, Prescott, AZ, received the scholarship for seniors.
- **Alexander Anderson**, St. Martin's University, Lacey, WA, received the scholarship for juniors.
- **Nicolas Spoetgen**, Purdue University, West Lafayette, IN, received the scholarship for sophomores.

ANNOUNCEMENT OF GROUP FORMATION:

United States Space Universal MOdular "SUMO" architecture - Special Interest Group (SUMO-SIG)

AUGUST 9, 2012

In response to public and private sector incentives to decrease the costs of satellite design and integration and to establish spacecraft modularity to improve interoperability, adaptability and agility, a "Space Universal MOdular architecture – Special Interest Group (SUMO-SIG)" is being established within the framework of the US Technical Advisory Group to ISO Technical Committee 20, Subcommittee 13 (ISO/TC20/SC13), Space Data and Information Transfer Systems. The Terms Of Reference for the group are attached.

This group will evaluate candidate architectural frameworks for standardized spacecraft avionics and will examine:
- Common areas where architectures and frameworks are the same
- Differing areas and subsequent assessment of which set is better
- Gap areas – where there is a lack of definition and further development is needed

The SIG will assess a range of standards and architectures, including: Integrated Modular Avionics (IMA); U.S. Air Force Research Lab's (AFRL) proposed Space Plug and Play Architecture (SPA) standards and their related **M**odular **O**pen **N**etwork **Arch**itecture (MONARCH); the European Space Agency's **S**pace **Av**ionics **O**pen **I**nterface a**R**chitecture (SAVOIR); and protocols for onboard data exchange. The goal is to identify the common features for interoperability and identify where a common set of standards would be beneficial to the space community.

There is a strong market need for the development of international technical consensus for standards that addresses future spacecraft avionics architectures. The desired outcome is sufficient U.S. consensus to request the formation of a multinational study group within the Consultative Committee for Space Data Systems (CCSDS), which could lead to the development of an international CCSDS Recommended Standard and its subsequent advancement to ISO.

Participation in the SUMO-SIG is open to qualified representatives of U.S. government, industry and academia who have a bona-fide interest in the subject matter. It is planned that the SUMO-SIG will meet during summer 2012 via a web-based teleconference to discuss the formulation of a technical position. Interested U.S. parties who wish to participate in the SIG are invited to submit their names, affiliation, and professional interest and contact information to the US-SUMO-SIG convener: Karen Jones: karen.l.jones@aero.org; 703-275-2902

UNITED STATES TECHNICAL ADVISORY GROUP TO ISO TECHNICAL COMMITTEE 20, SUBCOMMITTEE 13, "SPACE DATA AND INFORMATION TRANSFER SYSTEMS"

https://www.aiaa.org/Secondary.aspx?id=6920&terms=TAG13

TERMS OF REFERENCE:

US Space Universal Modular architecture - Special Interest Group (SUMO-SIG)

09 AUGUST, 2012

Considering that
1. A unified and internationally standardized open architecture for space vehicle components which will stimulate international competitiveness of space component and payload manufacturers across the global space community by providing a "level playing field" on which internationally-interoperable products can be based.
2. There is a strong international desire to eliminate proprietary and regional standards that introduce market barriers which undermine trade.
3. There is significant economic and strategic motivation among satellite component manufacturers to reduce non recurring engineering (NRE) expenses. By establishing an internationally standardized modular architecture for space vehicle components satellite component manufacturers would reduce duplicative design, testing and certification procedures could allow for more time and capital to focus on design and performance improvements
4. A goal of the ***US National Space Policy – 2011*** is to "promote a robust domestic commercial space industry" and "foster fair and open global trade and commerce through the promotion of suitable standards and regulations that have been developed with input from U.S. industry".

And recognizing that
1. Satellite integrators, primes, component, subsystem and payload manufacturers must be involved in the international standards development process. Participation should include space companies doing business in the global space marketplace.
2. It is imperative to forge international agreement on the best architecture among the various standard-based architectures that are currently being developed. A first and vital step in securing such an international agreement is to assemble a technical consensus across the US space community.

A US Space Universal MOdular architecture Special Interest Group (US-SUMO-SIG) is established within the framework of the US Technical Advisory Group to ISO/TC20/SC13 to:

1. Develop a consensus US technical position concerning the desirability of developing a standardized modular architecture for space vehicle avionics that blends the best parts of current standards and any other approaches that may be proposed during the SIG process.
2. Build that consensus by consulting and involving leading technical experts from the US satellite community, including the DoD, NASA, other space faring US government organizations and commercial providers.
3. Meet as necessary (face-face and/or virtually) to develop an agreed US technical position relative to the requirements for an internationally-standardized spacecraft avionics architecture. The group will initially focus on defining the problem and the desired characteristics of a preferred solution, rather than advancing any particular concrete implementation.
4. Advance the consensus US proposal to the Consultative Committee for Space Data Systems (CCSDS) in the form of a request for international participation on a CCSDS Birds of a Feather group (BOF), with a view towards chartering a CCSDS Working Group to create the necessary international standard(s) that would then be advanced to ISO.

NEW AIAA CORPORATE MEMBERS

AIAA is pleased to welcome the following corporate members to our roster. For more information on the corporate membership program, please contact merries@aiaa.org

- **Ball Aerospace & Technologies Corp.**, located in Boulder, CO, develops and manufactures spacecraft, advanced instruments and sensors, components, data exploitation systems and RF solutions for strategic, tactical, and scientific applications.
- **MSC Software**, located in Santa Ana, CA, makes products that enable engineers to validate and optimize their designs using virtual prototypes.
- **NextGen AeroSciences**, located in Williamsburg, VA, provides complexity science-derived agent-based tools for demand-supply modeling for the national transportation system, airspace modeling with interacting flight paths, and asset optimization solutions.
- **HRP Systems, Inc.**, located in Rolling Hills Estates, CA, specializes in the development of avionics systems, both for aircraft and spacecraft, focused on reducing the cost of software development, integration, and test.

OBITUARIES

AIAA Senior Member Gaines Died in April

John Emanuel Gaines passed away on 5 April 2012 at the age of 65.

Mr. Gaines received Bachelor's and Master's degrees in aerospace engineering from the Georgia Institute of Technology. He also served his country proudly in the United States Navy as a naval aviator. After spending several years working in construction with his father and then independently, Mr. Gaines relocated to southern California in 1980, where he enjoyed a 30-year career as an aerospace engineer with the Aerospace Corporation.

AIAA Senior Member Boraas Died in August

Stanton Orgene Boraas died on 5 August 2012. He was 84 years old.

Mr. Boraas graduated from the University of Minnesota in 1949 with a BS Degree in Aeronautical Engineering. He was in U.S. Army Ballistic Research Laboratory from 1951 to 1953.

Mr. Boraas began his early career for Boeing Aerospace in Seattle, WA. He then worked as an Aeronautical Engineer for Bell Aerospace, Niagara Falls, NY. Mr. Boraas assisted Bell in the design for the original Rocket Belt. Moving on, he worked for Morton-Thiokol in Brigham City, UT. There he assisted on several U.S. Space Shuttle projects with NASA. Mr. Boraas retired from Morton-Thiokol in 1990. He, along with partner Rashid Ahmad, recently U.S. patented a new Wind Chill Theory.

AIAA Associate Fellow Crawford Died in August

Charles C. Crawford, Jr. passed away on 14 August 2012. He was 81.

In 1954 Crawford graduated from the Georgia Institute of Technology. He worked from 1955 to 1962 for the U.S. Air Force Flight Test Center (AFFTC) at Edwards AFB, CA, as a flight test engineer. He became the chief of the rotary wing engineering branch in 1960, where he oversaw all rotary wing projects assigned to the center, including novel VTOL aircraft such as the Bell XV-3 tilt rotor, as well as airworthiness qualification tests of Bell UH 1B/C/D and Boeing Vertol CH-47A.

He worked from 1962 to 1966 for the U.S. Army Materiel Command as the Light Observation Helicopter (LOH), where he was responsible for the technical management of the LOH program, including development and initial production of over 1000 Hughes OH-6 helicopters, as well as the qualification of the T63 engine. Development was highlighted by an intensive competitive fly-off between three designs: the YOH-4, YOH-5, and YOH-6. He eventually became the LOH Deputy Program Manager.

Between 1966 and 1988, he worked for the Army's Aviation Systems Command (AVSCOM). He established the Flight Standards Office, where he oversaw the development of the Bell AH-1G Cobra. The organization was elevated to the Directorate of Development and Qualification just prior to the advent of the Utility Tactical Transport Aircraft System (UTTAS) and the Advanced Attack Helicopter (AAH) developments, with Crawford as Director.

He was the U.S. Army's airworthiness authority as delegated from the AVSCOM Commander and as such was responsible for establishing its airworthiness qualification process and for the planning and management of the qualification portion of all Army air items and modifications thereto. This included the overall responsibility for design criteria, qualification test requirements, test planning, and approval of each test/analytical reports which substantiated compliance with these requirements. Crawford was responsible for issuing all contractor flight releases and airworthiness releases for use of Army air items. He also served in a supervisory position on almost every major Army Aviation Source Selection Evaluation Board (SSEB) or Source Selection Advisory Council (SSAC) between 1963 and 1983.

Between 1983 and 1988, Crawford served as the AVSCOM Technical Director, and the Director of the Aviation Research, Development & Engineering Center (AVRDEC). Mr. Crawford was responsible for approximately 1400 employees at the 7 locations throughout the United States, including at the Ames, Langley, and Lewis NASA Research Centers, with an annual budget of $120 million. Crawford served as Tri-service Chairman of the Technical Assessment Committee for the Joint Services Advanced Vertical Lift Aircraft (JVX), which led to the V-22 Osprey program.

After retirement from the Department of the Army, Crawford was a full-time research engineer at the Georgia Tech Research Institute (GTRI) until 2004, and a part-time consultant until his death. At GTRI, Crawford served as the Aerospace, Transportation, and Advanced Systems Laboratory's Chief Engineer for Powered-Lift Technology, supporting the Army and Air Force Special Operations Forces. Crawford also served as a consultant to firms in the aerospace business in the area of developing new products and preparation of proposals for competitive solicitations. He was a consultant for several law firms relating to rotorcraft accidents and the Institute of Defense Analysis. He was also a consultant for the NASA Ames Research Center.

Crawford was an Honorary Fellow of the American Helicopter Society (1980), the winner of the AHS Nikolsky Honorary Lectureship (1989), and winner of the U.S. government's Meritorious Civilian Service Award (1965, 1972, 1983, and 1988), the Secretary of Defense Medal for Meritorious Civilian Service (1988) and the Exceptional Civilian Service Decoration (awarded by the Secretary of the Army) in 1977. He was an AIAA Associate Fellow, a longtime member and former Vice Chairman of the AIAA's VSTOL Technical Committee, a member of the AHS STOVL/Advanced Vertical Flight Technical Committee, and a Lifetime Member of the Army Aviation Association of America (AAAA). He also served as the AHS President in1978–1979 and Chairman of the Board in 1979–1980.

Donations for the Charles Crawford scholarship fund are being accepted by the AHS Vertical Flight Foundation: **www.vtol.org/vff**.

51st AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition

7–10 January 2013
Gaylord Texan Hotel and Convention Center
Grapevine, TX (Dallas–Fort Worth Region)

AIAA Aerospace Sciences Meeting

The AIAA Aerospace Sciences Meeting is the first major multidisciplinary event of the year for aerospace scientists and engineers from around the world. It provides an ideal forum for scientists and engineers from industry, government, and academia to share and disseminate scientific knowledge and research results with a view toward new technologies for aerospace systems.

This meeting is built around excellent technical paper presentation sessions. Plenary sessions that focus attention on program areas of current interest will start some sessions, followed by technical papers providing additional discussion of these topics. Distinguished lectures and evening networking events fill out the remainder of the program throughout the week.

New Horizons Forum

The New Horizons Forum is held in conjunction with the AIAA Aerospace Sciences Meeting. This Forum will feature keynote speakers from industry and government who will share their perspectives on the new challenges, future opportunities, and emerging trends in aerospace education, research, and programs. Panel discussions in which leaders from industry, government, and academia address current issues and trends in aerospace technology research and development are planned. See box on page **B16** for more information about the New Horizons Forum program.

Aerospace Exposition

The Aerospace Exposition will showcase exhibits from various sectors of the aerospace community—from larger organizations to small businesses. The Exposition provides opportunities for one-on-one discussions with exhibitors, hardware and software demonstrations, and side meetings with these organizations throughout the week. See page **B16** for more information about the Aerospace Exposition and the activities occurring in the Exposition Hall.

Special Program Activities

As part of the Aerospace Sciences Meeting, other activities are planned to provide specific attendees valuable knowledge, experience, and interaction.

New Horizons Forum

The New Horizons Forum has gained significant attention from leaders and managers in the aerospace industry and government research labs. This event will be held in parallel with the Aerospace Sciences Meeting, featuring renowned keynote speakers with companion interactive panel discussions that address critical aerospace issues and opportunities. Specially selected panel participants from government, industry, and academia will engage in timely topical discussions to enlighten the aerospace community about the issues, solutions, and opportunities that are likely to impact their professional lives. Confirmed keynote speakers include Lt Gen Larry James, Commander, USAF and Maj Gen Neil McCasland, Commander, AFRL, with potential keynote Linda Cureton, NASA OCIO. Each panel is structured to raise the difficult issues and diverse perspectives that are shaping these important topics. The panel participations are nationally recognized experts to assure a lively, informative discussion. At least four keynotes and three panels are being scheduled during the four days of the events … so plan to attend the entire series. For up-to-date panels please visit the website at **www.aiaa.org/asm2013** and select "agenda" on the right-hand toolbar.

Continuing Education Courses

AIAA is offering a number of continuing education courses on **5–6 January 2013** to provide focused learning opportunities for aerospace professionals. See the box on **B18** for more information about the course being offered and the course registration.

2013 AIAA Foundation International Student Conference

The 2012 Regional Student Conference first-place undergraduate, masters, and team winners will compete Monday, **7 January 2013** for the 2013 AIAA Foundation International Student Conference awards. Their papers, judged by AIAA professional members, have been deemed the best student papers for this year. The Community Outreach division features presentations that show how AIAA Student Branches are interacting with their community.

Support these students as they present their papers again to a larger audience. Information about the papers can be found in sessions ISC-1 (Undergraduate Division), ISC-2 (Masters Division), ICS-3 (Team Division), and ISC-4 (Community Outreach Division). The student winners will be announced at the AIAA Foundation International Student Conference Reception Monday night and honored at the Awards Luncheon.

NEW EVENT! Rising Leaders in Aerospace Forum

AIAA's Rising Leaders in Aerospace Forum is a special initiative that takes place during the Aerospace Sciences

AIAA Programs

ASM Executive Chair
Ray O. Johnson, Senior Vice President and Chief Technology Officer, Lockheed Martin Corporation

Aerospace Sciences Meeting Chair
Rob Vermeland
Lockheed Martin Aeronautics Company

New Horizons Forum Technical Chair
John T. "Tom" Sheridan, Lt General, USAF (Ret.)
Vice President, National Security Space
TheSI Organization, Inc.

Aerospace Exposition Chair
Kathy Gattis
United States Air Force

Official Media Sponsor
Aerospace America

Benefits of Attendance

ASM is Where it All Comes Together!

No matter where you go at the Aerospace Sciences Meeting (ASM), there is always something happening. From plenary sessions addressing critical topics for the future of the industry to presentations on current state-of-the-art technologies. From student paper competitions to panel sessions that foster discussion and debate among stakeholders. From hallway conversations with colleagues to meeting new contacts at receptions. From lectures by renowned speakers addressing topics of general interest to special presentations on the exhibit hall stage. From a luncheon that addresses a timely policy issue to an off-site social event that provides a fun and informal way to interact with other attendees.

ASM is the first major multidisciplinary event of the year for aerospace scientists and engineers from around the world. It provides an ideal forum for industry, government, and academia to share and disseminate scientific knowledge and research results with a view toward new technologies for aerospace systems.

This conference is built around excellent technical paper presentation sessions. Plenary sessions that focus attention on program areas of current interest will start some sessions, followed by technical papers providing additional discussion of these topics. Distinguished lectures and evening networking events fill out the remainder of the program throughout the week

Why Attend?
- For 50+ years the Aerospace Sciences Meeting has been ***THE*** place to present emerging and up-to-the-minute aerospace research and development findings.
- Gain valuable knowledge when you participate in the New Horizons Forum, featuring high-level speakers and panelists sharing their perspectives on the new challenges, future opportunities, and emerging trends in aerospace education, research, and programs.
- Meet with your clients and suppliers in the Aerospace Exposition. Exhibits from government, industry, and small businesses will feature hardware and software demonstrations and new products.
- Enhance your skill set as more than 1,000 engineers, researchers, and scientists report on their latest research and development findings and share views on new technologies for aerospace systems.
- Network, discuss challenges, and share ideas during panel sessions, luncheons, receptions, coffee breaks, and off-site events.
- Focused career development and public policy workshops provide access to top aerospace leaders and perspectives on issues affecting your career.

Who Should Attend?
- Engineering Managers and Executives
- Engineers, Researchers, and Scientists
- Young Aerospace Professionals
- Educators and Students
- Media Representatives

What to Expect?

Technical Program
- More than 1,500 papers presented in over 30 technical tracks
- AIAA Foundation International Student Conference

Management Program
- New Horizons Forum addressing air and space transportation for the future
- Career and Workforce Development Workshop

Networking
- Rising Leaders in Aerospace Forum
- Fun at the Dallas Cowboys Stadium
- Aerospace Happy Hours
- And More

Meeting and that provides a forum for young aerospace leaders, age 35 and under, to learn and engage with others. See the box on page **B15** for more information about this exciting new program.

Tactical Maneuvering—Charting Your Own Career: A Career and Workforce Development Workshop
Tuesday, 8 January, 0930–1200 hrs and 1400–1630 hrs

Are you just beginning your career, in your early career and preparing for a career transition, or mid-career and looking for a new direction? Get a jump start and attend the Career and Workforce Development Workshop. This activity will feature a series of presentations to guide and position you to get the most out of your career. The workshop will feature topics on what to expect in the first two years of aerospace career, how to develop your career by knowing yourself, and what managers want from their engineers for promotion.

NEW EVENT! Graduate Award Presentations
Tuesday, 8 January, 1000–1100 hrs

Winners of the 2012–2013 AIAA Foundation Graduate Awards will present their research and receive recognition on

Overview			
	Monday, 7 January	**Tuesday**	
0700 hrs	Continental Breakfast in Registration Foyer	Continental Breakfast in Exhibit Hall	Aerospace Exposition Located in Grapevine Ballroom A-D
0730 hrs	Speakers' Briefing (Session Rooms)	Speakers' Briefing (Session Rooms)	
0800 hrs	Technical Sessions (0800-1200 hrs)	New Horizons Forum Keynote	
0830 hrs			
0900 hrs		Technical Sessions (0900-1200 hrs)	
0930 hrs			
1000 hrs			
1030 hrs			
1100 hrs			
1130 hrs			
1200 hrs	Durand Lectureship in Public Services/AIAA Public Policy Luncheon	AIAA Awards Luncheon (*Tickets Required)	
1230 hrs			
1300 hrs			
1330 hrs	New Horizons Forum Opening Keynote		Aerospace Exposition (Coffee & Dessert)
1400 hrs		Speakers' Briefing (Session Rooms)	
1430 hrs	Speakers' Briefing (Session Rooms)	Technical Sessions (1430-1730 hrs) Rising Leaders in Aerospace: Leadership Exchange (1500-1630 hrs), Reception (1630-1730 hrs) (*Separate Registration Required)	
1500 hrs	Technical Sessions (1500-1730 hrs) New Horizons Forum Panel (1530-1730 hrs) Rising Leaders in Aerospace: Leadership Exchange (1500-1630 hrs) (*Separate Registration Required)		
1530 hrs			
1600 hrs			
1630 hrs			
1700 hrs			Happy Hour
1730 hrs	Dryden Lectureship In Research	Wright Brothers Lectureship in Aeronautics	
1800 hrs			
1830 hrs	Student Reception (1830-1930)	Waypoint National Harbor, MD Reception Located in the Exhibit Hall Texas Ballroom A-D (*Tickets Required)	
1900 hrs			
1930 hrs	AIAA Associate Fellows Dinner (*Tickets required)		
2000 hrs			
2030 hrs			
2100 hrs			
2130 hrs			

the presentation stage in the Exhibit Hall on Tuesday. This is an opportunity to hear about the latest university research from some of the best students.

Presentation Stage

Between sessions, grab a cup of coffee in the exhibit hall and join us at the presentation stage for additional learning and networking opportunities. Visit **www.aiaa.org/ASM2013** for the most up-to-date schedule and full descriptions of presentations.

Public Policy

Tuesday, 8 January, 0900–1200 hrs

Get Your Green Card—Immigration Options for Scientists and R&D Engineers

Attorney Mark Harrington will present an overview of "Green Card" options available for foreign-born scientists and R&D engineers. This presentation will cover employer-sponsored green card cases as well as cases that can be self-filed directly by immigrants without the need for official sponsorship from an employer. A Q&A session will follow the presentation (**www.harringtonlawfirm.com**).

Wednesday, 9 January, 0900–1200 hrs

Intellectual Property Law Workshop

The United States has recently implemented sweeping changes to the Patent Laws. These changes will have a profound impact on the rights of inventors. Intellectual Property Law Attorney, Richard Jaworski, with over 20 years of experience will present a workshop to provide insight into the various options that are available for protecting intellectual property. The workshop will discuss the process for obtaining patents, copyrights, and trademarks and the advantages/disadvantages of each type of protection. It will include a detailed discussion of the recent changes to the patent laws and how they will impact those who are currently navigating or considering navigating the patent process. A Q&A session will follow the presentation (**www.richardjaworski.com**).

Thursday, 10 January, 1300 hrs

NSTC National Aeronautics RDT&E Infrastructure Plan Public Meeting

The Aeronautics Science and Technology Subcommittee (ASTS) of the National Science and Technology Council's (NSTC) Committee on Technology will hold a public meeting to discuss the National Aeronautics RDT&E Infrastructure Plan. At this meeting, ASTS members will review the content of the National Aeronautics RDT&E Infrastructure Plan and receive input to help inform the future development of national aeronautics R&D planning documents. The focus of that discussion will be the transfer of technology from federal aeronautics and aeronautics-related technology R&D programs at several agencies.

AIAA **Programs**

Wednesday		Thursday
Continental Breakfast in Exhibit Hall	Aerospace Exposition Located in Grapevine Ballroom A-D	Continental Breakfast in Registration Foyer
Speakers' Briefing (Session Rooms)		Speakers' Briefing (Session Rooms)
New Horizons Forum Keynote		New Horizons Forum Keynote
Technical Sessions (0900-1200 hrs) New Horizons Forum Panel (0930-1130 hrs)		Technical Sessions (0900-1200 hrs) New Horizons Forum Panel (0930-1130 hrs)
Exposition Luncheon Reception (*Tickets Required)		Rising Leaders in Aerospace: Roundtable Luncheon (*Separate Registration Required)
Speakers' Briefing (Session Rooms)		Speakers' Briefing (Session Rooms)
Technical Sessions (1400-1730 hrs) Rising Leaders in Aerospace: Session (1600-1730 hrs) (*Separate Registration Required)		Technical Sessions (1330-1730 hrs)
	Happy Hour	
von Kármán Lectureship In Astronautics		
Busses load for off-site from Convention Center porte-cochere	at 1830	
Dallas Cowboys Off-Site Dinner (*Tickets Required)		

Recognition Activities and Lectureships

Recognizing the best in our profession for their outstanding achievement is one of the primary goals of AIAA. The Aerospace Sciences Meeting features a number of activities that help us honor achievements and contributions to the profession.

AIAA Associate Fellows Dinner

One hundred seventy-eight Institute members will be inducted as AIAA Associate Fellows during the AIAA Associate Fellows Dinner, which will be held at 1930 hrs, Monday, 7 January. Each year, the Institute recognizes exemplary professionals for their accomplishments in engineering or scientific work, outstanding merit, and contributions to the arts, sciences, or technology of aeronautics or astronautics. Please support your colleagues, and join us for the induction of AIAA's Associate Fellows class of 2013. Tickets to this prestigious event are available on a first-come, first-served basis and can be purchased via the registration form or on site for $97, based on availability. Business attire is requested.

Awards Luncheon

The Tuesday Awards Luncheon will be held in the Texan Ballroom A&B and is included in the registration fee where indicated. Additional tickets may be purchased for $52 at the AIAA on-site registration desk, based on availability.

NEW EVENT! 2013 Durand Lectureship in Public Service

This lectureship will be the keynote address for the 9th Public Policy Luncheon being held on Monday, 7 January, 1200–1300

NEW EVENT! Rising Leaders in Aerospace Forum

The multidimensional program features a speed mentoring leadership exchange, panel or keynote sessions, Q&A with top industry leaders, and multiple opportunities to networking. This exciting and energetic forum will provide access to top aerospace leaders and perspectives and subject matter relevant to career stage.

Monday, 7 January, 1600–1730 hrs: Rising Leaders in Aerospace Workshop

Tuesday, 8 January, 1500–1630 hrs: Leadership Exchange for Rising Leaders in Aerospace

Tuesday, 8 January, 1630–1730 hrs: Rising Leaders in Aerospace Networking Reception

Wednesday, 9 January, 1600–1730 hrs: Rising Leaders in Aerospace Workshop

Thursday, 10 January, 1215–1345 hrs: Rising Leaders in Aerospace Roundtable Luncheon and Featured Speaker

Separate registration required. To register for this program and events, please select the Rising Leaders in Aerospace track when registering to attend the ASM conference.

hrs in the Texas Ballroom A. The speaker is Gen. John R. Dailey (USMC, Ret.), Director, Smithsonian National Air and Space Museum, Washington, DC. The luncheon is open to all attendees but is on a first-come, first-serve basis. Once the room has met capacity, the doors will be closed.

2013 Dryden Lectureship in Research

The Dryden Lectureship in Research will take place on Monday, 7 January, 1730–1830 hrs. The lectureship emphasizes the great importance of basic research to advancement in aeronautics and astronautics, and is a salute to research scientists and engineers. It is named in honor of Dr. Hugh L. Dryden, renowned leader in aerospace research programs. The 2013 lecture will be given by Alan H. Epstein, Vice President, Technology and Environment, Pratt & Whitney Corporation.

2013 Wright Brothers Lectureship in Aeronautics

The Wright Brothers Lectureship in Aeronautics will take place on Tuesday, 8 January, 1730–1830 hrs. The lectureship commemorates the Wright Brothers' first powered flights at Kitty Hawk in 1903, and emphasizes significant advances in aeronautics by recognizing major leaders and contributions thereto. The 2013 lecture will be given by Thomas J. Cogan, Director, Airplane Product Development (Retired), Boeing Commercial Airplanes.

2013 von Kármán Lectureship in Astronautics

The von Kármán Lectureship in Astronautics will take place on Wednesday, 9 January, 1730–1830 hrs. The lectureship honors an individual who has performed notably and distinguished himself/herself technically in the field of astronautics. It is named for Theodore von Kármán, world-famous authority on aerospace sciences. The 2013 lecture will be given by James H. Crocker, Vice President and General Manager, Lockheed Martin Space Systems Company.

Networking Activities

Understanding the importance of networking with colleagues, we have planned a series of activities during the Aerospace Sciences Meeting that will help you connect with current colleagues and new acquaintances.

First Timers' Social

Join us for a special session on Sunday, 6 January, 1900–2030 hrs aimed at achieving the most value from your attendance at the Aerospace Sciences Meeting. Especially useful for first-time attendees, the social will offer the opportunity to meet with other professionals and young members who are experts at navigating the many sessions, speakers, paper presentations, and receptions. Enjoy an informal short program, followed by networking time! Please rsvp to joannez@aiaa.org.

NEW EVENT! Aerospace Happy Hours

Stop by to grab a drink and network with other attendees during Aerospace Happy Hour, Sunday–Wednesday, 1700–1800 hrs. There will be different themes at each of several stations, such as AIAA Committees, Texas culture, and relaxation lounges. Stay tuned for the final schedule events. A cash bar with happy-hour prices will be available at each station. This event is open to all attendees. No tickets required.

NEW EVENT! Continental Breakfasts

A great way to start the day and interact with exhibitors and other attendees, a continental break will be offered on Monday–Thursday, 0700–0800 hrs. Breakfast will be in the registration foyer on Monday and Thursday and in the Exposition Hall on Tuesday and Wednesday. This event is open to all attendees. No tickets required.

Receptions

There will be two receptions in the Exhibit Hall: Tuesday evening, 1830–2000 hrs, and Wednesday afternoon, 1200–1330 hrs. Tickets are included in the registration where indicated. Additional tickets may be purchased in advance via the registration form, or, based on availability, at the registration desk on site.

Offsite Event

Join us at the off-site event at the Dallas Cowboys Stadium on Wednesday, 1900–2130 hrs, at which AIAA will host a Passing Competition. First prize is complimentary hotel and conference registration for AIAA Science and Technology Forum and Exposition 2014 (AIAA SCI TECH 2014) at the Gaylord National, in National Harbor, MD. Wear your favorite team colors and get ready to show off your skills. Tickets to the off-site event are included in the registration fee where indicated. Ticket includes transportation and a Texas-style barbeque dinner buffet, including beverages. Additional tickets for accompanying persons and committee members may be available but will not be considered until closer to the event.

Aerospace Exposition

The Aerospace Exposition will be held Tuesday, 8 January through Wednesday, 9 January, in the Grapevine Ballroom. Organizations plan to exhibit an array of technology that includes workstations, mini-supercomputers, supercomputers, graphics, networking, and software. The Exposition is the place to network and conduct business for all attendees, as well as attend presentations featured on the Presentation Stage.

Exhibit Hall Hours

Tuesday 0700–1200 hrs, 1345–1600 hrs, 1830–2000 hrs
Wednesday 0700–1600 hrs

Exhibit Hall Events

Tuesday, 10 January
0700-0800 hrs, Continental Breakfast
0900–0930 hrs, Coffee Break
1345–1600 hrs, Dessert and Coffee
1830–2000 hrs, Waypoint Reception

Wednesday, 11 January
0700-0800 hrs, Continental Breakfast
0900–0930 hrs, Coffee Break
1200–1330 hrs, Luncheon Reception

Meeting Site—Gaylord Texan Hotel & Convention Center

Brimming with authentic Texas style and hospitality, the awe-inspiring Gaylord Texan Hotel and Convention Center invites you to experience the energy and excitement of the Lone Star State. Overlooking beautiful Lake Grapevine, Gaylord Texan is just six minutes from the Dallas-Fort Worth International Airport. Underneath our signature majestic and climate-controlled glass atriums, you'll find some of the most distinctive shopping, dining, and recreation options all under one roof!

Hotel Reservations

Gaylord Texan & Convention Center
1501 Gaylord Trail, Grapevine, TX 76051

Attendee: **hotel.aiaa.org/ASM2013/attendee**

Government Attendee: **hotel.aiaa.org/ASM2013/gov**

Room rates are $189 for a standard room (single or double occupancy) includes non-negotiable resort fee*, plus applicable taxes will apply. To make reservations via the Web, see hotel

AIAA Programs

	Registration Type	By 10 December 2012		Conference Sessions	Online Proceedings	New Horizons Forum	Tuesday Luncheon	Tuesday Reception	Wednesday Luncheon	Wednesday Off-Site Event	Exposition	CE Course	Monday Associate Fellows Dinner
		AIAA Member	Nonmember										
Option 1	Full Conference	$780	$930	■	■	■	■	■	■	■	■		
Option 2	Full-Time Undergraduate Student	$25	$55	■							■		
Option 3	Full-Time Undergraduate Student with Networking	$297	$327	■		■	■	■	■	■	■		
Option 4	Full-Time Graduate or Ph.D. Student	$75	$105	■							■		
Option 5	Full-Time Graduate or Ph.D. Student with Networking	$347	$377	■		■	■	■	■	■	■		
Option 6	AIAA Retired Member Only	$60		■		■	■	■	■	■	■		
Option 7	Discounted Group Rate	$698		■		■	■	■	■	■	■		
Option 8	Rising Leaders in Aerospace Forum*	N/A	N/A	You must be a paid Aerospace Sciences Meeting registrant to participate.									
Option 9	Continuing Education (CE) Course and Full Conference with Online Proceedings	$1,295	$1,400	■	■	■	■	■	■	■	■	■	
Extra Tickets					$200		$52	$65	$45	$110			$97

Pricing subject to change.

links above or visit **www.aiaa.org/asm2013** for hotel information. Should you prefer to call directly for reservations, call 866.972.6779 or 615.889.1000 and ask for the "AIAA" block.

*The Gaylord Texan™ Hotel & Convention Center on Lake Grapevine has a $10.00 per day plus tax, per room resort fee that will be posted to your account upon check in. This fee includes:

- Wireless internet access in each guestroom and throughout the hotel public space (not including the convention center and meeting rooms).
- Local phone calls up to 20 minutes ($.10/minute thereafter).
- Toll-free and credit card calls up to 20 minutes ($.10/minute thereafter).
- Bottled water (2 per room, per day).
- Access to the resort's state-of-the-art Fitness Center.
- Discounted shuttle service to Grapevine Mills Mall and Downtown Grapevine on pre-set schedule

These rooms will be held for AIAA until **17 December 2012** or until the room block is full, then released for use by the general public. There are also a small number of federal government per diem rooms available. If you reserve a government room you will need to present a government ID upon check-in. The Gaylord Texan requires a major credit card with expiration date to reserve a room. If you have issues making reservations under one of the AIAA blocks, please contact Anna Kimmel, Event Manager, annak@aiaa.org.

30% Off on All Books at ASM

AIAA publications is offering a special discount on all titles featured at ASM 2013. Attendees can take advantage of a 30% discount off the list price of all books for sale in the AIAA Pavilion. This show special will be available only during ASM. AIAA will be featuring one select title with a 35% discount. Take advantage of these super savings and visit the bookstore in the AIAA Pavilion.

Registration Information

All participants are urged to register online via the AIAA website at **www.aiaa.org/asm2013**. Registering in advance saves conference attendees time and up to $200. A PDF registration form is also available on the AIAA website. Print, complete, and mail or fax with payment to AIAA. Address information is provided. Payment must be received in order to process registration.

Early-bird registration forms must be received by **10 December 2012** and standard registrations will be available online through **8 January 2013**. All those whose registration forms have not been received by **4 January 2013** may register via the website for the standard price or on site at the on-site price. All nonmember registration prices include a one-year AIAA membership. If you require more information, please call 703.264.7503 or email Lynned@aiaa.org.

On-Site Check-in

Partnering with Expo Logic, we've streamlined the on-site registration check-in process! All advance registrants will

Continuing Education Courses

On 5–6 January 2013 at the Gaylord Texan Hotel and Convention Center in Grapevine, TX, AIAA will offer the following Continuing Education courses in conjunction with the 51st AIAA Aerospace Sciences Meeting. Register for any course and attend the conference for FREE! (*Registration fee includes full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.) Please check the conference website for up-to-date information regarding the courses.

Specialist's Course on Flow Control *(Instructors: David Williams, Professor of Mechanical, Materials & Aerospace Engineering Department, Director of Fluid Dynamics Research Center, Illinois Institute of Technology, Chicago, IL; Daniel Miller, Technical Lead and PInvestigator for Propulsion Integration R&D, Lockheed Martin Skunk Works, Bainbridge Island, WA; Dr. Kunihiko Taira, Assistant Professor, Department of Mechanical Engineering, Florida A&M/Florida State University, Tallahassee, FL)*

The techniques of Active Flow Control are becoming more sophisticated as Fluid Dynamics and Dynamical Systems and Control Theory merge to design control architectures capable of solving challenging flow control applications. The two-day course will examine advanced topics in active flow control, placing particular emphasis on "how to do flow control." This new course will complement the more fundamental AIAA Short Course on "Modern Flow Control." Modern dynamical systems and control theory related to closed-loop flow control and performance limitations will be discussed. State-of-the-art actuator and sensor design techniques will be covered. Two case studies will be presented that describe recent success stories about the implementation of active flow control on advanced aircraft. The six course lecturers have extensive backgrounds in flow control, coming from industry and academia.

Six Degrees of Freedom Modeling of Missile and Aircraft Simulations *(Instructor: Peter Zipfel, Adjunct Associated Professor, University of Florida, Shalimar, FL)*

As modeling and simulation (M&S) is penetrating the aerospace sciences at all levels, this two-day course will introduce you to the difficult subject of modeling aerospace vehicles in six degrees of freedom (6 DoF). Starting with the modern approach of tensors, the equations of motion are derived and, after introducing coordinate systems, they are expressed in matrices for compact computer programming. Aircraft and missile prototypes will exemplify 6 DoF aerodynamic modeling, rocket and turbojet propulsion, actuating systems, autopilots, guidance, and seekers. These subsystems will be integrated step by step into full-up simulations. For demonstrations, typical fly-out trajectories will be run and projected on the screen. The provided source code and plotting programs lets you duplicate the trajectories on your PC (requires FORTRAN or C++ compiler). With the provided prototype simulations, you can build your own 6 DoF aerospace simulations.

Systems Engineering Verification and Validation *(Instructor: John C Hsu, CA State University, The University of CA at Irvine, Queens University and The Boeing Company, Cypress, CA)*

This course will focus on the verification and validation aspect that is the beginning, from the validation point of view, and the final part of the systems engineering task for a program/project. It will clarify the confusing use of verification and validation. Familiarize yourself with validating requirements and generating verification requirements. Start with the verification and validation plans. Then learn how to choose the best verification method and approach. Test and Evaluation Master Plan leads to test planning and analysis. Conducting test involves activities, facilities, equipments, and personnel. Evaluation is the process of analyzing and interpreting data. Acceptance test assures that the products meet what intended to purchase. There are functional and physical audits. Simulation and Modeling provides virtual duplication of products and processes in operational valid environments. Verification management organizes verification task and provides total traceability from customer requirements to verification report elements.

receive an email with a registration barcode. In order to pick up your badge and conference materials, make sure to print the email that includes your ExpressPass Barcode, and bring it with you to the conference. Simply scan the ExpressPass barcode at one of the ExpressPass stations in the registration area to print your badge and receive your meeting materials.

Notice on Visas

If you plan to attend an AIAA technical conference or course held in the United States and you require a visa for travel, it is incumbent upon you to apply for a visa with the U.S. Embassy (consular division) or consulate with ample time for processing. To avoid bureaucratic problems, AIAA strongly suggests that you submit your formal application to U.S. authorities a minimum of 120 days before the date of anticipated travel. To request a letter of invitation, fill out and submit the online Invitation Letter Request Form. You can also request a letter of invitation by contacting:

ATTN: Customer Service
American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
703.264.7500 • 703.264.7657 FAX
Email: custserv@aiaa.org

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

Cyber Café (Internet Access)

Computers with complimentary Internet access will be in the Exhibit Hall for conference attendees during the following hours:

Monday, 9 January	0700–2000 hrs (Grapevine Ballroom Foyer)
Tuesday, 10 January	0700–2000 hrs
Wednesday 11 January	0700–2000 hrs
Thursday, 12 January	0700–1300 hrs (Grapevine Ballroom Foyer)

Conference Sponsorship Thank you

AIAA would like to thank Lockheed Martin Company for their premier sponsorship of this event.

Conference Sponsorship Opportunities

When your brand is on the line, AIAA sponsorship can raise the profile of your company and put you where you need to be. Available packages offer elevated visibility, effective marketing and branding options, and direct access to prominent decision makers from the aerospace community. Contact Merrie Scott at merries@aiaa.org or 703.264.7530 for more details.

AIAA AVIATION 2013
Charting the Future of Flight
Continuing the Legacy of the AIAA Aviation Technology, Integration, and Operations (ATIO) Conference
And Featuring the 2013 International Powered Lift Conference (IPLC) and the 2013 Complex Aerospace Systems Exchange (CASE)

12–14 August 2013
Hyatt Regency Century Plaza
Los Angeles, California

Abstract Deadline: 28 February 2013

Aviation is an essential component of the U.S. and global economy and our national security. The foundations of aviation success are built on the technological innovations that have provided an unprecedented level of capability, capacity, safety, and efficiency. The AIAA AVIATION 2013 is the premier venue for the presentation of both recent progress on aircraft design, aircraft systems, air traffic management and operations, and aviation-related technologies, as well as policy, planning, and market issues affecting the future direction of global aviation.

Distinguished keynote speakers, panel discussions among aviation luminaries, interactive learning sessions, and technical research presentations will provide a forward-looking conference experience conducive to collaboration and participation among attendees around critical issues and the future direction of global aviation. The major themes for the AIAA AVIATION 2013 focus on the following lines:

- Global Aviation: Outlook, opportunities, and challenges
- Air Traffic Management: Optimization for capacity, efficiency, and safety
- The Energy Imperative: The impact of energy on Aviation's future
- The Connectivity Challenge: Protecting our assets in a networked world
- Designing the Fleet for the Market: Integrating the platform with the mission

To cover the waterfront of these theme lines, AVIATION 2013 is including several conferences and forums for its introductory year. The Aviation Technology, Integration, and Operations (ATIO) Conference intentionally covers a broad range of topics—from the design and operation of aircraft of all kinds (including lighter-than-air and balloon systems, and unmanned aircraft), to the design and operation of the air traffic management system (from strategic traffic planning systems to tactical air traffic control methods and procedures), to the complex system-of-system connectivities to make it all operate smoothly, now and into the future—each of which is soliciting abstracts for the development of the technical program. The International Powered Lift Conference (IPLC) focuses on the latest developments in Vertical and/or Short Take-Off and Landing (V/STOL) aircraft research, concepts, and programs. And, through panel presentations and discussions, the new Complex Aerospace Systems Exchange (CASE) tackles some of the most important system development issues facing aerospace chief engineers, program managers, and systems engineers today, such as minimizing cost overruns and delays, and mitigating late test failures.

Detailed technical topics that are solicited by each conference component are listed below. Based on the responses to this Call for Papers, these conferences will integrate the AVIATION themes into a detailed technical program. Please refer to the conference website for a listing of the Technical Chairs, and how to contact them.

ATIO Call for Papers (or Technical Topics)

The AIAA Aviation Technology, Integration, and Operations (ATIO) Conference has an established reputation for bringing together aviation professionals, practicing engineers, researchers, and policymakers to explore ideas and share research. Building on this tradition, the AIAA AVIATION 2013 themes will be directly addressed by the 2013 ATIO conference in the following technical topics areas. Commercial, military, business, and general aviation issues will be addressed in a collaborative environment, allowing operators to interact with designers and engineers and researchers to network with government policymakers. The event program will be designed to appeal to senior industry leaders and university students alike.

Global Aviation: Outlook, Opportunities, and Challenges

Aviation, in all of its forms, has transformed the world in countless ways and continues to evolve; improving capability, safety, security, and efficiency through the continued advancement of technology. This track will focus on the future of aviation and will investigate the global market trends, policy issues, technology needs, and societal drivers that are impacting commercial, military, business, general, and unmanned aviation today. Presentations and papers, both technical and more general in nature, are sought addressing the broad spectrum of opportunities and challenges facing the future of aviation. Some topics to consider:

- Market and policy trends that will drive technology development and implementation
- Major challenges to increased capacity, capability, efficiency, and security
- Safety certification of commercial, military, and general aviation aircraft (both manned and unmanned)
- How are unmanned systems changing the nature of civil and military aviation, and what are the societal impacts
- How are economic and investment constraints impacting the business and general aviation markets

Air Traffic Management: Optimization for Capacity, Efficiency, and Safety

Playing a vital role in addressing environmental concerns and transportation issues are the air traffic systems that guide aircraft and transport people and cargo around the globe. Today's Air Traffic Management (ATM) system has been highly optimized based on the interdependencies of safety, capacity, weather, and individual stakeholder goals. There is, however, room for improvement. Research in technologies to increase system and aircraft efficiency and to manage aircraft operations at optimal levels are topics of particular interest for AVIATION 2013. Presentations and papers, both technical and more general in nature, are sought that discuss a broad range of topics related to ATM, including but not limited to:

- Diverse flight trajectory modes of operation (including surface, terminal and en-route, with phases of flight covering departure, climb, cruise, descent and arrival)
- Enterprise architecture systems for communications, navigation, surveillance, flight planning, and air traffic control
- Design and analysis of increasingly complex aviation systems, using integrated system-of-systems methodologies
- System operational efficiency with increased demand/capacity and new aircraft types (such as VLJs, LSAs, unmanned aircraft, and lighter-than-air systems)
- How will the integration of unmanned aircraft systems (UAS) into the NAS impact safety?

- UAS certification standards and regulations
- NextGen and SESAR implementation and integration—successes and challenges

Designing the Fleet for the Market: Integrating the Platform with the Mission

As new technologies move from research and development into operations, an increased emphasis on systems engineering and integration and value-driven design continues to shape aircraft design methodologies. The capabilities provided by advanced computational and analytical methods are being matched by developments in technologies such as materials and propulsion systems, in both military and civil sectors. Papers are sought on everything from design methods to case studies, from system and vehicle level down to detail subsystems. Topic areas include but are not limited to:

- Design synthesis and multidisciplinary optimization
- Advanced systems integration, and the application of systems analysis to aerospace design
- Innovative concepts and technologies (including energy optimized systems, balloons and lighter-than-air systems, electric aircraft, and fuel cell power systems), as expounded by NextGen and SESAR
- Unmanned aircraft systems (UAS) technologies and applications to the market, including
  - Cooperative UAS
  - System of systems architectures, technologies, & applications
  - Sense & avoid strategies and sensors
  - Science applications
- Cost effectiveness and value engineering of aerospace systems

The Energy Imperative: The Impact of Energy on Aviation's Future

Rising fuel costs and pricing volatility has dramatic implications for commercial, civil, and military operations. Experimentation with alternative fuels to hedge price and availability in the long term has gotten a lot of interest and media coverage. Presentations and papers, both technical and more general in nature, are sought that discuss a broad range of topics related to energy, including but not limited to:

- How far can we push efficiency?
- Current state and future of alternative fuels, electric power and propulsion, and other novel concepts
- Achieving operational and mission cost reductions through automation and autonomy
- How will global efficiency regulations impact commercial operators? What technologies are needed to enable compliance?

The Connectivity Challenge: Protecting our Assets in a Networked World

As connectivity continues to increase and benefits from information technology capabilities continue to impact aviation, opportunities for vulnerabilities are also created. Cyber threats to the aviation enterprise provide unique challenges and opportunities. Presentations and papers, both technical and more general in nature, are sought that discuss a broad range of topics related to the policy and technology issues surrounding an increasingly networked aviation endeavor, including by not limited to:

- Security systems for operators, airports and aircraft
- Integrated net-centric operations for Air Traffic Management
- Spectrum management and communications
- Secure GPS navigation

IPLC Call for Papers (or Technical Topics)

Complementing the AIAA AVIATION 2013 program, the International Powered Lift Conference (IPLC) will bring together engineers, technologists, and managers to discuss the latest developments in Vertical and/or Short Take-Off and Landing (V/STOL) aircraft research, concepts, and programs. IPLC 2013 topics will focus on the technologies, promise, and progress of powered lift systems, with applications ranging from helicopters to advanced rotorcraft to runway independent aircraft to jet-borne lift aircraft.

Powered-Lift Aircraft Operations and Their Impact to the Airspace System (Civil and Military)

- Status of current programs/future programs
- Budget sonsiderations on new programs
- Advocacy of powered-lift to the public and political leadership
- Economy of operations/reducing costs
- ESTOL commercial, military, and dual use
- Flight testing experiences, pilot reports
- Certification experiences/new regulations needed

Powered-Lift Design and Design Methodologies

- Modeling and simulation
- Jet-induced effects
- Circulation control aerodynamics and active flow control
- Powered-lift technologies
- JSF/F-35B technologies

Powered-Lift System Integration Technologies and MDAO

- PHM/HUMS
- Integrated flight and propulsion control (IFPC)
  - Green technology and operations
  - Simultaneous non-interfering operations
  - CV and LHA carrier operations and shipboard systems

Powered-Lift Concepts, Air Vehicles, and System Architectures

- Personal air vehicles
- UAV programs and operations
- Super heavy lift rotorcraft/joint heavy lift
- New Army, Navy, NASA, DARPA initiatives
- JSF/ F-35B program overview (emphasis on STOVL)
- History and lessons learned
- Tiltrotor concepts including V-22, BA609, and others
- Advanced rotorcraft concepts

Abstract Submittal Procedures

Abstract submissions will be accepted electronically through the AIAA website at **www.aiaa.org/aviation2013**. Once you have entered the conference website, log in, click "Submit a Paper" from the menu on the right, and follow the instructions listed. This website will be open for abstract submittal starting **1 October 2012**. The deadline for receipt of abstracts via electronic submittal is **28 February 2013**.

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

Questions pertaining to the abstract or technical topics should be referred to the corresponding Technical Program Chair. Authors will be notified of paper acceptance or rejection on or about **9 April 2013**. Instructions for preparation of final manuscripts will be provided for accepted papers.

Abstract Submittal Guidelines

Submittals should be at approximately 1,500 words and in the form of a draft paper. Submittals must clearly describe the purpose and scope of the work, the methods used, key results, contributions to the state of the art, and references to pertinent publications in the existing literature. The submittal should include figures and data that support the results and contributions asserted. Both abstracts and final papers should address adequately the accuracy of the numerical, analytical, or experimental results. Abstracts will be reviewed and selected based on technical content, originality, importance to the field, clarity of presentation, and potential to result in a quality full paper. As such, abstracts should describe clearly the work to be included in the full paper, its scope, methods used, and contributions to the state of the art. The abstract must include paper title, names, affiliations, addresses, and telephone numbers of all authors.

"No Paper No Podium" & "No Podium No Paper" Policies

If a written paper is not submitted by the final manuscript deadline, authors will not be permitted to present the paper at the conference. It is the responsibility of those authors whose papers or presentations are accepted to ensure that a representative attends the conference to present the paper. If a paper is not presented at the conference, it will be withdrawn from the conference proceedings. These policies are intended to eliminate no-shows and to improve the quality of the conference for attendees.

Duplicate Publishing

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

Why Submit a Paper?

Networking

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

Worldwide Exposure

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

Respect

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

Praise

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

Our members network with aerospace leaders from business, government, defense, and academia. Gain access to the latest technical information. Make connections among 35,000 of the best minds in aerospace. And form lifelong professional relationships and friendships in aerospace's premier community of excellence.

Standard Information for all AIAA Conferences

This is general conference information, except as noted in the individual conference preliminary program information to address exceptions.

Photo ID Needed at Registration

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

Conference Proceedings

This year's conference proceedings will be available in an online format only. The cost is included in the registration fee where indicated. If you register in advance for the online papers, you will be provided with instructions on how to access the conference technical papers. For those registering on-site, you will be provided with instructions at registration.

Young Professional Guide for Gaining Management Support

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

Journal Publication

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

Speakers' Briefing

Authors who are presenting papers, session chairs, and co-chairs will meet for a short briefing at 0700 hrs on the mornings of the conference. Continental breakfast will be provided. Please plan to attend only on the day of your session(s). Location will be in final program.

Speakers' Practice

A speaker practice room will be available for speakers wishing to practice their presentations. A sign-up sheet will be posted on the door for half-hour increments.

Timing of Presentations

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

Committee Meetings

Meeting room locations for AIAA committees will be posted on the message board and will be available upon request in the registration area.

Audiovisual

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

Employment Opportunities

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

Messages and Information

Messages will be recorded and posted on a bulletin board in the registration area. It is not possible to page conferees. A telephone number will be provided in the final program.

Membership

Professionals registering at the nonmember rate will receive a one-year AIAA membership. Students who are not members may apply their registration fee toward their first year's student member dues.

Nondiscriminatory Practices

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

Smoking Policy

Smoking is not permitted in the technical sessions.

Restrictions

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

International Traffic in Arms Regulations (ITAR)

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

Upcoming AIAA Professional Development Courses

3 October 2012
This 90-minute webinar will take place at 1300–1430 hrs EST.

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**		
AIAA Members	Nonmembers	Students
$99	$139	$50

Space Radiation Environment **(V. L. Pisacane, Ph.D.)**
This webinar defines the planetary and interplanetary charged particle radiation environment required to assess the effects of radiation on personnel and electronics appropriately. The effects of charged particle radiation are briefly addressed. Equations of motion are presented leading to an understanding of the mechanisms of particle gyration, gyro-frequency, Larmor radius, mirroring, and drift. The trapped radiation, cosmic ray, and solar event environments are then described in detail. Available models for each that are used to simulate the effects on electronics and personnel are presented with references. An understanding of the elements discussed here are important to address the detailed interactions with electronics and personnel that will be covered in a follow on webinar.

10–11 October 2012
This 90-minute webinar will take place at 1300–1430 EDT

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**		
AIAA Members	Nonmembers	Students
$199	$239	$50

Introduction to Communication Satellites and their Subsystems **(Instructor: Edward (Ed) Ashford)**
This webinar presents the basic technologies and designs used in communication satellites, and the system considerations that underlie the selection of a particular type of system. A brief history will be given of the field prior to beginning the coverage of system, economic, and technical aspects. An introduction to the environments encountered in space will be given. The various orbits used for satellite communications will be described along with the pros and cons associated with the selection of any specific orbit(s). There will then be a breakdown given of the various subsystems making up typical communication satellites, with an introduction to the types of technologies used in these. The synthesis and analysis techniques on which the subsystem designs are based also will be described. Finally, the typical test program for a communication satellite will be discussed.

17 October 2012
This 90-minute webinar will take place at 1300–1430 EDT

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**		
AIAA Members	Nonmembers	Students
$99	$139	$100

Overview of Missile Design and System Engineering
(Eugene L. Fleeman)
This webinar presents the fundamentals of missile design, development, and system engineering. It addresses the broad range of alternatives in satisfying missile performance, cost, risk, and launch platform integration requirements. The methods presented are generally simple closed-form analytical expressions that are physics-based, to provide insight into the primary driving parameters. Typical values of missile parameters and the characteristics of current operational missiles are discussed, as well as the enabling subsystems and technologies for missiles. Videos are presented to illustrate missile development activities and performance.

7 November 2012
This 60-minute webinar will take place at 1300–1400 EDT

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**		
AIAA Members	Nonmembers	Students
$89	$129	$40

Flight Dynamics and Einstein's Covariance Principle
(Peter Zipfel, Ph.D.)
The great divide between Newtonian dynamics and Einstein's Relativity is a chimera. Einstein had great respect for Newton and made sure that his theory would converge to Newton's three laws as conditions approach classical proportions. Flight dynamics, which is based on Newton's laws, is no exception. During a one-hour perambulation, I will acquaint you with Special and General Relativity as it applies to classical dynamics. Modeling of flight dynamics benefits greatly from such a vantage point. The physics of the problem are separated from its computational aspects. Tensors—independent of coordinate systems—model the physics, while matrices, created from these tensors by introducing coordinate systems, are coded for execution.

14 November 2012
This 90-minute webinar will take place at 1300–1430 EDT

To register, go to **www.aiaa.org/CourseListing.aspx?id=3200.**		
AIAA Members	Nonmembers	Students
$99	$139	$50

Risk Analysis and Management **(Dr. Vincent L. Pisacane)**
This course is intended for technical and management personnel who wish to gain an understanding of techniques that can be implemented to minimize premature failure of space systems. It first identifies selected typical space system failures and their causes. Failure analyses includes the Weibull distribution and its failure rate, mean time to failure, hazard function reliability (survival) function, and conditional, reliability function. Mitigation techniques discussed includes burn in and risk management techniques that includes failure identification, fault tree analyses, event tree analyses, failure modes and effects analyses, failure modes and effects analyses, and risk matrices.

6 December 2012
This 90-minute webinar will take place at 1300–1430 EDT

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

AIAA Members	Nonmembers	Students
$99	$139	$50

Advanced Composite Materials and Structures

(Carl Zweben, Ph.D.)

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

5–6 January 2013
The following Continuing Education courses are being held at the 51st AIAA Aerospace Sciences Meeting in Grapevine, TX. Registration includes course and course notes; full conference participation: admittance to technical and plenary sessions; receptions, luncheons, and online proceedings.

To register for one of the ASM 2013 courses, go to
www.aiaa.org/asm2013.

	Early Bird by 10 Dec	*Standard (11 Dec–4 Jan)*	*On-site (5 Jan)*
AIAA Member	$1295	$1395	$1495
Nonmember	$1400	$1500	$1600

Specialist's Course on Flow Control

(Instructor: David Williams, Professor of Mechanical, Materials & Aerospace Engineering Department, Director of Fluid Dynamics Research Center, Illinois Institute of Technology, Chicago, IL; Daniel Miller, Technical Lead and PI for Propulsion Integration R&D, Lockheed Martin Skunk Works, Bainbridge Island, WA; Dr. Kunihiko Taira, Assistant Professor, Department of Mechanical Engineering, Florida A&M/Florida State University, Tallahassee, FL)

The techniques of active flow control are becoming more sophisticated as fluid dynamics, control and dynamical systems theory merge to design control architectures capable of solving challenging flow control applications. The two-day course will examine advanced topics in active flow control, placing particular emphasis on "how to do flow control." This new course will complement the more fundamental AIAA Short Course on "Modern Flow Control." Modern dynamical systems and control theory related to closed-loop flow control and performance limitations will be discussed. State-of-the-art actuator and sensor design techniques will be covered. Two case studies will be presented that describe recent success stories about the implementation of active flow control on advanced aircraft. The six course lecturers have extensive backgrounds in flow control, coming from industry and academia.

Six Degrees of Freedom Modeling of Missile and Aircraft Simulations

(Instructor: Peter Zipfel, Adjunct Associated Professor, University of Florida, Shalimar, FL)

As modeling and simulation (M&S) is penetrating the aerospace sciences at all levels, this two-day course will introduce you to the difficult subject of modeling aerospace vehicles in six degrees of freedom (6 DoF). Starting with the modern approach of tensors, the equations of motion are derived and, after introducing coordinate systems, they are expressed in matrices for compact computer programming. Aircraft and missile prototypes will exemplify 6 DoF aerodynamic modeling, rocket and turbojet propulsion, actuating systems, autopilots, guidance, and seekers. These subsystems will be integrated step by step into full-up simulations. For demonstrations, typical fly-out trajectories will be run and projected on the screen. The provided source code and plotting programs lets you duplicate the trajectories on your PC (requires FORTRAN or C++ compiler). With the provided prototype simulations you can build your own 6 DoF aerospace simulations.

Systems Engineering Verification and Validation

(Instructor: John C Hsu, CA State University, The University of CA at Irvine, Queens University and The Boeing Company, Cypress, CA)

This course will focus on the verification and validation aspect that is the beginning, from the validation point-of-view, and the final part of the systems engineering task for a program/project. It will clarify the confusing use of verification and validation. Familiarize yourself with validating requirements and generating verification requirements. Start with the verification and validation plans. Then learn how to choose the best verification method and approach. Test and Evaluation Master Plan leads to test planning and analysis. Conducting test involves activities, facilities, equipments, and personnel. Evaluation is the process of analyzing and interpreting data. Acceptance test assures that the products meet what intended to purchase. There are functional and physical audits. Simulation and Modeling provides virtual duplication of products and processes in operational valid environments. Verification management organizes verification task and provides total traceability from customer requirements to verification report elements.

Technical Committee Nominations

Membership nominations are now open for AIAA Technical Committees (TC) for 2013/2014. Our TCs have between 30 and 35 members each. Nearly one-third of the members rotate off the committees each year, leaving six to ten openings per TC.

The TC chairs and the Technical Activities Committee (TAC) work diligently to maintain a reasonable balance in (1) appropriate representation to the field from industry, research, education, and government; (2) the specialties covered in the specific TC scopes; and (3) geographical distribution relative to the area's technical activity. TAC encourages the nomination of young professionals, and has instituted a TC associate member category (see associate membership guidelines). Associate members, with identified restrictions, are included on TCs in addition to the 35 regular member limit.

If you currently serve on a TC, do not nominate yourself. You will automatically be considered for the 2013/2014 TC year.

Enclosed are instructions for nominations as well as the form needed. Please feel free to make copies as necessary. Nominations may also be submitted online. The TC nomination form can be found on the AIAA Web site at **www.aiaa.org**, under My AIAA, Nominations and Voting. We look forward to receiving your nominations. If you have any questions or need more forms, please call Betty Guillie at 703.264.7573.

Nominations are due by **1 November 2012**.

Current AIAA Technical Committees

Adaptive Structures

Aeroacoustics

Aerodynamic Decelerator Systems

Aerodynamic Measurement Technology

Aerospace Power Systems

Air Breathing Propulsion Systems Integration

Air Transportation Systems

Aircraft Design

Aircraft Operations

Applied Aerodynamics

Astrodynamics

Atmospheric & Space Environments

Atmospheric Flight Mechanics

Balloon Systems

Communications Systems

Computer Systems

Design Engineering

Digital Avionics

Economics

Electric Propulsion

Energetic Components & Systems

Flight Testing

Fluid Dynamics

Gas Turbine Engines

General Aviation

Ground Testing

Guidance, Navigation & Control

High Speed Air Breathing Propulsion

History

Hybrid Rockets

Information and Command & Control Systems

Intelligent Systems

Legal Aspects of Aeronautics & Astonautics

Life Sciences & Systems

Lighter-Than-Air Systems

Liquid Propulsion

Management

Materials

Meshing, Visualization & Computational Environments

Microgravity & Space Processes

Missile Systems

Modeling & Simulation

Multidisciplinary Design Optimization

Non-Deterministic Approaches

Nuclear & Future Flight Propulsion

Plasmadynamics & Lasers

Product Support

Propellants & Combustion

Sensor Systems

Society & Aerospace Technology

Software

Solid Rockets

Space Architecture

Space Automation & Robotics

Space Colonization

Space Logistics

Space Operations & Support

Space Resources

Space Systems

Space Tethers

Space Transportation

Structural Dynamics

Structures

Survivability

Systems Engineering

Terrestrial Energy Systems

Thermophysics

V/STOL Aircraft Systems

Weapon System Effectiveness

Instructions for Completing Technical Committee Nomination Forms

1. Submit one nomination form for each nominee. Nominees who are not selected for committee membership for 2013 will automatically be considered for membership in 2014. As the nomination forms are held for an additional year, it is not necessary to resubmit a form for someone not selected for the 2012/2013 term. You may send updated information to be attached to an existing nomination form.
2. You do not have to be nominated by someone else; you may submit an application for yourself.
3. A resume or biographical data must be attached and submitted with the nomination form.
4. Membership is usually restricted to one technical committee (TC) at a time. If you nominate someone to more than one committee, use one form. All information should be detailed and complete. Please list each TC for which you wish to be considered. It is recommended that you do not apply to more than 2 TCs at a time. This form will be duplicated at AIAA and sent to each TC indicated. In the event of selection by more than one TC chair, the nominee will be contacted to select one committee for membership.
5. The Technical Activities Committee (TAC) strongly suggests that special consideration be given to members 34 years of age and under or who obtained their professional degree less than 10 years ago. See attached Technical Committee Associate Membership Guidelines.
6. All TC members must join AIAA (if they are not already members) within 45 days of their appointment to a technical committee.
7. TC membership is generally for one year with two additional years possible, but contingent upon committee participation, ongoing projects, and AIAA membership. It is not necessary to send a new nomination form for someone who is already on a committee. All committee members are automatically considered for a second and third year of membership.
8. Deadline for receipt of nominations is **1 November 2012**. Nominations received after this date will be held for consideration until the next year.

Technical Committee Associate Membership Guidelines

1. Associate membership is restricted to those who have not yet reached their 35th birthday, or who obtained their professional degrees less than 10 years ago.
2. Associate membership is a one-year term renewable to three years.
3. Associate membership is restricted to current AIAA members.
4. Selection to associate membership is based on technical merit. The associate members should show promise within the field of the technical committee.
5. Associate members may attend TC or subcommittee meetings and will assist in carrying out committee work.
6. At the discretion of the TC, associate members may be assigned a volunteer full member as a counselor. The counselor will advise and guide the associate member on TC procedures and activities.
7. Associate members will have no voting privileges on the TC, but may (with consent) act as a substitute for their counselor.
8. Associate members will not count toward the TC membership limit.
9. Application forms for associate membership are the same as those of full membership, but a resume is a required attachment. Applicants for full membership who were not selected may be considered associate members provided they meet the age restriction.
10. At least two associate members should be appointed to each TC. At no time should the number of associate members exceed that of full members.
11. An endorsement form from the nominee's department head, indicating that the nominee may travel to two meetings per year and have some time to devote to committee business, must accompany each nomination form.

Send nominations to:

AIAA TC Nominations
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344

AIAA
The World's Forum for Aerospace Leadership

AIAA TECHNICAL COMMITTEE (TC) NOMINEE FORM

Please submit one copy (photocopies are acceptable) of this form, and one copy of nominee's resumé to: AIAA Technical Committee Nominations, 1801 Alexander Bell Drive, Reston, VA 20191. Fax number is 703.264.7551. Form can also be submitted via our web site at www.aiaa.org, My AIAA, Nominations and Voting

For additional information about AIAA Technical Committees, please see https://www.aiaa.org/secondary.aspx?id=458

Date__________________

Name: Mr/Ms/Dr/Prof____

Title ______________________________________

Are you applying for an associate membership? (Yes/No)________
Associate membership is available only for members under 35 years.

Organization ____

Address ____
____
____

Telephone ____________________ Fax _________________

E-mail ____

Home Address ____
____
____

Home phone (to be used by TC chairman only - not published)
____

Preferred mailing address: (This is the address where your Aerospace America and Technical Journals will go, and this is the address that will be published in the Technical Activities Roster)
( ) Business ( ) Home

Technical Activities Committee

College or University ____

Degree ______________________________________Year __________

Major/Field of Study ____

Graduate degrees: ____

College or University __________________________Year __________

AIAA Membership Grade and Number __________________________
You must be a current member of AIAA to join a Technical Committee.

Are you currently a member of any AIAA Technical Committee? Yes / No

If yes, what technical committee are you a member of, and when does your term end?____
____

Individuals should not apply for membership on more than 2 Technical Committees at the same time.
Individuals are not allowed to join two Technical Committees simultaneously. After you have been a member of a Technical Committee for at least 1 year, you may apply to join a second Technical Committee.

Please list the TC(s) you are interested in joining in priority order:
1.____
2. ____

Please explain briefly why you would like to join these Technical Committees, any activities associated with these Technical Committees that you are currently supporting, and what you hope to accomplish as a member of the Technical Committee.

____
____
____
____
____

AIAA
The World's Forum for Aerospace Leadership

Technical Activities Committee

Please list activities you have been active in that are relevant to the Technical Committee charter ______________________________

____

____

AIAA offices held ______________________________

____

____

Membership in other societies, committees, boards, or other AIAA activities

____

____

____

Primary professional interest ______________________________

____

____

Secondary professional interests ______________________________

____

____

Positions held pertinent to above ______________________________

____

____

Professional publications (attach additional pages if necessary)

____

____

____

Honors and/or awards ______________________________

____

____

Please provide a brief description on what projects you have recently worked on or are currently working on ______________________________

____

____

____

____

Nomination submitted by (if other than self)

____

Title ______________________________

Organization ______________________________

Address ______________________________

____

E-mail ______________________________

Please feel free to attach separate sheets as needed. If you have any questions, please contact Technical Activities at 703.264.7573.

ENDORSEMENT

This form must be signed by the nominee's supervisor to document the understanding of time and travel commitments.

I endorse the nomination of ______________________________

for membership on the ______________________________

______________________________ Technical Committee.

I understand that he/she will be expected to commit time and travel resources to support committee activities and meetings.

SIGNATURE ______________________________

NAME ______________________________

TITLE ______________________________

ORGANIZATION ______________________________

TELEPHONE ______________________________

National Aeronautics and Space Administration

NASA TECHNOLOGY DAYS

NOVEMBER 28–30, 2012

PUBLIC AUDITORIUM
CLEVELAND, OH

Come join NASA for “Technology Days” in Cleveland, OH, November 28–30, 2012.

AEROSPACE

ADVANCED ENERGY

HUMAN HEALTH

INNOVATIVE MANUFACTURING

AUTOMOTIVE

Engage NASA leaders about the Space Technology Program’s objectives, successes and future plans. This 3-day event and technology showcase will bring together a broad community of stakeholders from industry, academia, and the U.S. government to engage in strategy development, partnership building, and implementation of ways to foster technology transfer and innovation.

Registration is now open!

For more information visit

www.aiaa.org/NASATechDays

AIAA
The World’s Forum for Aerospace Leadership

National Institute of Aerospace

www.nasa.gov