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American Astronautical Society
6352 Rolling Mill Place, Suite 102
Springfield, VA 22152-2354 USA
Tel: 703-866-0020 Fax: 703-866-3526
aas@astronautical.org www.astronautical.org

The Banality of Success

Like many others involved in space activities, I have found it discouraging to see the waning of our nation's attention given to space events. As shown on the recent Discovery channel miniseries When We Left Earth, in the Apollo era, hundreds of thousands would converge on Cape Canaveral to witness America's earliest efforts to send humans into space. A Shuttle launch will still draw a decent crowd these days, but they are nothing like they used to be. The missions and spacewalks performed by astronauts at the International Space Station rarely generate significant public attention. Interplanetary probes continue to make amazing discoveries long after the initial flush of attention has faded.

To be certain, new developments such as the Phoenix lander's arrival on Mars do generate flurries of twittering and increased hits at the JPL web site. Still, such activity pales against what would have occurred in the past. Does this lack of excited interest mean that our nation is less supportive of NASA's space exploration efforts and other space activities?

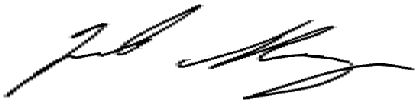
I would strongly argue that this is not the case. In fact, I believe that the public's apparently blasé attitude towards space should be a source of pride. In the early years of the twentieth century, thousands would descend on fields to witness the arrival of airplanes and the often dramatic aerial acrobatic performances by barnstormers. Now, aircraft many times faster and larger routinely take off and land with zero public attention - unless they are meeting someone on a delayed flight.

Does this mean the American people do not support air travel? Of course not. It merely indicates that in the early years of the twenty-first century, air transportation is a mature means of conveyance. It is consequently unremarkable, just as the modern equivalents of the ships that would have once attracted large crowds to the port of colonial Jamestown are now confined to port areas miles away from cities.

We in the AAS and other space supporters are, in reality, victims of our own success. We are often frustrated when we cannot generate the same excitement in space activities as our predecessors did. It is important to recognize, however, that our inability to do so is not failure. Rather, it is a measure of our success. Space transportation has become so routine that we expect it to work every time, despite physical realities which have not changed, and still cause space travel to be difficult.

I recently took my two young children to watch the launch of a Delta II rocket at Vandenberg Air Force Base in California. I have seen dozens of launches, but this was the first for my children. Despite how much my children have heard (and also viewed on TV, DVD, and video) about launches, it was remarkable to witness their astonishment at what most now take for granted – that is, what goes up does not necessarily come down. Most people may now see space travel as routine, which is progress. In witnessing it through the eyes of my children, though, I was reminded of its wonder.

AAS – Advancing All Space



Frank A. Slazer
digaslaze@mac.com

ON THE COVER

FRONT: A delicate ribbon of gas floats eerily in our galaxy. This image, taken by NASA's Hubble Space Telescope, is a very thin section of a supernova remnant caused by a stellar explosion which occurred over 1,000 years ago. The image is a composite of observations captured in 2006 and 2008 using the Advanced Camera for Surveys and the Wide Field Planetary Camera 2. *(Source: W. Blair (JHU), NASA, ESA, and the Hubble Heritage Team (STScI/AURA))*

BACK: Lightning from storms in late June sparked dozens of wildfires in California. This image by the MODIS instrument on the Terra satellite shows the fires on July 8, 2008. The red dots show the locations of active fires. Many of the fires have visible gray plumes of smoke rising from them, and a great deal of smoke has drifted over the Pacific Ocean. *(Source: Jeff Schmaltz/MODIS Land Rapid Response Team/NASA GSFC)*

Lessons from Apollo, Space Shuttle, International Space Station, and the Hubble Space Telescope: Learning from These Great Legacies

by Frank J. Cepollina

"Make no little plans. They have no magic to stir men's blood. ... Make big plans; aim high in hope and work." –Daniel H. Burnhan, Architect

"It is dumb to launch complicated, expensive telescopes into space that cannot be serviced." –Michael Griffin, NASA Administrator

The advent of NASA's Constellation Program offers great opportunities for the space science communities. Now is the critical point when the Constellation Program can become even more broadly relevant than originally planned through the incorporation of on-orbit servicing into its mission. The Shuttle (STS) program has demonstrated the feasibility and importance of on-orbit servicing, as well as criticality of the human factor in maintaining, repairing, and upgrading valuable space assets. The lessons learned from the Shuttle program, and particularly from the Hubble Telescope servicing missions, should be incorporated into the Constellation Program to provide significant benefits to the scientific community and to broaden the public appeal of human spaceflight.

In 2004, President George W. Bush announced the Vision for Space Exploration (VSE). He directed NASA to complete the International Space Station (ISS), return humans to the lunar surface in preparation for the long voyage to Mars, embark on a long-term human and robotic program to explore the Solar System, and search the universe for Earth-like worlds. This article examines a key theme enunciated by the White House in directing NASA's future. That theme is to achieve major national goals in space using humans, whether in space or on the Earth's surface, along with robots and autonomous systems. In addition, I identify how early investments and modest augmentations will make NASA's Constellation architecture more widely useful and publically appealing than is presently the case. These investments and augmentations will also lay the groundwork for further, more ambitious goals for NASA. In essence, I am advocating an additional, valuable emphasis for the Constellation Program.

A Bit of History

NASA recognized the adaptability of human spaceflight vehicles to achieve multiple goals early in the Apollo Program. In the mid-1960s, a variant of the Lunar Module (LM) was proposed to the Apollo Applications Program as an Earth-orbiting scientific laboratory. This version of the LM had its engines and propellant tanks removed (see Figure 1) to provide space for experiments and as many as ten tons of scientific equipment. Its estimated two-week low-Earth orbit (LEO) mission lifetime was comparable to that of the lunar surface missions of the time. During the proposed mission, astronauts could carry out numerous stellar and solar experiments, most of which would take advantage of having humans to operate the complex instruments proposed for this facility.

Due to fading public interest in (and political support for) the Apollo program, this configuration never flew, although a variant became the Apollo Telescope Mount for the Skylab mission in 1973. Skylab successfully demonstrated how astronauts and augmented human spaceflight hardware could achieve multiple major science goals while simultaneously functioning as a "stepping stone" for even more ambitious in-space operations. A similar philosophy has been adopted more recently by several ad hoc working groups around the country: achieving important goals not originally incorporated within the human spaceflight program via adaptation of the new hardware.

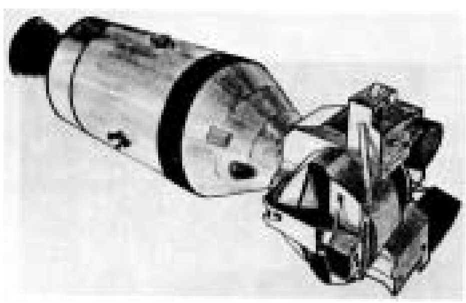


Figure 1. Modifying the Apollo Lunar Module to permit astronaut-tended scientific missions. The Apollo Applications Program in 1965 and 1966 developed concepts that broadened the applicability of hardware developed primarily for sending humans to the lunar surface. (Source: NASA)

As the Apollo program was completed and Skylab became operational, NASA began the Space Shuttle program. As was the case with the Apollo vehicles, members of the science and human spaceflight communities urged early investment in Shuttle capabilities that would broaden that vehicle's value beyond its most immediate and narrowly defined goals. Figure 2 shows an early satellite-servicing concept. By adopting capabilities such as special tools, a highly capable robotic arm, the ability to approach and rendezvous with a variety of spacecraft, and especially the demonstrated adaptability of astronauts, NASA developed a spacecraft that achieved far more than its original designers had conceived.

Figure 2. Early design for augmenting the Space Shuttle for satellite servicing. Capabilities not originally planned for the program were made possible by coordinated advocacy by the science and human spaceflight communities. These augmentations broadened the value of the vehicle to NASA and achieved major science goals not otherwise possible. (Source: NASA)

The Shuttle offered very large mass-return and volume-return capabilities, enabling scientific and human spaceflight experiments requiring return to Earth (e.g., SpaceLab, SpaceHab). These enhanced capabilities allowed for the on-orbit rescue and significant upgrade of numerous satellites, most notable of which is the Hubble Space Telescope (HST). The repeated on-orbit servicing of Hubble is NASA's most dramatic, publicly engaging, and scientifically valuable example of employing humans in space to achieve science goals. The lessons for NASA seem clear.

But interestingly, the Shuttle in its initial design architecture had very few services it could provide to payloads. For example, it had only one power and data umbilical, no latchdown provisions and no means of grappling a spacecraft in flight (no RMS arm). It was not until the advent of a payload pathfinder mission for Shuttle that provisions began to be incorporated in order to make STS more user-compatible. Solar Max was the pathfinder modular spacecraft for STS. Four years later, HST incorporated many of the same modularity and external carrier and interface features of Solar Max and became the flagship mission for STS repair and upgrade capabilities.

From 1976 to 1984, modularity of systems and external interfaces were the primary catalysts for on-orbit satellite servicing. From 1985 to 2002, there were nine servicing missions—Solar Max, Syncom IV, Westar/Palapa, Compton GRO, Intelsat IV, and four to Hubble Space Telescope. In late 2008, the fifth servicing mission to Hubble Space Telescope will demonstrate the improved Extravehicular Activity (EVA) efficiencies, including advanced, miniature tools, equipment caddies and tool boards, quick release latches, tool-less latches, and on-orbit repair that has progressed to the circuit board level. These missions show that architecture, incorporating standardized modularity, is the single most significant aspect of cost.

Since 1984, we have learned the value of repair in orbi,t and have evolved human interaction to ever more demanding and complex tasks. We have discovered that it truly does not cost more money to make serviceable telescopes. Modular architecture results in lower ground ground-based I&T costs and easier in-flight hardware upgrades. Historically, no funds for servicing were in the budget during development, yet Solar Max, Weststar/Palapa, Syncom IV, Compton Gamma Ray Observatory, Intelsat VI were successfully serviced.

Thus, every major human spaceflight program since the mid-1960s has been significantly modified and upgraded to achieve multiple goals beyond those originally planned. Each leap in technology springboards the next leap in technology. The concept of close collaborative programs of scientific discovery and human exploration, enabled by long-term technology investments, were the basis of a series of "stepping stones" developed about a decade ago for NASA senior management by the Decadal Planning Team (DPT) and its successor, the NASA Exploration Team (NExT).

Contrast with Current Plans

Beginning in the late summer of 2004, small NASA, academic, and industrial teams have proposed options, augmentations, and upgrades to the early designs of the Orion/Crew Exploration Vehicle (CEV) that would permit in-space servicing and replace some of the capabilities that will be lost when the Shuttle is retired in a few years. These proposals from NASA's stakeholders and likely international partners often include development plans for near-term technology investment, precursors, demonstration missions, and pathfinder programs to achieve critical goals over the next few years. They also seek to extend human activities beyond the ISS, even before humans are returned to the lunar surface.

NASA's implementation plan of the Vision for Space Exploration is the Constellation Program. This program is strictly focused on replacing the aging Space Shuttle and retaining a national capability to ferry astronauts to the International Space Station. About a decade from now, according to current plans, this capability will be expanded to return humans to the lunar surface. The components of the Constellation architecture consist of the Ares I and V, the Orion/Crew Exploration Vehicle, the in-space transfer stage, and the Altair lunar landing system.

Orion, the Crew Exploration Vehicle, will be capable of carrying crew and cargo to the ISS. It will be able to rendezvous with a lunar landing module and an Earth departure stage in low-Earth orbit to carry crews to the Moon and, far in the future, to Mars-bound vehicles assembled in low-Earth orbit. Orion will be the Earth-entry vehicle for returns from the Moon and Mars.

Altair will be capable of landing four astronauts on the Moon, providing life support and a base for week-long surface exploration missions. It shall also return the crew to the Orion spacecraft, which will bring them home to Earth. Altair will launch aboard an Ares V rocket into low Earth orbit, where it will rendezvous with the Orion crew vehicle.

Additional opportunities enabled by the Constellation architecture are being actively explored by the science community to achieve major science goals that are not otherwise possible. Examples of these efforts include workshops sponsored by the Space Telescope Science Institute, a workshop supported by the NASA Advisory Committee (NAC) in Tempe, Arizona in March, 2007, and international conferences in the United Kingdom and France during the past year. Furthermore, the National Research Council is currently considering a large number of formal concepts for major science goals enabled by the Constellation architecture.

A consensus is emerging that, although human operations on the lunar surface offer distinct advantages for a handful of important science programs, the Constellation architecture has potential to enable very major science facilities throughout the Earth-Moon system. Consequently, most of the recommendations developed via these multiple meetings encourage NASA to begin to assess in a substantive way how the Constellation Architecture might be evolved to achieve multiple goals, building upon the costly and hard-won experience with construction of ISS and servicing of HST. This experience shows that rapid improvement in technology leads to big science discoveries - but only if we can get this new technology to orbit quickly.

In our experience, the most significant contributions of major science discoveries have occurred as humans worked together during the Telescope servicing missions, and when advanced detector and spacecraft hardware were brought to orbit for those servicing missions. For example, new technology has transformed HST's capabilities with all four servicing missions to date. This technology includes:

- 4,754% increase in detector technology
- 2,400% increase in computational power
- 1,633% increase in onboard data storage
- 455% increase in infrared science
- 150% increase in number of scientific instruments operating simultaneously
- 00% increase in gyros flex lead life
- 57% increase in safemode energy margin
- 50% increase in gyro redundancy margin
- 35% increase in power generation
- 30% gain in Fine Guidance Sensor performance
- 10% increase in thermal margin for electrical units.

Also, by using new application-specific integrated circuit (ASIC) technology, detector noise-limited observations for HST's Advanced Camera for Surveys will potentially double following its repair.

The improvements to Hubble over its lifetime include eleven new and three repaired science instruments. This fresh, sophisticated technology brought to orbit in three- or four-year cycles is what has enabled new scientific discoveries.

To date, NASA has carried out relatively limited assessments regarding how its Constellation architecture could extend human and robot capabilities in free space. Here I describe some concepts that have been presented to NASA by teams that have adopted the philosophies of innovators working with the human spaceflight program for the past 40 years. These philophies include building upon existing experience, adapting new facilities to achieve multiple goals, and beginning early! NASA has taken a very positive first step by incorporating a Soft Capture Mechanism on the back end of Hubble to effect soft capture by an Orion-type vehicle in the future for either de-orbit or emergency repair capability. This mechanism is shown in Figure 3.

Enabling the Future: Augmenting the Constellation Architecture

The Vision for Space Exploration directs NASA to operate very large optical systems in space to search for Earth-like worlds. This technological goal was also included by the National Research Council in its last decadal review for astronomy and astrophysics. Large optics, either as segmented, filled apertures or as spatial in-

Figure 3: The Soft Capture Mechanism will be installed on the back end of Hubble during SM4 to effect soft capture by an Orion-type vehicle in the future for either de-orbit or emergency repair capability. It is circled in red for ease of identification. (Source: HST Development Office, NASA)

terferometers, are also highlighted as technological goals in the most recent (2007) Science Plan for NASA's Science Mission Directorate. A large optical system (and its precursors) in space would constitute perhaps the premier astronomical observatory of the 21st Century, able to carry out numerous science programs in addition to those identified for NASA in the VSE.

Such future telescopes may be far larger than can be launched as a single monolith, so the capability to assemble in space will be highly desirable. Furthermore, expensive and complex facilities, whether in free space or on the lunar surface, are likely to require significant external involvement by astronauts and/or robots to ensure that taxpayer investment will be well used. After years of assessment and discussion, the astronomy community is concentrating on the second Sun-Earth libration point (S-E L2) as the optimum site for major observatories for the foreseeable future. Consequently, the capability to operate with robots and/or astronauts throughout cis-lunar space seems to be an essential operational capability in achieving future priority astronomical goals.

In addition, operating with humans and robots at the Earth-Moon libration points may provide valuable support for contingencies or emergencies on the lunar surface. This could spell the difference between success and failure for major science missions, just as has been the case for terrestrial exploration programs. Repair equipment and back-up systems that may not need to be immediately available may more cost-effectively be "warehoused" in space until needed. Similarly, serious medical emergencies on the lunar surface appear to be far better treated on-site, within a gravity well, without subjecting patients to brutalizing transportation back to Earth. Hypothetically, a well-stocked "emergency-room-in-a-can" may be kept on-orbit, perhaps never to be used, but ready to be sent to the lunar surface if required. Thus, for example, a single storage and work site at one of the Earth-Moon

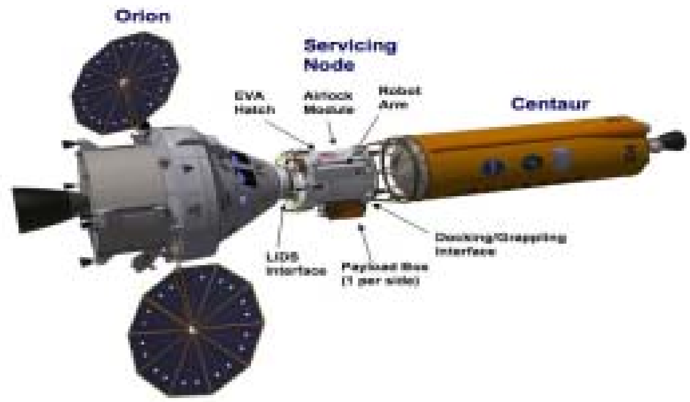


Figure 4. An Orion/Crew Exploration Vehicle that would be able to operate throughout cis-lunar space (Thronson, Lester, and Budinoff, 59th International Astronautics Conference). From left to right, a Centaur transfer stage, a servicing node designed around the Altair airlock system, and an Orion CEV. The Centaur and Servicing Node are launched by an Ares I vehicle to rendezvous with an Orion already in LEO via a previous Ares I launch. (Source: Thronson et al., 59th International Astronautical Congress)

libration points may make more logistical sense than landing expensive, rarely used resources at multiple locations where astronauts or robots are working.

One measure of the relative value of various locations in the Earth-Moon system is the velocities required to travel from one location to another. NASA's Decadal Planning Team in 1999-2000 examined a series of architectures for human exploration beyond the immediate vicinity of the Earth with an emphasis on flexibility to achieve multiple goals, as opposed to traveling to a single destination.

A near-future application of hardware developed for the Constellation program may be in-space telerobotics operated from the Earth's surface, or from a modestly modified Orion/Crew Exploration Vehicle (CEV). One capable concept is shown in Figure 4. The Orion/CEV in this concept is launched with two astronauts to low Earth orbit, where it later docks to a Centaur/servicing node assembly launched by a second Ares I vehicle. The combined propulsion of the Centaur and Orion service module is sufficient for the stack to travel throughout cis-lunar space. This is one of a series of variants of the Orion system that have been proposed over the years to enable astronaut-based servicing with telerobotics assistance at, for example, an Earth-Moon libration point jobsite.

To cover the entire span from 2015 to 2035, I have suggested a phased approach, shown below, in Table 1.

Table 1. Phased Approach

Phases	Span of Years	Size of Optical Telescope	Assembly
Phase I	2010-2015	2-3 Meters	Servicing Only
Phase II	2015-2025	10 Meters	LEO
Phase III	2025-2035	16 Meters or Larger	In-Situ (e.g., Libration Points)

Orion/CEV alone is limited to contingency or emergency EVA. In any case, it is a very constrained environment with a limited lifetime. To enable extended capabilities, Thronson, et al., have proposed adapting a servicing node designed around the airlock system that will be developed for the Altair lunar lander. This will provide additional pressurized volume, storage areas, consumables, and an airlock for astronaut EVA. The design also uses the NASA GSFC-developed "carriers" concept intended to permit modest additional cargo on Orion. A very preliminary estimate of the combined Orion-servicing node suggests that 14–21-day missions can be supported for two astronauts.

With the capability to carry things to an orbiting facility - whether with robots or the Constellation crew vehicle - changes, upgrades, servicing, repair, recovering, and rescue can be accomplished. With careful management, brand new technologies can be taken to orbit on a planned, periodic basis. Hardware wears out, and technology becomes outdated. The ability to upgrade is a real asset, because technology for items such as detectors, optics, electronics, computers, and communication systems continues to improve exponentially. As we have learned through Hubble and other on-orbit servicing, astronomical observatories or other satellites can be kept useful and relevant. They can be brought to the cutting edge of technology in order to address the latest scientific questions.

Just as was the case with the Apollo Applications Program forty years ago, NASA must continue to think ahead. Many of us believe that the Constellation architecture is capable of more than merely being a ferryboat from the Earth's surface. NASA needs to start thinking now about how to modify and augment Orion to make in-space servicing possible. A grapple arm fixture and a storage location to carry reasonably sized instruments can be designed into Orion now, as shown in Figures 5. Trying to do it ten years from now, when the hardware is built and moving out to the Kennedy Space Center, will be too late and too expensive. If the investment is already being made for transportation, we should ensure that the capabilities for servicing are also present.

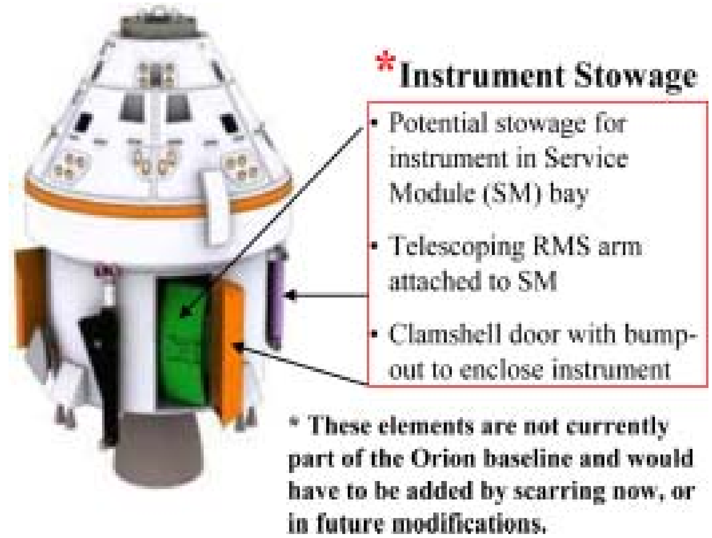


Figure 5. Instrument Stowage, a telescoping arm, and a modified door are not currently a part of the Orion baseline (Source: HST Development Office, NASA)

Near-term investments, demonstration missions, and pathfinders must begin within the next very few years to take advantage of existing, perishable experience, to demonstrate the value of astronaut operations in free space, and to expand public support for the Constellation program. Every NASA Program and Project Manager, including those on the Constellation Program, must look toward the future as they prepare hardware, so that they can take advantage of systems as they come online. The potential for upgrading systems must not be precluded.

In the case of Phase III, in situ servicing of telescopes 16 meters or larger (Figure 6), astronauts and advanced space robots will operate throughout the Earth-Moon system for long periods of time, taking advantage of the heavy-lift capability of the Ares V launch vehicle. During the same timeframe, NASA plans to have the capability for extended lunar-surface operations with astronauts. Phase III concepts, especially robotics to achieve major science goals, can be used to identify priority technologies in which NASA currently can be investing.

For the Crew Exploration Vehicle, designers should provide points for attachment and the capability of controlling robotic systems from the vehicle. Cargo storage provisions need to be added to the service module. If architecture cannot be designed with a general purpose, widely applicable system, it should at least be designed for easy upgradability in the future. Observatories also need to be designed with higher degrees of modularity. For example, it makes no sense to bury a fine guidance telescope control system in the middle of an instrument or instrument cluster. Program cost would skyrocket if one had to deintegrate and reintegrate such a science instrument to repair a failed control system component on the ground. Now, imagine the cost of such a situation on orbit.

Conclusions

NASA must begin studying how the Orion can continue the benefits of human exploration, and this must be done in parallel with Orion development and a science pathfinder mission. But time is of the essence. Preparations must begin now. On-orbit servicing by astronauts has saved NASA million of dollars in space assets, yet the savings of science otherwise lost is priceless.

The nation's leaders have directed NASA to extend human operations beyond the Earth's surface, complete the remarkable International Space Station, replace the aging Space Shuttle, return humans to the lunar surface, one day travel with humans to Mars, and achieve major scientific goals - all within a very constrained budget. History has shown that the elements of the human spaceflight architecture can be adapted to achieve goals in space beyond those originally planned, which in turn meant that "limited resources" was not synonymous with "limited achievement." Although to date, NASA has concentrated its design and development work on a concept for the Constellation architecture that will be initially focused on ferrying astronauts to the ISS, numerous ad hoc groups have explored augmented capabilities. These designs have in common:

1. Early detailed assessment of augmented capabilities offered by the Constellation architecture, along with a plan to deploy astronauts and robots for in-space servicing of expensive space assets as soon as the capability exists, presumably around the middle of the next decade.

2. Extending the capabilities of the Constellation architecture—specifically the Orion/CEV and lunar habitation module—to operate for weeks at time throughout the Earth-Moon system, perhaps even before humans return to the lunar surface. Forty years ago, with Apollo missions 7, 8, 9, and 10, NASA's human spaceflight leaders chose to assess in depth the performance of their designs before sending humans into the deep gravitational well of the Moon.

3. Preparation for longer human voyages beyond the vicinity of the Earth-Moon system, for example to Mars or the infrequent Near-Earth Objects (NEOs). Human occupation of the Moon's surface has been identified as a necessary "stepping stone" before humans travel further into space. At the same time, successful operations with humans in free space seems equally necessary before we undertake long, challenging voyages of many months in duration. Increasingly capable servicing, repair, upgrade, and assembly with an augmented Constellation system in the Earth-Moon system may be essential preparation for even more ambitious human missions.

4. Initiation of a sustained program of investment in the technologies necessary for space robotics, either with astronaut partners or increasingly autonomous. Although NASA has declined for some years to allocate significant resources to a robotics technology program, this promising technology area has been pursued on the Earth's surface, undersea, and in space by the US military and numerous private interests. It may be possible for NASA to leverage this work and apply the capabilities to enable its priority missions.

5. The experience of Hubble servicing demonstrates the scientific advantages of flying the most technologically advanced detectors available, often within one year of instrument flight. This is possible by building modular, serviceable telescopes, which are cost-effective and scientifically beneficial. Based on Hubble experience, the development cost of a new instrument is typically less than five percent of the development cost of the observatory.

6. Continuous rejuvenation of knowledge, from old instrumentation to new, results in a pace of innovation and discovery four to five times faster than that which can be achieved with expendable telescopes. Given the achievements accomplished with the Space Shuttle and Hubble, why not continue the cost and time savings with the Constellation system? ■

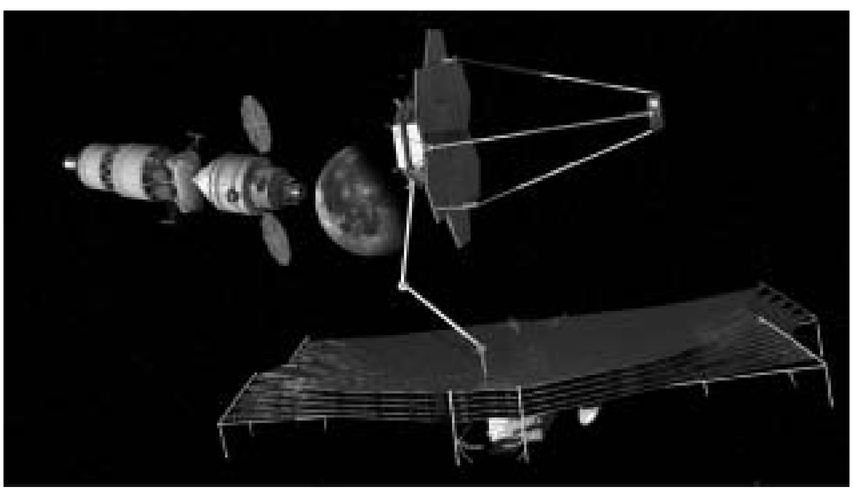


Figure 6. An Orion/Crew Exploration "stack" at an Earth-Moon libration point stands off from the Single-Aperture Far-Infrared (SAFIR) observatory, which has returned from its observation location at the Sun-Earth L2 location. NASA's Constellation architecture, developed to return humans to the lunar surface, may be adapted to achieve multiple additional priority goals such as this. (Source: John Frassantio & Associates and H.A. Thronson)

Frank J. Cepollina **directs the Hubble Space Telescope Development Office at NASA's Goddard Space Flight Center. Parts of this article were first delivered by Mr. Cepollina at a Maryland Space Business Roundtable luncheon in June, 2008.**

Sea Launch Regains Launch Tempo

by Paula Korn

On January 15, 2008, Sea Launch accomplished what some speculated would be impossible, or at least improbable: Sea Launch returned to launch operations with the flawless launch of the Thuraya-3 mobile communications satellite. The achievement marked Sea Launch's 25th mission since the international team began operations with its first launch in 1999, and the first mission since a failure one year before which lost the NSS-8 communications satellite. Sea Launch described the recovery process after that failure in the 2007 May/June edition of *SPACE TIMES*. A year later, we look back at the return to the world stage of the dynamic launch industry.

The outstanding performance of each individual Sea Launch employee made a vital contribution to the success of Mission Recovery, transitioning from launch failure to launch readiness in a remarkable period of just eight months. Not only was the launch system ready for operations, but the launch team was eager to return to what it does best: executing flawless launches.

The diversity and experience of the Sea Launch's international team are the most important assets of the company. Known for their marine expertise, the Norwegians are well respected by their American, Russian, and Ukrainian partners alike. Likewise, the Russians and Ukrainians are highly regarded for their experience, history, and knowledge of rockets and launch operations. And the Americans bring their systems integration and operations management capabilities to a proven, working launch service and team.

The Sea Launch vessels in launch position on the Equator, during countdown. The launch platform, one of the world's largest semi-submersible vessels, is ballasted about 65 feet for stability. The Sea Launch Commander is nearly four miles uprange, accommodating the Launch Control Center as well as remotely controlled marine operations for the platform. All personnel evacuate the platform before fueling operations are initiated. (Source: Sea Launch)

Return to Launch Operations

In September 2007, Sea Launch took delivery of the Thuraya-3 communications satellite, which was processed and mated with a Zenit-3SL rocket, in preparation for resuming launch operations. The vessels departed Home Port at the end of October and arrived at the launch site with all systems and personnel ready for liftoff.

The Zenit-3SL vehicle is assembled on the Sea Launch Commander and then transferred to the Odyssey Launch Platform. This image was made from the stern of the ship, positioned directly in front of the platform during the transfer operations. The rocket is rolled onto the ship's stern ramp and then lifted 200 feet to the fore end of the hangar. Heavy cranes do the lifting and then move the rocket into the hangar, where the rocket rests on the transporter erecter. (Source: Sea Launch)

Then, a new challenge emerged: an unusual set of ocean-state conditions, including a convergence of powerful currents, created difficulty in station-keeping capabilities. The Launch Platform was subject to ocean currents of up to twice the historical trends and normal levels, coupled with high winds. Maintaining a launch position within established launch commit criteria became impossible as sea-state conditions continued to deteriorate. On November 26, the team made a unanimous decision to terminate the countdown and return to Home Port.

"Notwithstanding the ingenuity and positive attitude of every person in every segment on this mission, and the absolute readiness of all systems to support the launch of Thuraya-3, Mother Nature is not cooperating," said Rob Peckham, president and general manager of Sea Launch. "Therefore, the integrated team (Marine Segment, Mission Director, Rocket Segment, and Spacecraft) agreed to terminate the countdown. We will now focus on extending the campaign and scheduling the corresponding activities required to return to the launch site and launch our customer's satellite."

As the team sailed home with its precious cargo, personnel quickly regained energy and resolve with problem-solving tactics. Following the delays in November and thensubsequent extensive analysis, Sea Launch increased power and fuel capabilities on the Launch Platform and began evaluating the use of existing margins on identified launch parameters, as needed.

The Launch Platform maintains a position that is optimal for the launch trajectory and minimizes the loads on the launch vehicle. The marine crews verify and hold the relative headings of the vessels to ensure their exact orientation. The Launch Commit Criteria requires the Launch Platform to be in position +/-50 meters of the designated launch site and the vessel's axis must be within +/- 3 degrees of the specified launch heading. Sea Launch has expanded the station-keeping capabilities of the Launch Platform by opening up the vessel's heading requirement and enlarging the launch site tolerance.

The Sea Launch Commander houses its own weather station, manned by a professional meteorologist. The team monitors winds aloft by releasing weather balloons at specific intervals prior to launch. They also monitor sea conditions in real time using data acquired from the Sea Launch buoy at the launch site, at 154 degrees West Longitudelongitude.

But, while While buoys and Earth observing systems track and predict many environmental characteristics of the sea and air, the idiosyncrasies of deep ocean currents remain a mystery. The team consulted with oceanographers and various experts who were studying the winter's unusual ocean conditions at the Equator, much of which was credited to a La Nina event. As a result of the experience, Sea Launch has learned a lot more about this part of the Pacific Ocean and also about optimizing capabilities for enhanced launch availability.

As a result of the experience in November, Sea Launch has implemented a variety of other measures to increase launch availability, particularly in the event of off-nominal environmental conditions.

The Payload Assembly for the Thuraya-3 mission is moved out of the Payload Processing Facility onto a transporter that takes it to assembly with a Zenit-3SL vehicle, on the Sea Launch Commander. (Source: Sea Launch)

An additional generator on the Launch Platform now provideswill provide nearly 20% more power for use in contingency scenarios by reconfiguring the allocation of power generation. In addition, the vessels are now prepared for a longer stayto be at the launch site for a longer stay, as needed. Other options are under study.

As is typical of the Sea Launch team, challenges begetChallenges begat new solutions and enhancements, resulting in new possibilities for customers. From the start of operations ten years ago, problem-solving capabilities and energy hashave been a hallmark of the Sea Launch team. Much of what this team does, has never been done before. And no problem goes unsolved.

While we celebrate the 50th year of NASA and Sputnik, all of the extraordinary accomplishments of the world's launch operations have been initiated from land-based sites. Sea Launch has the only team in the world that assembles its rockets on a ship and then transfers the fully integrated rocket onto a floating launch platform;. Sea Launch also has the only team that deals with such things as ocean currents and vessel headings to assure exact trajectory and mission success.

Current Status

On January 2, 2008, the Odyssey Launch Platform and the Sea Launch Commander ventured out to the launch site again for "part two" of the Thuraya-3 mission. Liftoff on January 15 proceeded right on schedule, and all systems performed nominally throughout the flight. Sea Launch has successfully launched all three of the Thuraya spacecraft, supporting the start of the Thuraya Satellite Telecommunications Company's mobile communications business as well as its growth.

Without losing any momentum, the team immediately began preparations for the next mission on the manifest, the launch of the DIRECTV 11 broadcast satellite. On

The Odyssey Launch Platform enroute to the equatorial launch site at 154 degrees West Longitude (Source: Sea Launch)

Liftoff of the EchoStar XI mission on July 15, 2008. The launch pad is located at the stern of the launch deck on the Launch Platform. (Source: Sea Launch)

March 19, Sea Launch successfully delivered the DIRECTV 11 satellite to orbit, marking its 4thfourth successful launch for DIRECTV. On May 21, Sea Launch executed its 25th successful mission, with the launch of the Galaxy 18 telecommunications satellite for Intelsat. That was followed by another success on July 15, with the launch of the EchoStar XI direct broadcast satellite for DISH Network.

Rob Peckham congratulated participants, as he often does: "Thanks to everyone involved in achieving this successful launch, particularly the people of Sea Launch and our partners, contractors and families around the world who supportAs this issue goes to press, Sea Launch is preparing for its fifth missionthird of the yearsix planned missions in 2008, the launch of the Galaxy 1918 satellite for Intelsat. Sea Launch is regaining its launch tempo and is, once again, strongly positioned for a successful and growing future. In addition, operations are moving forward with the new Land Launch system, operating out of the Baikonur Space Center in Kazakhstan in cooperation with Space International Services, based in Moscow. Using the Zenit-3SLB vehicle, a variant of the Sea Launch Zenit-3SL, Land Launch provides launch services for medium-weight commercial satellites. The first of these missions was successfully completed on April 28, with the successful launch of the AMOS-3 communications satellite. A second Land Launch mission, the launch of the MEASAT 1R satellite, is planned for August. As a result of the market's positive response to this new service, Sea Launch is now filling manifest opportunities in 2010.

About Sea Launch

Established in 1995, Sea Launch Company, LLC, is an international partnership of American, Russian, Ukrainian and Norwegian businesses that provides the most direct and cost effective route to geostationary orbit for commercial communications satellites. With the advantage of a launch site on the Equator, the robust Zenit-3SL rocket can lift a heavier mass or provide longer life on orbit, offering best value plus optimized spacecraft orbital delivery. In addition to its ocean-based heavy lift launch service from the Equator, Sea Launch also offers a land-based service for medium weight payloads, originating from an existing launch site at the Baikonur Space Center in Kazakhstan.

For additional information, visit the Sea Launch website at www.sea-launch.com. ■

***Paula Korn*, former AAS VP of Publications, is Communications Director for Sea Launch, where she is responsible for corporate communications, as well as media and public relations, presentations, marketing materials, website, advertising, and launch coverage.**

Feedback Forum

by Donald Beattie

In the March/April 2008 issue of *SPACE TIMES*, John Klineberg, former Goddard Space Flight Center Director and aerospace executive, wrote a thoughtful article concerning some of NASA's ongoing problems. He used the allegory of the Emperor's New Clothes to illustrate his concerns. Referring to the Vision for Space Exploration he wrote: "We pretend we see it and exclaim how wonderful it is, but there's nothing there at all."

NASA faces two major problems, one near term, the other longer term. The near term problem is the FY 2009 appropriation and whether or not NASA will be forced to operate in FY 2009 on a continuing resolution. The longer term problem is that regardless of the size of the FY 2009 appropriation, future appropriations will almost certainly not permit current NASA programs to be achieved, including returning astronauts to the Moon.

As Klineberg pointed out, aeronautics research is deficient in several areas. In the past decade the NASA aeronautics budget has declined almost 25 percent. As an old Navy pilot, I would add that NASA has lost its aeronautics R&D edge by not continuing to pursue major flight demonstration programs as it did in the past. NASA and DOD must decide quickly how to develop a long range plan that will keep NASA involved at the cutting edge of future flight technology, as called for in the 2007 National Aeronautics Plan. To do this will require a much larger funded NASA aeronautics program.

Because NASA budgets will continue to be less than needed to carry out all the important work NASA should and can do, there must be a reevaluation of NASA priorities. Returning to the Moon should not be at the top of the list. Besides aeronautics, much higher priority programs are not being fully funded and, in my judgment, may never be funded if NASA continues to place lunar programs at the top of the list. It is not just a case of "been there, done that," though that is certainly a part of the problem.

NASA Aeronautics research has tackled some enormous aviation challenges in its history. Among them are technologies developed to address wake vortices - horizontal tornadoes trailing from wing tips that are created as a byproduct of lift. Wake turbulence has an impact on how closely planes can be spaced, especially during landing and take-off. (Source: NASA/Langley)

NAS/NRC Earth observation recommendations should be at the top of the list, followed by NEO research advocated by Rusty Schweikert. The latter should become a major international effort including how to divert a large object that is or could be on a collision course with Earth. Robotic Mars sample return should also have a higher priority than lunar missions. NASA is having a hard time scheduling Mars sample return because of budget constraints.

Full use of the ISS beyond 2015 should also have a higher priority. To do this means keeping the shuttle flying past 2010. The Constellation program should be tailored to missions other than returning to the Moon, and if the shuttle keeps flying (perhaps twice a year until Orion is operational) it will take pressure off the program schedule - which, as GAO has pointed out, is overly optimistic. The budget should be reallocated to allow this outcome.

The problem NASA has, as I see it, is what to do with the astronaut corps - currently and in the past, over 60% of NASA's budget has been dedicated to human space flight. There is a solution, but it means a much less ambitious near-term human space flight program until all the other higher priority programs are funded.

What the next administration will endorse is anyone's guess. My judgment, along with many others, is that federal budgets for the foreseeable future will be so tight that NASA will not receive major increases.

So what should the next administration do? It should reprioritize programs with the help of experienced space and aeronautics panelists, but not with panels dominated by former or current astronauts. Otherwise, the new administration and congress will get the same old recommendations. These will neither be sustainable nor in the best interests of the country. ■

Donald A. Beattie is a former NASA engineer and manager. He also directed programs at the National Science Foundation, Energy Research and Development Administration, and the Department of Energy. He currently works as a private consultant. He is also the author of several books, including _Taking Science to the Moon_ and _ISScapades: The Crippling of America's Space Program_.

Fourth CanSat Competition a Success

College students from around the country and Mexico gathered June 13-15 in Amarillo, Texas to compete in the annual Student CanSat Competition. In order to experience a hands-on space program at an affordable cost, each team had to build and launch a payload the size of a 12 ounce soda can to an altitude of one mile. The basic mission required that the payload transmit its altitude to the ground station at least every five seconds and land in a defined upright position, or upright itself within ten minutes. Bonus points were given for taking panoramic images after landing, extracting 5 grams of soil, and measuring the ground surface temperature, wind speed, and direction. Each team was also required to write a mission proposal, generate design documentation, conduct preliminary and critical design reviews with staff engineers, and prepare/present a post-mission debrief.

A total of $6,500 in prize money went to the winning CanSat teams, with the University of New Hampshire taking first place, University of Alabama in Huntsville second place, University of Michigan (with two teams) third and fourth places, and Virginia Tech fifth place.

This year's competition was sponsored by the AAS, the American Institute of Astronautics and Aeronautics, Jet Propulsion Laboratory, Naval Research Laboratory, Orbital Sciences Corporation, and NASA Goddard Space Flight Center. Planning for next year's competition is already underway. It will be held June 12-14, 2009, back in Amarillo with the continued support of the Panhandle of Texas Rocketry Society (POTROCS). To view additional photographs and video of this and past years' events, visit www.cansatcompetition.com. For corporate sponsorship opportunities for the 2009 competition, contact the AAS Business Office. ■

Teams prepare for the competition (Source: AAS)

Texas-style chuckwagon barbeque (Source: AAS)

CanSat payload (Source: AAS)

Mexico City team briefs their mission (Source: AAS)

First place team members from the University of New Hampshire (Source: AAS)

26th International Symposium on Space Technology and Science

Dr. Peter Bainum (right) presents the AAS Award for the Most Innovative Application of Space Technology to Professor Komurasaki on behalf of winning student Mr. Fukushima, both representing the University of Tokyo (Source: Dr. Hirayama/Kyushu University)

Held every two years, the International Symposium on Space Technology and Science (ISTS) is the second largest international space conference worldwide, second only to the annual International Astronautical Congresses in terms of attendance, countries represented, exhibitors, and number of papers submitted.

The theme of the 26th ISTS, held in June 2008 in Hamamatsu, Japan, was *Space!! Go for it!* More than 30 student papers at the Ph.D. and Masters levels were submitted during the ISTS Student Conference and Competition, held in conjunction with the Symposium. Peter Bainum, who served on the ISTS Overseas Program Committee, provided comments at the Opening Ceremony on behalf of the AAS, co-chaired three sessions during the Student Conference, and participated in the Student Award Ceremony during the Closing Banquet.

The 27th ISTS will break from its bi-annual tradition to celebrate the 50th Anniversary of ISTS. This event will be held July 5-12, 2009 in Tsukuba City, Japan, the location of a major JAXA facility. ■

F. Landis Markley Astronautics Symposium

Dr. F. Landis Markley, one of the pillars of spacecraft attitude estimation as well as one of our most important mission engineers, was honored at a special symposium June 29–July 2, 2008 at the Hyatt Regency Chesapeake Bay Golf Resort, Spa and Marina in Cambridge, Maryland. Dr. Markley was specifically recognized for his many innovations in astronautical engineering, for his many algorithms and methodologies for spacecraft attitude support, and for his numerous seminal publications. Additionally, this event gave his many friends, colleagues, and admirers a perfect opportunity to show how much they respect and admire both him and his accomplishments.

The symposium was organized with the cooperation of the AAS and sponsored by the University at Buffalo-State University of New York, Hubble Space Telescope Project, Computer Sciences Corporation, The Johns Hopkins University Applied Physics Laboratory, Spacecraft System Engineering Services, and the American Institute of Aeronautics and the Astronautics (AIAA) Baltimore Section.

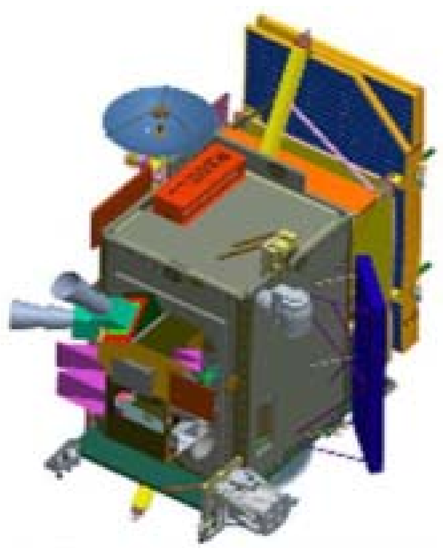
The well-attended symposium featured presentations of over fifty papers, as well as social events and a special banquet. It is expected that the papers will be published by the AAS in a special Proceedings, with many appearing in a future issue of *The Journal of the Astronautical Sciences*.■

F. Landis Markley (Source: AAS)

Corporate Member Profile

Edge Space Systems, Inc.

Edge Space Systems, Inc. is a woman-owned small business, founded in 2003 and located in Glenelg, Maryland. Edge specializes in thermal and mechanical systems engineering for space applications, with one of the largest thermal engineering industry groups in the Maryland area. Customers include NASA Goddard Space Flight Center, NASA Kennedy Space Center, the Naval Research Laboratory, Analex Corporation, Sigma Space Corporation, and SGT.



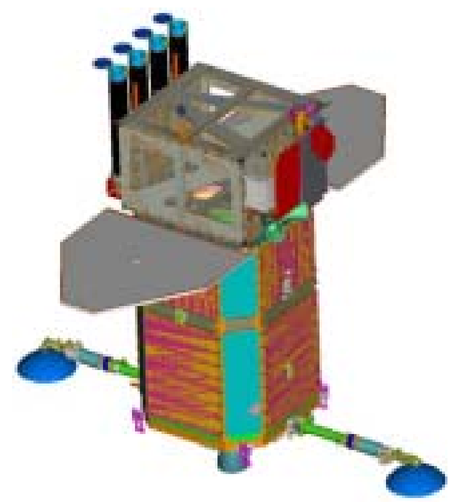
Lunar Reconnaissance Orbiter (LRO) (Source: NASA)

Edge expertise includes: thermal analysis from back of the envelope to detailed flight and test models; design from concept through full integration; requirements generation/review; thermal testing; integration; thermal requirement definition; hardware procurement; and venting analysis. Edge engineers support space science instruments, spacecraft, launch vehicles, and flight components such as electronics, structures, solar arrays, deployables, batteries, and cooling systems. Edge has cryogenic thermal expertise as well as extensive experience in Structural-Thermal-Optical (STOP) analysis. The staff works with low earth orbits (LEO), geosynchronous orbits (GEO), highly elliptical orbits (HEO), interplanetary, lunar, L1 and L2, solar, and high altitude balloon missions. Edge thermal engineers are expert in a variety of industry software, including Thermal Desktop, TSS, SINDA, TMG, and TRASYS, providing geometry and thermal mathematical models to meet customer needs. Edge engineers are supporting SDO, LRO, JWST, NPP, GOES, POES, SAM and ELC.

Edge Space Systems engineers and technicians support the Goddard Thermal Laboratory, providing subassembly thermal design and testing, test bed design, and advanced thermal control development.

Edge believes in the continuous development and education of technical staff, creating an environment of mentoring, reviewing, and sharing knowledge. They are developing the next generation of engineers by hiring college students and new graduates as frequently as possible and encouraging all employees to continue learning.

Sample Analysis at Mars (SAM) (Source: NASA)



Solar Dynamics Observatory (SDO) (Source: NASA)

Edge has consistently and successfully expanded their capabilities and expertise, most recently with growth in mechanical systems. They continue to increase their capabilities by adding and developing mechanical engineering personnel with expertise in the areas of mechanical design, structural analysis, and mechanical systems. ■

EDGE Space Systems

Call for Papers

The 32nd Annual Guidance and Control Conference
Beaver Run Resort
Breckenridge, Colorado

The 32nd Annual Guidance and Control (G&C) Conference will be held January 30 through February 4, 2009 at the beautiful Beaver Run Resort in Breckenridge, Colorado. Attached please find the agenda for the 2009 Conference. Abstracts for potential papers to be presented at the Conference are being accepted. The deadline for abstract submission is September 12, 2008.

The 2009 Conference will have the following sessions. Their themes are listed as well as the session organizer(s) to contact for abstract submission. Sessions 1 through 8 are the traditional open sessions, including international participation. Session 9 will be limited to U.S. citizens and permanent residents only.

SESSION I - ***Recent Experience***
Theme: Lessons learned through experience prove most valuable when shared with others in the G&C community. This session, which is a traditional part of the conference, provides a forum for candid sharing of insights gained through successes and failures. Past conferences have shown this session to be most interesting and informative.
Organizers:
Dave Chart, Lockheed Martin Space Systems, david.a.chart@lmco.com, 303-977-6875
Ian Gravseth, Ball Aerospace & Technologies Corp., igravseth@ball.com, 303-939-5421
National Chairperson:
Owen Brown, DARPA, owen.brown@darpa.mil, 571-218-4206

SESSION II - ***Technical Exhibits***
Theme: The Technical Exibits Session is a unique opportunity to observe displays and demonstrations of state-of-the-art hardware, design and analysis tools, and services applicable to advancement the of guidance, navigation, and control technology. The latest commercial tools for GN&C simulations, analysis, and graphical displays are demonstrated in a hands-on, interactive environment, including lessons learned and undocumented features. Associated papers not presented in other sessions are also provided and can be discussed with the author. Come enjoy an excellent complimentary buffet and interact with the technical representatives and authors. This session takes place in a social setting, and family members are welcome.
Organizers:
Scott Francis, Lockheed Martin Space Systems, scott.francis@lmco.com, 303-977-8253
Kristen Terry, Lockheed Martin Space Systems, kristen.terry@lmco.com, 303-971-7450
Vanessa Baez, Lockheed Martin Space Systems, vanessa.baez@lmco.com, 303-971-6481

SESSION III - ***Advances in G&C (includes Smart Sensors)***
Theme: Many programs depend on heritage, but the future is advanced by those willing to design and implement new and novel architectures, technologies, and algorithms to solve the GN&C problems. This session is open to papers with topics ranging from theoretical formulations to innovative systems and intelligent sensors that will advance the state of the art, reduce the cost of applications, and speed the convergence to hardware, numerical, or design trade solutions.
Organizers:
Jay Speed, Ball Aerospace & Technologies Corp., jspeed@ball.com, 303-939-5322
Shawn McQuerry, Lockheed Martin Space Systems, shawn.c.mcquerry@lmco.com, 303-971-5262
National Chairperson:
Stephen Airey, European Space Agency, stephen.airey@esa,int, +31 (0) 710 565 5295

SESSION IV - ***N&C of Earth and Space Observing Environmental Spacecraft***
Theme: There are unique guidance navigation and control challenges in the design, development, and operations of earth orbiting observations that monitor earth and space weather. These challenges increase as requirements for long-term climate monitoring are added, with GNC implications on instruments and the bus. This session will cover such aspects for operational and experimentsl observations in low earth geosynchronous orbits. This includes GN&C design, image navigation and registration (INR), pointing stability, geo-location, station keeping, and end-to-end calibration and validation.
Organizers:
Bill Emery, University of Colorado, emery@colorado.edu, 303-492-8591
Bill Frazier, Ball Aerospace & Technologies Corp., wfrazier@ball.com, 303-939-4986
National Chairperson:
TBD

SESSION V - *Lunar and Martian Navigation*
Theme: This session focuses on navigation in orbit, during entry descent and landing, and on the surface of the Moon and Mars. Papers may include discussion of precision gravity models, atmospheric models, entry descent and landing (EDL) developments, autonomous rover navigation, and others.
Organizer:
Mary Klaus, Lockheed Martin Space Systems, mary.a.klaus@lmco.com, 303-971-2724
National Chairperson:
Steve Lee, JPL, steven.w.lee@jpl.nasa.gov, 818-393-6685

SESSION VI - *Rendezvous Management*
Theme: While rendezvous between two objects in space has begun to seem almost common place in recent years, the technology to accomplish this feat has become increasingly complex. Greater autonomy and tighter constraints drive to more specialized systems. This session will explore curren trends in rendezvous, including sensor technology, navigation methodology, and flight demonstrations.
Organizers:
Michael Osborne, Lockheed Martin Space Systems, michael.l.osborne@lmco.com, 303-977-5867
Larry Germann, Left Hand Design, lgermann@lefthand.com, 303-652-2786
National Chairperson:
Jack Brazzel, NASA, jack.p.brazzel@nasa.gov

SESSION VII - *Geriatric Spacecraft*
Theme: Despite the harsh environment in which spacecraft must function from the beginning of their operational lives, many will finish their intended missions successfully, possibly experiencing only the occasional hiccup. However, either by design or luck, some of these spacecraft will outlive their contemporaries and remain useful for many years to decades. Even then, these extended missions will face their own challenges as actuator and sensor components begin to deteriorate and propellant is depleted, among other potential issues. This session will explore the orbite maintenance and attitude control issues faced by these spacecraft and the unique and often clever efforts devised by their operators to seek out every bit of operational life and, in some cases, to give them a fitting retirement.
Organizers:
Heidi Hallowell, Ball Aerospace & Technologies Corp., hhallowe@ball.com, 303-939-6131
Zack Wilson, Lockheed Martin Space Systems, zachary.s.wilson@lmco.com, 303-971-4799
National Chairperson:
Phil Sabelhaus, Goddard Space Flight Center, phillip.a.sabelhaus@nasa.gov, 301-286-5712

SESSION VIII - *CubeSats and Nanosats*
Theme: A number of recent commercial and university efforts have taken advantage of the reduced resources required to develop small, secondary-payload spacecraft. The CubeSat initiative in particular, with standardized design guidelines and logistics support for picosats constrained to a 1-liter volume, has proven highly successful in providing space access to resource-constrained university research labs. The first CubeSat launch occurred ini 2003, and today the collaboration includes more than 60 universities and high schools. These programs have benefited from a remarkable level of collaboration among the participants, and have produced some noteworthy achievements. This session highlights creative guidance and control approaches for CubeSats and other small spacecraft, where the performance goals may be modest, but the innovation and learning experiences can be exceptional.
Organizer:
Jim Chapel, Lockheed Martin Space Systems, jim.d.chapel@lmco.com, 303-977-9462
National Chairpersons:
Jordi Puig-Suari, Cal Poly, San Luis Obispo, jpuigsua@calpoly.edu, 805-756-6479
Therese Moretto Jorgensen, National Science Foundation, TJorgens@nsf.gov, 703-292-8518

SESSION IX - *Orion Navigation (U.S. only)*
Theme: This session will address the challenges and recent advances associated with U.S. investment to develop a new manned space vehicle, the Orion Crew Exploration Vehicle. Topcis include guidance and control during ascent, rendezvous and docking, transit to the moon, landing and hazard avoidance technologies, sensors, situation awareness systems, and considerations for humans in the control loop.
Organizer:
Ed Friedman (acting), Ball Aerospace & Technologies Corp., 2009GCConferenceChair@gmail.com, 303-939-5701
National Chairpersons:
Tim Crain, NASA Johnson Space Flight Center, tim.crain@nasa.gov, 281-244-5077

For additional information, including Conference registration and Beaver Run reservation information, local attractions and activities, the latest updates for the 2009 G&C Conference, and much more, please visit our website at www.aas-rocky-mountain-section.org.

Thank you in advance. We look forward to your participation and seeing you at the Conference!

Ed Friedman
2009 Conference Chair
Ball Aerospace & Technologies Corp.
303-939-5701

Jay Brownfield
Rocky Mountain Section Secretary
Honeywell Defense & Space
303-681-3316

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Universities Space Research Association

AAS Events Schedule

August 18-21, 2008
***AIAA/AAS Astrodynamics Specialist Conference**
Hilton Hawaiian Village
Honolulu, Hawaii
www.aiaa.org

October 21-22, 2008
***Special Symposium**
"Building on the Past to Power the Future"
Von Braun Center
Huntsville, Alabama
703-866-0020

November 17-19, 2008
AAS National Conference and 55th Annual Meeting
"Space Exploration and Science in the Next Decade"
Pasadena Hilton
Pasadena, California
www.astronautical.org

January 30-February 4, 2009
AAS Guidance and Control Conference
Beaver Run Resort and Conference Center
Breckenridge, Colorado
Abstract Deadline: September 15, 2008
www.aas-rocky-mountain-section.org

**AAS Cosponsored Meetings*

February 8-12, 2009
***AAS/AIAA Space Flight Mechanics Winter Meeting**
Hilton Savannah DeSoto
Savannah, Georgia
Abstract Deadline: October 6, 2008
www.space-flight.org

March 10-12, 2009
47th Robert H. Goddard Memorial Symposium
Greenbelt Marriott
Greenbelt, Maryland
703-866-0020

May 26-29, 2009
***12th International Space Conference of Pacific-basin Societies (ISCOPS)**
Holiday Inn Select
Montreal, Canada
703-866-0020

June 12-14, 2009
***5th Student CanSat Competition**
Amarillo, Texas
www.cansatcompetition.com

August 9-13, 2009
***AAS/AIAA Astrodynamics Specialist Conference**
Renaissance Pittsburgh Hotel
Pittsburgh, Pennsylvania
www.space-flight.org

Charitable Giving and the AAS

A popular way of donating to an organization is through a gift by means of a will (i.e., to make a bequest). You may decide to consider either a general bequest to the AAS or a bequest targeted to an existing or new AAS scholarship or an award fund. These bequests are deductible against estate and inheritance taxes. There are also tax advantages when making charitable donations to the AAS while you are living. Such gifts could contribute to the memory of someone who has passed away or be made in the honor of a person who is still alive. In addition, special occasions offer opportunities for gifts to be directed to the Society. As a final note, although the AAS is able to provide suggestions for charitable giving, your financial or legal advisor should be consulted about such actions.

Membership Application

American Astronautical Society

703-866-0020
www.astronautical.org

Mr./Ms./Dr.	*Last Name*	*First Name*
Title	*Company*	
Address		
City	*State*	*Zip Code*
Phone	*E-mail*	

Membership Benefits Include: Subscriptions to the quarterly *The Journal of the Astronautical Sciences* and the bi-monthly *SPACE TIMES* magazine, as well as reduced rates at all AAS conferences. Visit the AAS website for additional information about benefits.

Membership Type

- ❐ Member $85
- ❐ Affiliate $85
- ❐ Senior Member $100
- ❐ Retired $35
- ❐ Teacher (K-12) $35
- ❐ Student (full-time) $35

Payment Method

- ❐ Check Enclosed
- ❐ Credit Card
  - ❐ Visa ❐ Amex ❐ MasterCard

Credit Card Number

Expiration Date

Signature

Mail to: AAS
6352 Rolling Mill Place
Suite 102
Springfield, VA 22152-2354

Fax to: 703-866-3526

SPACE TIMES Article Submission Guidelines

Feature articles of 1500 to 3000 words, op-eds of 500 to 1500 words, and book reviews of 600 words or less are encouraged and accepted by the AAS for production in *SPACE TIMES* magazine. Exceptions to the length of any article must be discussed in advance with the editor. Articles may cover virtually any topic involving space science, technology, exploration, law, policy, or issues relevant to the civil, commercial, and military and intelligence space sectors.

SPACE TIMES is a magazine, as opposed to a technical journal, with a well-educated audience that has a great interest in space topics but may not necessarily be familiar with your specific topic. Therefore, write with an active voice and provide a clear explanation of technical concepts. Conversational rather than formal is the preferred tone.

Submission deadlines are the 15th of the month prior to the first month of the issue (i.e., August 15 for the September/October issue). Articles should be submitted in Microsoft Word format and Times New Roman font, with a title, subtitle, or one to two sentence summary of the subject matter for use in the index, subheadings for separation between major sections of the article, and a one to two sentence author biography to appear at the end of the article. Also, please provide a mailing address for shipment of complimentary copies of the issue in which your article appears.

Photos or other visual support are encouraged, although not required, and must be provided in high resolution (at least 300 dpi) and JPG or TIF format, separate from, not imbedded in, the article. Proof of permission to reproduce from the owner of any photos or visuals must be provided. Contact information of the owner will be accepted if permission has not already been obtained prior to submission of an article.

Units of measurement should be conveyed in metric, not English, terms, acronyms should be used sparingly, and numbers one through one hundred should be spelled out. In addition, names of specific spacecraft (e.g., *Columbia*) should be italicized, but general spacecraft names (e.g., space shuttle Delta) should not be.

Contact: Jeffrey Elbel, Editor (elbel@saic-chicago.com) ■

Is Pluto a Planet? A Historical Journey through the Solar System

Reviewed by Mark Williamson

Is Pluto a Planet? A Historical Journey through the Solar System? by David A. Weintraub, Princeton University Press, 254 pages, 2007, $27.95 (hardback), ISBN: 978-0-691-12348-6

Is Pluto a planet? More or less anyone you asked prior to 2006, amateur or professional, would have frowned in response, "Well, of course it is...unless you're talking about that cartoon dog!" The very fact that the answer, which has been more or less the same since Clyde Tombaugh discovered Pluto in 1930, is now less clear indicates that something momentous – in terms of astronomical definitions - happened in 2006. Indeed, it was on August 24 of that year, at the 26th General Assembly of the International Astronomical Union (IAU), that a majority of the 424 members present passed a resolution defining "planet" in a way that appeared to exclude Pluto.

There followed a ripple of dissent, fuelled by inaccurate media reports, that grew into a tide of indignation within the astronomical community, and, among other things, produced this book by David Weintraub, himself a professor of astronomy at Vanderbilt University. Like all good detective stories, this one does a good job of not revealing the conclusion until the end.

In fact, the author concentrates on providing a detailed historical background to the Pluto issue by tracing the way our view of what constitutes a planet has evolved since the Mayans and the Babylonians began to observe the heavens. Some of his chapter titles, such as "The Earth Becomes a Planet" and "Not Everything That Orbits the Sun is a Planet," tell a story in themselves. Others, such as "Uranus!," "The Celestial Police," and "Goldilocks," are perhaps more enigmatic, but the book itself is written in an engaging and accessible way.

The author explains that scientists, in common with the rest of us, like to categorize things, as a way of understanding them and placing them in their correct context. But what does the astronomer do if he observes three bright points in the sky, which differ only in their colour? Are they individual examples of objects in three separate categories (red stars, blue stars and yellow stars), or three examples of the same category (stars) that "differ only in the incidental quality of color?" Although he doesn't draw the analogy, the question is common to broader human issues such as class and race.

Weintraub goes on to analyze some ancient and modern definitions of the word 'planet' and concludes that he is "very dissatisfied [with the Oxford English Dictionary] definitions," labelling them "essentially worthless." It's not clear how many other dictionaries he might have consulted, but that's not the point. If even professional astronomers can't decide what constitutes a planet, what hope is there for dictionary writers?

Readers who enjoy immersing themselves in the history of astronomy, however many times they've read of Aristotle, Copernicus, and Kepler, will like this book. In fact, Pluto doesn't get much of a mention until about half way through, when it is introduced as "the fourth ninth planet," a reference to how planetary definitions have changed in the past. According to Weintraub, "Pluto generated controversy" almost from the day its discovery was announced. "Was it Lowell's Planet X or Pickering's Planet O? Was it neither?" (You will have to read the book to find out).

As the author states, whether Pluto is a planet or the largest Kuiper Belt Object (KBO), or, indeed, part of a KBO subgroup known as the Plutinos, is "a scientific question, not a matter of public opinion or a decision to be made by NASA or a panel of distinguished astronomers." (No doubt he has in mind that the IAU's decision was made among a group of just over 400 of a total of 10,000 members.) Following a discussion of many of the factors by which planets might be defined (size, mass, orbit, roundness, etc.), he comes to the surprising conclusion that "The solar system has more than twenty planets!...Pluto is a planet and a Plutino and a KBO." An arguably more important conclusion is that the jury is still out on the status of Pluto.

Is Pluto a Planet? is well illustrated with black and white photos and diagrams, and comes complete with an index, chapter notes, and an appendix on "What we know about Pluto." Perhaps unsurprisingly, there is no glossary of terms. Offering a list of definitions would be a 'can of worms' beyond that already opened. ■

Mark Williamson **is an independent space technology consultant and author.**

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