

SEPTEMBER/OCTOBER 2006

SPACE TIMES



THE MAGAZINE OF THE AMERICAN
ASTRONAUTICAL SOCIETY

ISSUE 5 | VOLUME 45

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SPACE TIMES is published bimonthly by the American Astronautical Society, a professional non-profit society. *SPACE TIMES* is free to members of the AAS. Individual subscriptions can be ordered from the AAS Business Office. © Copyright 2006 by the American Astronautical Society, Inc. Printed in the United States of America.

PERIODICALS

SPACE TIMES, magazine of the AAS, bimonthly, volume 45, 2006—\$80 domestic, \$95 foreign
The Journal of the Astronautical Sciences, quarterly, volume 54, 2006—\$160 domestic, \$180 foreign
To order these publications, contact the AAS business office.

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Turning engineering and policy concepts into a compelling, visual story is a critical part of transforming vision into reality. Dramatic, technically accurate images can help audiences imagine how the various pieces of a space exploration architecture will come together years down the road, making the whole concept more real and more supportable. But engineers and scientists need high-quality visual materials, too, particularly when the act of creating these images helps technical experts refine their designs. John Frassanito & Associates has been in the forefront of this effort, and along the way has already created iconic images that have already become synonymous with the Vision for Space Exploration.

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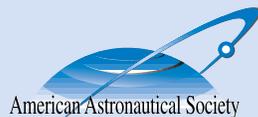
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AAS and the Flow of Discovery



The last issue of *Space Times* contained two excellent articles on Mars entitled “Thirty Years After: The Science of the Viking Program and the Discovery of a ‘New Mars’” by Dr. Joel Levine and “The Golden Age of Mars Exploration” by Dr. Michael Meyer. These articles remind us of how Viking revolutionized our view of Mars (and of Earth) and they paint the broad outline of the flow of discovery as missions are undertaken to search for life and now, more specifically, to “follow the water.”

The flow of discovery will continue with the recently-arrived Mars Reconnaissance Orbiter (MRO) as it returns more data about Mars than all previous missions combined. The size of a bus, MRO carries the most powerful camera ever flown on a planetary exploration mission. Previous Mars cameras were able to identify objects no smaller than a dinner table; this camera will be able to spot something as small as a dinner plate. The MRO also carries a sounder to find subsurface water. In addition, it will serve as the first element of an “interplanetary Internet” to provide a communications link back to Earth for several international Mars spacecraft in coming years.

MRO is the leading edge of another flow of discovery, one in space flight mechanics and in guidance, navigation and control. To increase the instrument complement by 600 kilograms, the need for thruster fuel was reduced by that amount using aerobraking to shrink and shape the orbit to the nearly circular, low-altitude configuration required to observe the planet. MRO dipped into the upper fringe of Mars’ atmosphere 426 times between early April and Aug. 30 to gradually decrease the apoapsis from 45,000 kilometers to 486 kilometers. The periapsis ranged from 98 to 105 kilometers. When it arrived at Mars on March 10, the spacecraft took more than 35 hours to complete an orbit. During the final weeks of aerobraking, it was flying more than 10 orbits a day. And finally, on September 11, MRO fired its thrusters for 12.5 minutes to shift the periapsis to stay near the Martian south pole and the apoapsis to stay near the north pole. Quite a dance!

The space flight mechanics and the guidance, navigation and control required to plan and execute these maneuvers at Mars are discoveries themselves based on experience and years of hard work by dedicated professionals, many of whom are members of our society. To hone and share expertise, and to pass it along to the next generation, each year the AAS sponsors three world-class conferences devoted to the professionals in these disciplines:

- The AAS/AIAA Space Flight Mechanics Meeting (Jan. 28 - Feb. 1, 2007)
- The AAS Guidance and Control Conference (Feb. 3-7, 2007)
- The AAS/AIAA Astrodynamics Specialist Conference (Aug. 19-23, 2007)

We are very proud of these conferences and the contributions that they, and our members, make to the flow of discovery in space exploration.

A handwritten signature in black ink that reads "MARK CRAIG". The letters are bold and stylized, with some overlapping.

Mark Craig
mark.k.craig@saic.com

ON THE COVER

FRONT: Soyuz TMA-9 blasts off from Baikonur Cosmodrome in Kazakhstan carrying Astronaut Michael Lopez-Alegria, Cosmonaut Mikhail Tyurin, and the worlds first female Spaceflight Participant Anousheh Ansari. (Source: NASA/Bill Ingalls)

BACK: A view of the recently installed 240ft solar wings of the International Space Station. Installed by the crew aboard STS-115, the solar wings will double the power available to the ISS when they are brought online during the next shuttle flight currently scheduled for December 2006. (Source: NASA)

CORRECTIONS

There were three errors on page 4 in the July/August feature article *Thirty Years After: The Science of the Viking Program and the Discovery of a "New Mars."* The Viking 1 landing date was erroneously given as 20 June 1976; the correct date was 20 July 1976. Also, the lander that touched down on Utopia Planitia on 3 September 1976 was Viking 2, not Viking 3. Finally, Mariner 6 made its closest approach to Mars on 31 July 1969. *Space Times* regrets these errors.

Lunar Interferometry: The Future Home of Astronomy

A little over forty years ago, the Moon was an alien place, still untouched by the hand of man. With the dawn of the space age, humanity's view of the Moon began to change. No longer was the Moon merely a barren expanse of dust and rock; now it was possible for the Moon to serve as a springboard for further human activity in space and a platform for advanced astronomical observations. The first step could lie in placing a structure, an observatory, on the Moon that can be robotically controlled. One kind of observatory that may be ideally suited to the lunar surface is an array of interferometric telescopes.

by Megan C. Kirk

Two major goals of astronomy in the past couple decades have been to create better imaging systems and to find extrasolar terrestrial planet with qualities similar to Earth. It would be far easier to spot these extrasolar terrestrial planets from the Moon than from the Earth because the Earth's atmosphere interferes with images produced by ground-based instruments, greatly increasing the challenge of finding the faint signals of Earth-like planets. Without the radio noise and atmosphere of Earth, the far side of the moon would be the best choice for a radio observatory close to home.

Interferometry was first used to measure the positions and structures of discrete radio sources. An interferometer

collects the electromagnetic radiation from a celestial object (say, a star or planet) along two different paths using, in the case of a radio telescope, two antennas. The radio waves strike the antennas at different times, thus giving each antenna a different part of the wave. The difference between the two waves is then measured. Since the difference in the waves depends on the angle of their source with respect to the telescopes, it is easy, at least conceptually, to find the origin of the waves.

Yet radio interferometry, while proven immensely useful in researching the cosmos over the years, provides only "audio" imaging, and an audio imaging is but a fragment of the larger picture that

is the universe. Within the past twenty years, the science of optical interferometry has appeared to fill in the gaps that radio interferometry has left. Great strides in this field have been made with the optical interferometer on Mount Wilson, Georgia, which has emerged as a world-class instrument capable of providing astronomers with unprecedented data and beautiful images of some of the most distant celestial object ever seen.

However, even with current optical technology, astronomy still strives to achieve a clearer picture of the sky. This clearer picture depends on the resolving power of a telescope. If the optics are perfect, the resolution of a telescope depends on the diameter of its mirror. The

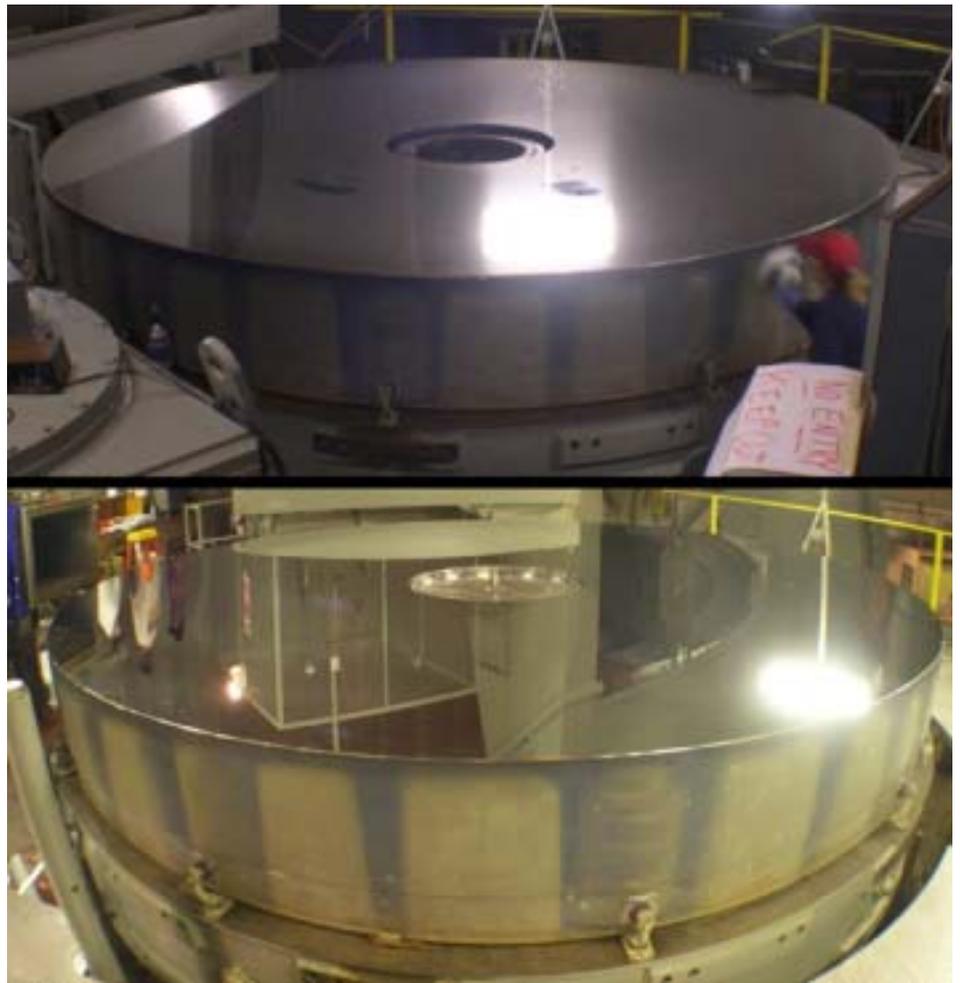


Images like this one, a 400x900 light-year mosaic of images captured by the space telescope Chandra, provide new perspectives on the nature of our universe. An interferometric telescope could provide more detail than any of NASA's Great Observatories can currently supply. (Source: NASA/UMass/D. Wang et al)

larger the mirror, the better resolution one can achieve. An enormous telescope would have excellent resolution, but this it is not a straight forward case of bigger is better. As with most dreams, physical impossibilities get in the way.

The biggest problem in constructing a telescope of this magnitude would be its own, massive size. To the human eye, glass does not appear to sag over time, mostly because its movement is too slow to see. Yet gravity does act on glass, and the heavier that glass is the greater the tendency to bend under its own weight. Normally, sagging doesn't affect the performance of an average, everyday mirror because it does not have to conform to a certain shape. However, in an optical instrument such as the mirror of a telescope, the exact shape of the mirror makes an enormous difference in getting a clear picture. The mirror in a telescope should be a perfect parabola to get a clear image. If that parabola is off only by a small fraction of an inch here and there, then it will distort the image. The 200 inch mirror of the Hale telescope, for example, possesses a surface that is accurate to two millionths of an inch. Two millionths of an inch is the requirement to get the mirror to reflect properly, a requirement if the telescope is to return scientifically useful data.

This leads to two other problems with building such a large telescope: cost and construction. Making a small and accurate mirror isn't an inexpensive venture, but neither is it a simple one. A large telescope has the same problems, only amplified. Plus there's the added question of how to move an extremely large telescope, say one that is on the order of one kilometer in diameter. Location is also a problem for such a large telescope because there is no obvious place on Earth where one could construct such an instrument that would have suitable atmospheric properties (such as the clear, non-turbulent air on a mountain top). Clearly the idea of building such a large, single mirror telescope is impractical. So what can be done to increase the resolution of



In order to maintain the extreme accuracy of the Hale Telescope primary mirror, the mirror surface must be re-aluminized periodically to maintain its accuracy. The top photo shows the original primary mirror before only 3 millionths of an inch of aluminum were applied (bottom). (Source: Caltech)

the telescope within the constraints of practicality?

The answer is to use an interferometric array. An interferometric array uses several individual telescopes linked together to produce a resolution equal to a mirror the size of the spread of the telescopes. For example, if telescopes that are linked by fiber optics cover a distance of one kilometer, then the interferometers jointly have the resolving power of one mirror one kilometer in diameter in the direction of two linked mirrors. Not only is such an array more economical to build, but it's also less cumbersome to operate. It takes less time to position several smaller telescopes than to move one large one. Also, if anything breaks on a larger telescope, then data can no longer be collected on that telescope until the problem is fixed. If something breaks on

an individual telescope in an array, then the problem is isolated to that telescope only and data can still be received from the other telescopes in the array.

There has already been an attempt at building an interferometric array with great success. CHARA, the Center for High Angular Resolution astronomy, is an optical and infrared interferometric telescope. Often considered the most powerful telescope of its kind in the world, CHARA can resolve details as small as two-hundred micro-arc seconds. This is roughly the resolving capability of one telescope a fifth of a mile in diameter. Each one of the telescopes in the array is equipped with a one meter mirror. If such an array can be built on the Earth, where all the terrestrial factors such as high gravity and atmospheric turbulence must be considered, imagine what kind of in-

strument can be built in the right location on the low-gravity, airless lunar surface.

The surface of the Moon consists of dust and rock and is almost flat in the craters. This removes the need of clearing a site for construction. Another convenient aspect of the Moon's landscape is the fact that it lacks significant seismic activity that could jostle and break the telescope. Recent studies have attempted to challenge the stability of the Moon for interferometry, claiming that the moon was unstable due to "tidal and meteoroid induced-seismic disturbances." This con-

results have been excellent, but even the most sophisticated techniques still can not completely compensate for all the blurring. Orbiting telescopes like Hubble fly above the tenable atmosphere, but these telescopes tend to have very small mirrors, and are costly to operate. In free-fall telescopes have to be oriented using gyros. This takes far more effort than would be needed on the Moon because it is a lot easier to orient the telescope in different direction against the large mass of the Moon then using moment wheel (gyros).

tions for such an instrument. Prime astronomical real estate is on the Moon is not likely to be an issue anytime soon.

The next question is how we may consider building such an array. One of the more common array designs envisions a hub-and-wheel type structure. At the center is one primary telescope, or a hub, that is elevated. Surrounding it are several other interferometers linked to the hub by fiber optic cables.

Weight will be a deciding factor for the materials used to build the telescope. If an optical interferometer would require carrying significant amounts of mass to the lunar surface, then the overall cost of the project might become prohibitively expensive. A large part of the mass of such an array would come from the heavy and, not to mention, fragile mirrors required by the imaging system in the telescopes. Recent advances may help in this regard. NASA recently developed a sturdy and lightweight composite fiber resin mirror specifically for telescopes that may be as effective as the glass mirrors found in terrestrial observatories. A mirror made of this material may also have a self-repair capability. If the mirror is damaged, an electric current can be applied to the fiber laminate of the mirror. The electric current will melt the resin to form a smooth surface on cooling. Such self-repair capabilities are essential for a telescope that won't have contact with humans for some decades.

Crews will be able to visit the array sporadically to repair and upgrade it, but the system design must be inherently robust and reliable, able to be used for long periods of time with minimal need for maintenance. A telescope drive and bearing mechanism needs to be capable of very slow and very smooth movements. Since this telescope is on the Moon, it needs to be able to operate in an environment that is very cold, dusty, and very close to a hard. High Temperature Superconductors (HTS) might work well for this purpose. In an HTS bearing, the rotor (a magnet) and the stator (the HTS) never come in contact with one another.

"As the next phase in space age comes about, there is little doubt that more and more people will arrive on the Moon in the next century and, as is common with human expansion, industry will come as well. This Moon-based industry will be able to service, repair and expand the array."

tention, however, is immediately negated by the data collected by the Apollo flights. In the 127 collisions that occurred in the course of a typical year, only one critical disturbance impact was record by the Apollo 14 station. This makes the rate and magnitude of asteroid impacts a negligible concern for the array unless it takes a direct hit which, statistically speaking, is highly unlikely.

The atmosphere of Earth envelops the planet and, fortunately, protects the Earth from the various negative effects of space weather. However, the Earth's atmosphere also absorbs infrared waves from space, while the radio noise generated from our planet frequently makes it difficult to discern signals from further out in space. Earth's weather, such as storms, fog and diurnal cycles, can also prevent a terrestrial telescope from seeing the sky for indefinite periods of time.

The atmosphere also frequently blurs the images taken by telescopes. Blurring can be offset by adaptive optics which compensates for the movement of the atmosphere. Most modern observatories make use of adaptive optics and the

The potential for astronomy on the Moon is therefore based on at least two traits – its small but non-negligible gravity and its lack of atmosphere. The fact that there is nothing between the telescope and the sky it is trying to study, along with the gravitational mass of the Moon serving as a means of telescope control, makes the Moon an excellent potential site for an astronomical observatory.

The last thing that makes the Moon a perfect site for interferometric telescope arrays is its endless future possibilities. Assuming that there is regular access to the lunar surface, it would be far easier to increase the size of the interferometric array on the Moon then it would be on Earth or with satellites. This is not without reason. Various surface features on Earth are not suitable for building gigantic astronomical instruments, while many of the most prime pieces of real estate like the top of Mauna Kea in Hawaii are already nearly oversubscribed. Furthermore, an array-type instrument in particular needs space to grow if it is to realize its full potential over the long term, further constraining the potential loca-

If these two parts don't touch, the potential for wear and tear is greatly reduced. Using HST bearings, it may be possible for the telescope's mechanisms to survive for a long period of time, perhaps even indefinitely, without intervention.

Most of the newer technology needed to operate such a telescope is already developing. However, the technology to take the telescope to the Moon is slightly more speculative. While a telescope by itself is a slightly heavy load, hauling only one up with a standard rocket shouldn't be a problem. Unfortunately, one telescope does not an array make. It is neither economical nor practical to haul all of the telescopes into Low Earth Orbit (LEO) and on to the Moon at once.

In one scenario, an array is assembled in space. Using standard rockets, pieces of the array are brought into LEO, where they are assembled at a space station. This space station will have to be an entirely new space station; the International Space Station CANNOT satisfy this requirement. A far more adequate orbit would be a near equatorial orbit around the Earth.

The next step is to place the assembled pieces on a specially designed, robotically-controlled interplanetary ship and send them to the Moon. For efficiency's sake, this ship will use an ion drive for propulsion. An ion drive is essentially a rocket engine that, instead of using a chemical reaction, uses an electric propulsion system. In the engine, ions (generally the ions of hydrogen, helium and cesium) are accelerated across an electric field at 100 kilometers per second or more. Solar arrays would create the electricity needed to power the drive.

Within a couple days the ship would then enter a low moon orbit (LMO). Once in LMO, a part of the ship similar to a lunar excursion module will descend to the lunar surface. From there telescopes, which are equipped with rover-like modules at their base, will move into the positions dictated to them from controllers on Earth.



High temperature ceramic superconductors, like the one pictured above, are made from a material that has only very low alternating-current resistance and thus dissipate less power. The magnetic forces between ceramic superconductor and magnet allow the magnet to float above the superconductor. (Source: Pacific Northwest National Laboratory)

A prime spot on the Moon for this array would be the shadowed crater below Malapert Mountain, located 122 kilometers from the lunar South Pole. The mountain itself is five kilometers high, but what makes it appealing is the lack of sharp, steep slopes along the peak, which would simplify construction. Another thing to keep in mind about this perfect peak is that it gets sunlight more than 90% of the time, making it an excellent platform for solar energy generation. Finally, the Earth is always in the direct view of this peak, thus making communication to and from Earth relatively simple by setting up relay stations.

The passage of time will change how the telescope is crewed and serviced, and will dictate its eventual overall size. The array will initially start with two telescopes. As flights to the Moon become more regular, it will be relatively easy to link more telescopes into this array, with the potential of eventually covering several kilometers of the Moon's surface.

The Moon is prime real estate for building an interferometric telescope. Not only does it lack the atmosphere and noise of Earth that normally interferes

with an Earth-based telescope, but it also has vast stretches of untapped land necessary for building such a large instrument. The only real cost will come from its space-based assembly and transportation to its location. Yet, these costs will be well worth the results of the telescope as it continues to search the sky for more Earth-like bodies and expands the knowledge of the space frontier. As the next phase in space age comes about, there is little doubt that more and more people will arrive on the Moon in the next century and, as is common with human expansion, industry will come as well. This Moon-based industry will be able to service, repair and expand the array. The array will be the first step in a line of human occupation and the services used for its construction will be able to be used in similar extra-terrestrial construction projects in the future.

The Moon is for the taking; it's a matter of reaching out to touch it. ■

Megan Kirk is currently an undergraduate student a Georgia Tech majoring in Civil Engineering.

A Leader from Apollo: Rocco Petrone

Rocco A. Petrone, 80, an Apollo-era NASA executive known for his toughness and drive to see NASA succeed, passed away August 24 at his home in Palos Verdes Estates, CA.

by Richard Faust

Mr. Petrone, who truly believed that spaceflight could serve towards the betterment of humanity, was a tireless worker and promoter of NASA and the manned spaceflight program in particular. Upon his retirement from NASA, he said:

I see man in the program as the essential element of adventure and discovery that we need. You start talking about adventure and discovery and anyone who tells you what's going to come out of it has got to be a fool to try, because out of discovery man has moved from the caves to where he is today, and we ain't finished moving.

I look upon all those things out there (in space) as challenges, put there by someone for us to try to understand, and in trying to understand, we're going to be better. (*Los Angeles Times*, April 23, 1975)

Mr. Petrone graduated from West Point in 1946 and attained the rank of Lieutenant Colonel during his career in the U.S. Army. He received a master's degree in mechanical engineering from the Massachusetts Institute of Technology in 1951 and began working as a mechanical engineer working on the Redstone ballistic missile system. In 1960, the army loaned Mr. Petrone to NASA, where he worked as Saturn Project Officer focusing on the development and construction of the Saturn launch system. He retired from the army in 1966 and joined NASA as Director of Launch Operations at the Kennedy Spaceflight Center, a position

he held until September 1969, when he was appointed Apollo Program Director at NASA Headquarters.

During his time with Apollo Mr. Petrone was instrumental in all aspects of the missions. He worked tirelessly on quality control and held his people to the highest level of standards. He took the *Apollo 1* fire and the loss of the three astronauts particularly hard. His toughness earned him the respect and dedication of his people. His longtime colleague and friend Jim Odom, who went on to become Associate Administrator for Space Station, recalls Mr. Petrone as "a very intense person. He could be demanding, but fair." Mr. Odom "thoroughly enjoyed working with him and for him because of those attributes." Axel Roth, who retired from NASA as the Marshall Spaceflight Center Associate Director, dates his interaction with Mr. Petrone back to 1961. He recalls Mr. Petrone as a "pretty hard task master" who "held people's feet to the fire," noting that while "he may have been a tough task master, he was very fair."

The value of the work that Mr. Petrone and other engineers and designers contributed to the success of Apollo cannot be overstated. Dr. Roger Launius, Chair of the Division of Space History at the National Air and Space Museum says in regard to Mr. Petrone that "he was one of a band of brothers captured by the dream of spaceflight. While they didn't get to go themselves they are the ones who made it real."

While Mr. Petrone may not have been as famous as the Apollo astronauts, he was certainly known and respected within NASA and the aerospace community. *The Washington Post* put him on a



Dr. Rocco Petrone, NASA's third Director of Marshall Space Flight Center, stands before a Saturn V rocket. Dr. Petrone supervised the Apollo 11 Lunar Landing and later directed the Apollo program in 1969. (Source: NASA)

short list for the position of NASA Administrator at the beginning of both the Carter and Reagan administrations.

Mr. Petrone ended his Apollo career as the Program Director for the NASA component of the Apollo-Soyuz Test Project. On January 26, 1973, he became Center Director for the Marshall Spaceflight Center. This move brought his career full-circle to where he started in 1952 at the Redstone Arsenal. This time his reputation preceded him. In the announcement of his appointment on January 24, 1973, *The Huntsville Times* noted that "'The Rock' is what some of his associates call Rocco Petrone. It is a sobriquet that is much more a reflection of solid dependability than a mere play on a name."

Mr. Petrone left Marshall in March 1974 and returned to Headquarters to become NASA's Associate Administrator – the third-highest position in the agency. He retired from NASA in April 1975 at the age of 46. Even though he left the agency at a young age, Mr. Odom notes that "he was an extremely strong proponent of NASA throughout his career."

Continued on page 18

A Case For Exploration

In his article “A Different Vision for Space Exploration” in the July/August 2006 issue of Space Times, Donald Beattie raised a number of interesting points concerning the value of lunar science and the wisdom of investing money in returning astronauts to the lunar surface. Like Mr. Beattie, I have been involved in various aspects of space science since the Apollo era. However, I would like to propose a different perspective, one that is significantly less pessimistic about the potential for lunar exploration than that offered by Mr. Beattie.

by Yoji Kondo

Central to the arguments in that article seems to be the notion that going back to the Moon will not answer the 125 questions raised in the July 2006 issue of *Science* magazine. I don’t think that anyone who supports the idea of returning to the Moon claimed that it would answer any of those 125 questions. Although those 125 questions are quite interesting from a purely scientific standpoint, many of those have little or nothing to do with the space program.

The article appears to support the status quo in the space program; i.e., let us keep doing what we are doing now, and it is certainly consistent with opinions expressed by some in the 1950s and 1960s about “all that money in space”. [The money for the space program has all been spent here right on Earth. None of the work has been out-sourced to the putative Martians or ETs.] Some supporters of spending the money here complained that for the price of one Orbiting Astronomical Observatory, we could build ten Palomar Mountain 5-meter class telescopes, the largest in the world at that time. In turn, the supporters of the robotic telescopes in space argued that we should spend all our money in robotic missions in space. Manned missions in space, according to this view, are a waste of money. Anything a human astronaut can, a robotic experiment could accomplish better, cheaper, and with less risk.

But, is such an argument valid?

I am one of those who believes that the desire to explore new and unknown frontiers is deeply embedded in our genes. Our intellectual drive to understand the universe is related to our desire to explore the unknown territories – our in-

born curiosity about the universe we have been born into. If you stifle one, you stifle the other. Both manned and unmanned (e.g., robotic) exploration of space go hand in hand whenever and wherever practical. We have seen that, when the financial support for manned space flights has declined, so has the support for robotic missions.

In general, opening a new frontier would open new possibilities, both physically and culturally, for the society undertaking it. Let me cite a few examples of what they could be for us in this instance, particularly if we use this unique moment in history to develop a significantly better way of getting to and from space.

First, let’s look at what going back to the Moon economically and safely can do for us. A significant part of the costs of going anywhere in space is associated

with jettisoning space ships after using it only once – the way we have been doing it. Think how expensive it will be to purchase a seat on a flight from New York to Paris if we must throw away or junk the airplane every time. It would probably cost several orders of magnitude more. That is how expensive reaching low-Earth orbit (LEO) is now. The Space Shuttle, although it is a fine piece of engineering from an era a few decades ago, is not exactly a completely reusable launch vehicle. You might call it a “rebuildable” space ship. It takes some ten thousand engineers and technicians to put it in a flyable condition and to keep it flying a few times a year.

Once we have an entirely reusable space vehicle (such as those envisioned in DC-X, originating in the U.S. Air Force Space Command, and by several entrepreneurial groups like Mojave



An artist's conception of NASA astronauts using an unpressurized bulk transport vehicle to assemble components of a distributed lunar telescope. (Source: NASA)

Desert neighbors Scaled Composite and XCOR), some studies have shown that the cost of reaching LEO could potentially be reduced to one percent of the present cost of using the Space Shuttle, i.e., from \$10,000 per pound using the Shuttle down to \$100 per pound using the reusable launch vehicle. DC-X, for example, was serviced by only a dozen or so engineers for a reflight within a day or two in

performed in a work station – a new space station – in an orbit economical to reach from a U.S. launch site, such as the Kennedy Space Center at Cape Canaveral in Florida. The present International Space Station has a highly inclined orbit relative to the equator, a compromise made in the early 1990s to facilitate access by Russian launch vehicles launched from a site in Central Asia. While this

away, for building a new space station as a mid-way port to the rest of the solar system. Combined with a new generation of space suits that do not require pre-breathing and that incorporate lessons learned from the International Space Station assembly experience, lunar shuttles optimized for trans-lunar flight could be built at the new orbiting facility. Once at the Moon, lightweight, highly-optimized lunar landers could be dropped on nearly any part of the lunar surface. Such an architecture would be a significant improvement over that which was deployed during the Apollo era, and would in fact be much more in line with pre-Apollo notions of how one builds out a useful interplanetary transportation infrastructure.

Once we solve the (not-inconsiderable) problem of ensuring economical and safe access to space, the frontier suddenly becomes much easier to explore, and the opportunities for science are blown wide open. Ready access to the lunar surface would enable a whole host of new, radically more capable scientific instruments like the interferometric array discussed on pages 4 - 7 in this magazine. Such an array, built in the near vacuum of lunar surface using indigenous lunar materials, would enable the collection of more and better types of data than any astronomical instrument in history, at wavelengths and resolutions far beyond the capabilities of any similar instrument built either on the Earth's surface or in free space.

The Moon is also a great platform for constructing and launching interplanetary probes and crew facilities out into the solar system at high speed. For example, solar-powered magnetic catapults (sometimes called mass movers) have been proposed since at least the 1970s. The potential for high-g acceleration from the lunar surface opens up fantastic possibilities for the exploration of Mars and other celestial bodies.

Of course, these scenarios above would assume an easy and economic ways to get to the Moon so we can have a number of workers on the Moon for construc-

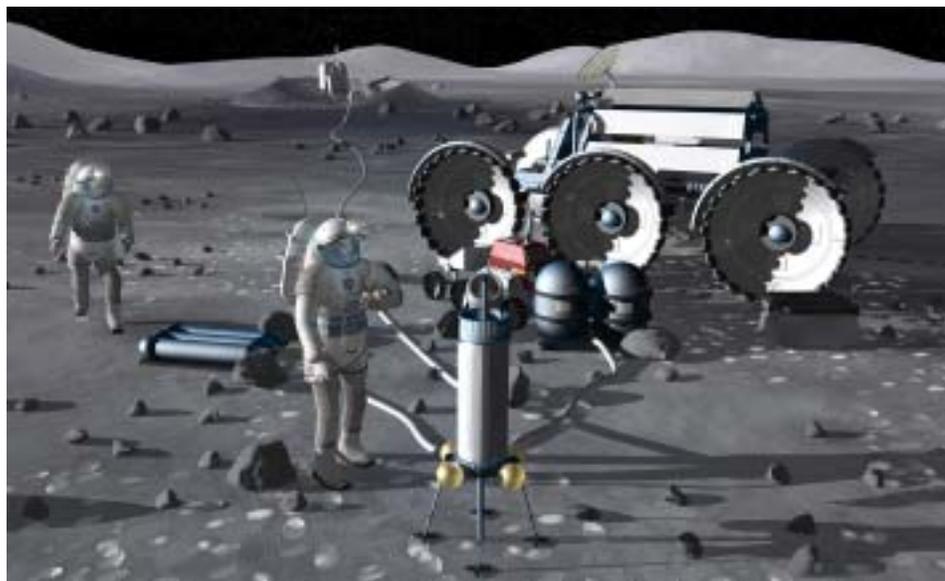
“In general, opening a new frontier would open new possibilities, both physically and culturally, for the society undertaking it. Let me cite a few examples of what they could be for us in this instance, particularly if we use this unique moment in history to develop a significantly better way of getting to and from space.”

a public demonstration flight at White Sands a decade ago.

In LEO, we could assemble Moon shuttles that will not have to punch through the Earth's atmosphere, making it unnecessary to protect the ship with massive outer skins and without the need to break away from the heavy Earth gravity. Such an assembly work would be

orbital inclination makes life easier for Russian launch vehicles, it severely impacts the ability of the United States to take maximum advantage of the International Space Station as a staging point for missions beyond LEO.

There are serious engineering proposals to use spent Space Shuttles external tanks, which are currently thrown



In this concept drawing, NASA astronauts are deploying a field site for scientific data collection away from their lunar base with the assistance of a lunar transport vehicle and a lunar robot. (Source: NASA)

AAS National Conference and 53rd Annual Meeting

"The Human + Machine Equation"

November 14-15, 2006 at the Pasadena Hilton in Pasadena, California

TUESDAY, NOVEMBER 14

7:30 Registration and Continental Breakfast

9:00 Welcome and Introduction

Mark Craig, AAS President and Vice President/Manager,
Assurance Engineering Operation, SAIC

Opening Video

9:10 Introduction of Keynote Speaker

Charles Elachi, Director, Jet Propulsion Laboratory

9:15 Carl Sagan Memorial Lecture & Award Presentation

G. Scott Hubbard, Carl Sagan Chair for the Study of Life
in the Universe, SETI Institute

10:00 Break

Video

10:15 *The Exploration Systems Mission Directorate*

10:35 Session 1: Robotics and the New Age of Space Exploration

- A discussion of the potential for synergy that humans and robots bring to the future of space exploration. Panelists will discuss the kind of robots humans will likely work with in space; what they will do for us and with us; interactions that are possible between people and robots; the roles of each in space exploration; and the nature of these relationships over time as the "minds" of robots and computers become able to replicate and improve themselves. This session provides an intellectual foundation for the rest of the conference - don't miss it!

Moderator: Susan Ruth, The Aerospace Corporation

Panelists:

- * TBD, NASA HQ
- * Yoseph Bar-Cohen, Robotics Engineer, JPL
- * Walter Sipes, Crew Psychologist, NASA JSC
- * Janice Voss, NASA Ames (invited)

12:00 Luncheon - Guest Speaker: Maja J. Mataric, Professor of Computer Science and Neuroscience; Founding Director, USC Center for Robotics and Embedded Systems; Director, USC Robotics Research Lab; President, Academic Senate Senior Associate Dean for Research, Viterbi School of Engineering, University of Southern California

1:30 Session 2: Motivating Tomorrow's Scientists and Engineers - Strengthening the U.S. Position in the Global S&T Environment - In 2005 the National Academy of

Sciences was asked by members of the U.S. Congress to conduct a study to recommend what federal policy-makers could do to enhance the science and technology enterprise in the U.S., so that the U.S. could compete, prosper and be secure in the global environment in the 21st century. One of the recommendations from that study was to "make the U.S. the most attractive setting in which to study and perform research so that we can develop, recruit and retain the best and brightest students, scientists and engineers from within the U.S. and throughout the world." Congressional legislation has now been offered which is titled "Protecting America's Competitive Edge" and is aimed at ensuring the U.S. successfully competes in the 21st century global environment. In the session, these issues will be discussed to include perspectives on what role the federal government and academia should play, and how the private sector can play a role in addressing this issue.

Moderator: Angela Phillips Diaz, NASA Ames

Panelists:

- * Ronald A. Madler, Embry-Riddle
- * Brian Duffy, Lockheed Martin
- * Gabriel Elkaim, UC Santa Cruz

2:45 Session 3: Human-Robotic Cooperation - The Vision for Space Exploration charters NASA with a return to the moon—and later Mars—through a succession of robotic precursors, short term crew visits, and durable human-robotic outpost encampments. Opportunities for human-robotic synergy in implementing such mission sets are rich and challenging.

Moderators: Paul S. Schenker, JPL and Nancy J. Currie, NASA JSC

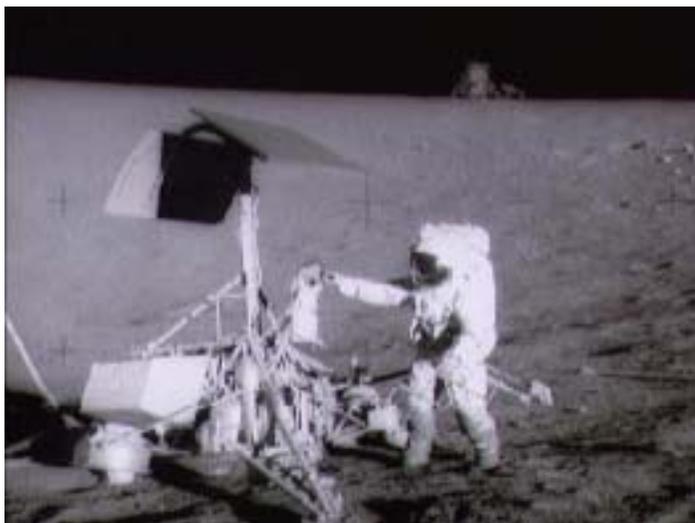
Panelists:

- * David L. Akin, University of Maryland
- * Robert O. Ambrose, NASA JSC
- * Douglas Gage, DARPA
- * Andrew H. Mishkin, JPL
- * Brian H. Wilcox, JPL

4:15 Break

4:30 Session 4: Lessons Learned From Other Industries: The Art of Integrating Science, Technology, and Humans

- Space exploration is not the only discipline working to solve the human + robotic equation. Many industries have already developed applications - and learned lessons - about human-robot interaction. This session examines some lessons about human-robot interaction from other industries, and how space explorers can learn from them.



Apollo 12 Visits Surveyor 3. (Source: NASA)

The session includes experts from the aviation and automotive industries, where robotics and automation are used extensively. They are joined by experts from the Department of Defense and the entertainment industry. A fascinating application-oriented discussion!

Moderator: David Fitts (invited)

Panelists:

- * Michael Feary, NASA Ames
- * Brent Weathered, NASA Langley
- * Mark I. Nikolic, Boeing/JSC
- * Steven Shladover, UC Berkeley

7:00 Pre-Banquet Reception

7:30 Awards Banquet

WEDNESDAY, NOVEMBER 15

8:00 Registration and Continental Breakfast

9:00 Session 5: Inter-center Collaboration: Making NASA's Vision for Space Exploration Happen

Moderator: TBD

Panelists:

- * Charles Elachi, Director, JPL
- * Mike Coats, Director, NASA JSC
- * S. "Pete" Worden, Director, NASA Ames

11:30 Luncheon - Guest Speaker: Al Diaz, Vice Chancellor for Administration, UC Riverside and former Goddard Center Director; AA for Science at NASA HQ

1:00 Session 6: Humans and Machines Exploring Space: Moon, Mars, and Astronomy - Increasingly challenging exploration goals for NASA will almost certainly require more ambitious human-machine interaction, whether it is remote robotic operation from the Earth's surface or direct astronaut-machine interaction. This panel will review the lessons learned from the Mars rovers and the Shuttle servicing missions to HST and discuss future concepts that advanced astronaut capabilities and robots will make possible.

Moderator: Harley Thronson, NASA GSFC

Full Registration: includes all sessions, continental breakfasts, break refreshments, two luncheons, and Nov. 15th reception.

AAS Member	\$365
New / Renewing Member	\$450
U.S. Government / Academia	\$300
One-Day Registration	\$225

Special Registration: includes all sessions, continental breakfasts, break refreshments, and Nov. 15th reception.

Student (full-time) / Teacher (K-12)	\$30
Retired (and over 65)	\$75
Press (with credentials)	No Charge

www.astronautical.org

Video

Panelists:

- * John Grunsfeld (NASA JSC): *The HST Experience with Advanced Tools and Humans in Space and on the Ground*
- * Richard Cook (JPL): *The First Generation of Mars Rovers: Lessons Learned for Future Surface Exploration*
- * James Garvin (NASA GSFC): *The Future of Mars Robotic Exploration*
- * Dan Lester (Univ of Texas): *The Future of Space Astronomy: Using Astronauts and Robots to Achieve the VSE*
- * Wendell Mendell (NASA JSC): *Exploring the Moon: Robots and Astronauts as Partners*

2:30 Break

3:00 Session 7: Human Attitudes Towards Robots - Taking a careful and considered look at the emotional responses humans have toward robots and robotics. Working robotics scientists and engineers discuss questions like: Does the use of robots increase a sense of fear or risk within humans who work with them? Can this happen in the exploration scenario? Do robots increase dependency, and decrease competence in humans? What causes the various attitudes humans have, and how do we know they are realistic? Is working with robots really safe? And how will current attitudes affect future attitudes, as the work of space exploration progresses?

Moderators: Bill Bluethmann, NASA JSC and Andrew Mishkin, JPL

Video: Robots in action

Panelists:

- * Robert Anderson, MSL Investigation Scientist, JPL
- * Scott Maxwell, MER Rover Planner, JPL
- * Nancy Currie, Astronaut, NASA JSC
- * Cynthia Breazeal, MIT Media Lab

4:30 Session 8: Mars Reconnaissance Orbiter (MRO): Status and Update

Richard Zurek, MRO Project Scientist

5:00 Adjourn / Closing Reception

IPC Welcomes Shana Dale — AAS/AIAA Seminar Planned

The AAS International Programs Committee (IPC) was honored to have NASA Deputy Administrator Shana Dale as special guest at a recent IPC meeting, hosted by Mr. Kiwao Shibukawa, Director of the Japan Aerospace Exploration Agency Washington D.C. office. Ms. Dale discussed NASA's Global Space Exploration Strategy process, and participated in a spirited question and answer session with committee members. Lyn Wigbels, Vice President International and chair of the IPC, noted that Ms. Dale's

comments were particularly relevant in light of an upcoming AAS/AIAA initiative, organized in conjunction with George Mason University.

This initiative will include a series of events to examine exploration objectives, plans and industrial capabilities and develop a single integrated data base of space exploration activities worldwide. The events will focus on the comprehensive range of plans, encompassing Moon and Mars programs and other missions and precursor research that contribute to

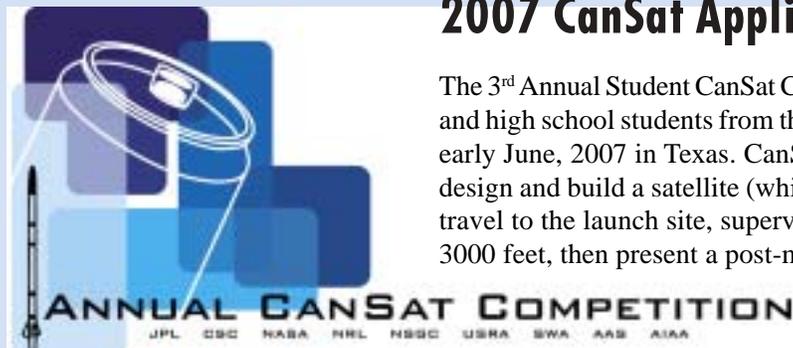
space exploration overall. National space exploration objectives, plans and industrial capabilities worldwide will be reviewed and presented in relation to a standard template. The template approach will aid an independent assessment of the overall space exploration endeavor and the roles of individual national space exploration components within it. The template approach will also aid the identification of gaps, overlaps and strategic redundancies, providing useful input to discussions on and planning for exploration activities in the coming decades.

The initiative's first event will be a public seminar on November 1–2, where Ms. Dale will speak, followed by an invitation only workshop January 30–February 1, 2007. It is the first activity being undertaken by AAS and AIAA under a new collaborative agreement on international activities. A written report containing the summary document and workshop findings will be released at public events in Washington and at non-U.S. venues in addition to being circulated within space agencies. Papers summarizing the report will be given at International Astronautical Congress and other relevant conferences.

For further information on the November Seminar, and for on-line registration, visit www.astronautical.org. ■



Jon Malay (Lockheed Martin), Lyn Wigbels (AAS VP International), Shana Dale (NASA Deputy Administrator), and Peggy Finarelli (AAS Executive VP).



2007 CanSat Application Deadline is October 30

The 3rd Annual Student CanSat Competition for college (undergraduate and graduate) and high school students from the United States, Canada and Mexico will be held in early June, 2007 in Texas. CanSat teams are required to write a mission proposal, design and build a satellite (which must fit into a 12-oz soda can, hence the name), travel to the launch site, supervise preparations and launch to an altitude of 2000–3000 feet, then present a post-mission debrief. See www.cansatcompetition.com

for application, mission details and to view photos and video of the 2006 competition.

Eleventh International Space Conference of Pacific-basin Societies (11th ISCOPS)

May 16-18, 2007 in Beijing, China



Aim of the Conference

The Chinese Society of Astronautics (CSA), the American Astronautical Society (AAS) and the Japanese Rocket Society (JRS) are pleased to hold jointly the 11th International Space Conference of Pacific-basin Societies (ISCOPS) from May 16 to 18, 2007 in Beijing, China.

The aim of the conference is to provide a forum for the space decision-makers, experts, engineers and technicians to exchange ideas and experiences in space technology and prospect the future of space development and its applications mainly in the Pacific Basin under the theme "Space Exploration for the 21st Century."

Conference Venue

The 11th ISCOPS will be held in Beijing, China. More information will be released in 2nd announcement.

Conference Language

English will be the working language of the conference.

Main Sessions

- A National and International Space Programs
- B International Students Conference and Competition (graduate level)
- C Technical Sessions

- C1 Astrodynamics, Guidance and Control (including space robotics and ground operations)
- C2 Satellite Communications, Broadcasting and TT & C
- C3 Satellite Remote Sensing, Meteorology, Small Satellite Systems/Constellations, etc.
- C4 Human Space Flight, Space Station and Pacific Space Port (including Lunar Research and Exploration)
- C5 Materials and Structures
- C6 Space Transportation and Propulsion
- C7 Micro-gravity Sciences (including Space Debris and Environment) and Life Science

Abstracts

Abstracts for proposed papers must be received by January 5, 2007. An abstract of 1000 to 1500 words in English should be submitted to the regional representatives with Microsoft Word and PDF documents as attachments. Student abstracts should indicate the level (Master or Ph.D.) and the name of the student presenter. The abstracts will be gathered in a bound volume and distributed to all participants at the conference.

Authors are requested to prepare their abstracts as follows:

Use...

- A text area of 170mm X 240mm. The preferable page size is A4 (210mm X 297mm).

- Single spacing, starting in the top quarter of the page.

Include

- Title
- Author's full name
- Author's affiliation and mailing address
- Email address and phone & facsimile numbers
- No less than two key words

Authors should suggest the most suitable session for their presentation.

Regional representatives:

CSA The secretariat ISCOPS
Chinese Society of Astronautics
P.O. Box 838
Beijing 100830 China
Fax: 86-10-68768624
iscops2007@yahoo.com.cn
(for Chinese and other participants)

AAS Prof. Peter Bainum
Dept. of Mechanical Engineering
Howard University
Washington, D.C. 20059 USA
Fax: 1-202-806-5258
pbainum@fac.howard.edu

Prof. Arun Misra
Dept. of Mechanical Engineering
McGill University
817 Sherbrooke St. W.
Montreal, Quebec, H3A 2K6
Canada

Fax: 1-514-398-7365
arun.misra@mcgill.ca
(for North and South American participants)

JRS Prof. Takashi Nakajima
The Institute of Space and
Aeronautical Science
Japan Aerospace Exploration
Agency
3-1-1 Yoshinodai, Sagami-hara
Kanagawa 229-8510, Japan
Fax: 81 42 759 8458
nakajima.takashi@jaxa.jp
(for Japanese participants)

Proceedings and Preprints

Proceedings of the conference will be published. The format instructions for full papers is provided in 2nd announcement.

Conference Fees

Before May 15, 2007

Full Participant \$500
Full Participant (Retired) \$350
Student Speaker Free
Student Participants (not speakers) .. \$70
Accompanying Person \$150

After May 15, 2007

Full Participant \$550
Full Participant (Retired) \$400
Student Speaker Free
Student Participants (not speakers) \$120
Accompanying Person \$200

Full participant and student registration fees include admission to all technical sessions and social programs, including the welcome reception, the award banquet, coffee breaks and half day technical visit, as well as a book of

abstracts and the proceedings of the conference.

Additional banquet tickets can be purchased for USD 50.

Spark Matsunaga Memorial Award

During the conference, the Fifth Spark Matsunaga Memorial Award will be presented to a person from the Pacific region who has made distinguished contributions to the regional or global space cooperations. In order to simplify the process of selection, the following principles agreed by the three sides of AAS, JRS and CSA will be followed:

1. Each ISCOPS in principle selects one winner;
2. The winner should be selected from the candidates nominated by the host society from their own country;
3. The other two societies are asked to respect the hosting society's nomination and support the selected winner;
4. One additional winner from another pacific-basin country not involved with hosting future ISCOPS might be possible upon the agreements by the three societies. All the nomination materials should reach CSA ISCOPS Secretariat by January 5, 2007.

Technical Visit

A half-day technical visit will be organized in Beijing in the afternoon of May 18. Free of charge.

Social Events

The Welcome reception will be provided on evening May 16, 2007, Banquet will be provided on evening May 18, 2007 together with the Award Pre-

sentation for full participants and student participants. Additional banquet tickets can be purchased for USD 50.

Accommodations

Accommodations are available at and nearby the conference site. More information will be released in the 2nd announcement.

Post-Congress Tours

More information will be released in the 2nd announcement.

Conference Organization

Honorary co-chairmen

CSA TBD

AAS TBD

JRS TBD

General co-chairmen

CSA Prof. Zhang Qingwei

AAS Mr. Mark K. Craig

JRS TBD

Technical co-chairmen

CSA TBD

AAS Prof. Peter Bainum

Prof. Arun Misra

JRS Prof. Takashi Nakajima

International Program Committee co-chairmen

CSA TBD

AAS TBD

JRS TBD

For further information, contact:

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P.O. Box 838

Beijing 100830, China

Tel: 86-10-68768623

Fax: 86-10-68768624

iscops2007@yahoo.com.cn



Editor Wanted

Space Times is seeking a new editor, beginning early next year. If you have the desire to communicate, the skill to lead a vigorous editorial team, and the time to volunteer to AAS, please contact the AAS business office at 703-866-0020 or aas@astronautical.org for more information.

Spacecraft Technology: The Early Years

Reviewed by Jonathan Krezel

***Spacecraft Technology: The Early Years*, Mark Williamson, The Institution of Electrical Engineers History of Technology Series (Dr B. Bowers and C. Hempstead, editors), 2006, 388 pages, \$80.00, ISBN 0863415539 [hardbound]**

Histories of spaceflight generally fall into one of two categories. The first tend to look at the rise of this peculiar capability as a primarily human activity,

focused on the nuances of how a particular piece of spaceflight technology came to fruition (or not, as the case may be). For big projects and programs like Apollo or the Space Shuttle, there can be a lot of overlap between the two approaches. For others, like those that deal with the development and evolution of spacecraft computers, spacesuits, or astronomical instruments, the intent is often to show how individuals and small groups seek to bend

of the Apollo-era lunar exploration architecture. Though not a trained historian, Williamson also takes the opportunity to reach back deep into the history of spaceflight technology, and to look ahead at the political and cultural implications of recent advances in both technology and policy.

While Williamson does not break a lot of new ground in terms of historical detail, he succeeds in drawing together a host of technical details, personal stories, and historical background into a very engaging and readable summary of some key advances in spaceflight. His insights are also very timely, coming as they do as the U.S. and other governmental and private agencies look to bring a whole host of new spaceflight hardware online over the next two decades. *Spacecraft Technology* should be on the reading list for decisionmakers and technology entrepreneurs alike, if only to remind the current generation how the great innovations that we take for granted ultimately came to be. ■

“Spacecraft Technology should be on the reading list for decisionmakers and technology entrepreneurs alike, if only to remind the current generation how the great innovations that we take for granted ultimately came to be.”

and thus tend to view the history through the lens of the social scientist. These are the big picture treatments, embedding spaceflight within the context of the larger social, economic, political, or cultural issues of the time. Many of the themes in this body of literature have become intellectual touchstones for the spaceflight community. For example, to borrow a phrase from military theorist Carl von Clausewitz, spaceflight has been seen by some as simply politics by other means, particularly as one battle along what President John Kennedy called the “fluid front” of the Cold War. Others place the evolution of spaceflight squarely within the context of American exceptionalism, citing authors like Frederick Jackson Turner and concepts like the “Frontier Thesis” or “Manifest Destiny.” Still others see a continuity of exploration running through all of human history, perhaps reflecting some basic genetic trait that separates *homo sapiens* from other species on this planet.

At the other end of the spectrum are those histories that tend to be more

metal around the immutable laws of physics for novel new purposes. There is often an intimacy to these histories, a sometimes dry but often fascinating look at the minutiae of technology development that speaks to the soul of the scientist and the engineer.

Mark Williamson’s *Spacecraft Technology: The Early Years* certainly has its heart squarely in the latter school (minus the dry part). Drawing primarily from secondary source materials, Williamson uses a number of representative spaceflight technologies to drill down into the heart of the hardware design and development process. The case studies focus on the two decades from the 1950’s to the 1970s, a timeframe Williamson calls, “one of the most important periods of technological development mankind has ever known.” Based on a series of talks the author gave over the past several years to the Institution of Electrical Engineers, the case studies cover the development of space launch systems, space and Earth science instruments, communication satellites, and key pieces

Jonathan Krezel is Editor of Space Times.





Department Chairperson - Space Studies

The Department of Space Studies in the Odegard School of Aerospace Sciences at the University of North Dakota in Grand Forks invites applications for the position of Department Chairperson. We are searching for candidates with demonstrated administrative leadership and professional expertise in a space-related field of public policy, law, economics, business, history, engineering, remote sensing, planetary science, life science or astronomy.

The Space Studies Department is a strongly interdisciplinary program featuring an M.S. degree and an undergraduate minor. A Ph.D. is planned. The Department has both a campus and a distance education program, with a student body comprised mostly of highly motivated early career professionals seeking a degree for professional advancement or personal interest.

Candidates must have an earned doctorate or terminal degree in one of the departmental disciplines listed above and should have an established record in teaching and in research and/or professional activities. A broad insight into the interdisciplinary nature of space activities and significant ongoing contact or connections with the space community is highly desirable.

A detailed position announcement and additional information concerning the Department is available at <http://www.space.edu>. For more information on UND Aerospace, visit <http://www.acro.und.edu>. Interested individuals with specific questions can contact search committee chair Prof. Michael Gaffey at gaffey@space.edu or at 701-777-3167.

Applicants should submit a letter of application, a vita and contact information for three professional references. Applications will be reviewed beginning August 1, 2006 and will continue to be accepted until the position is filled. Submit applications or general inquiries to:

Gary A. Ebel, Senior HR Manager
Odegard School of Aerospace Sciences
3980 Campus Rd. Stop 9007
Grand Forks ND 58202-9007
Email: ebel@aero.und.edu.

The University of North Dakota is an AAEO Employer.

A Case of Exploration

(Continued from page 11)

sible dream of powered flight was to become, not only a reality, but one of the most disruptive developments in human history over the last thousand years:

Now, there are two ways of learning how to ride a fractious horse: one is to get on him and learn by actual practice [and] the other is to sit on a fence and watch the beast ... It is very much the same in learning to ride a flying machine; if you are looking for perfect safety, you will do well to sit on a fence and watch the birds; but if you really wish to learn, you must mount a machine and become acquainted with its tricks by actual trial.

As I have noted in the previous discussion of reusable launch vehicles, the details of how we execute the sweeping scope encompassed in the Vision for Space Exploration is certainly a worthy topic of vigorous debate. The real burden of proof, however, is on those who would assert, despite all the evidence of history, that the civilization that steps back from the brink of exploring new frontiers, be they physical or intellectual, is somehow better off for doing so. Until then, the ambitions of other nations and the realities of our existence as inhabitants of a beautiful, lonely, fragile world have and will continue to compel the ambitions of the United States in space exploration. ■

Dr. Yoji Kondo headed the astrophysics laboratory at the Johnson Space Center during the Apollo and Skylab Missions. He was also director of the IUE geosynchronous satellite observatory for 15 years. He served as President of the International Astronomical Union Commission on Astronomy from Space, among other offices. He was also professor, adjunct, at several universities, including the University of Pennsylvania and the Catholic University of America.

A Leader from Apollo: Rocco Petrone

(Continued from page 8)

Rocco Anthony Petrone was born March 31, 1926, in Amsterdam, NY, the son of Italian immigrants. He was proud of his Italian heritage, and in February 1973 the Italian Government conferred on him one of its highest honors – the Commander of the Order of Merit. The Italian Ambassador noted that “his government was especially proud that a man of Italian descent had been a leader in the Apollo program” (*Los Angeles Times*, Sunday February 11, 1973).

He is survived by his wife of 50 years, Ruth Holley Petrone; four children Michael, Theresa, Nancy, and Kathryn; a brother; and a half brother. He also moves on with the respect and gratitude of the space agency and space community to which he gave so much. ■

Richard Faust is a Research Analyst for Valador, Inc at NASA Headquarters with the Academy of Program Project and Engineering Leadership. He has over 10 years experience researching space policy and history. A version of this article also appeared in the NASA Office of the Chief Engineer newsletter Ask OCE.

Visualizing the Vision

Turning engineering and policy concepts into a compelling, visual story is a critical part of transforming vision into reality. Dramatic, technically accurate images can help audiences imagine how the various pieces of a space exploration architecture will come together years down the road, making the whole concept more real and more supportable. But engineers and scientists need high-quality visual materials, too, particularly when the act of creating these images helps technical experts refine their designs. John Frassanito & Associates has been in the forefront of this effort, and along the way has already created iconic images that have already become synonymous with the Vision for Space Exploration.

by Keitha Nystrom

When President Kennedy first declared NASA's goal of landing on the Moon, he set a standard for United States world leadership in space. As we entered the 21st century, senior NASA managers and policy makers, under Executive direction, began to outline clearly defined goals and a roadmap that could secure our national leadership in space for coming generations. The results of their efforts culminated in President Bush's announcement of the Vision for Space Exploration (VSE) on January 14, 2004.

One of the teams that crafted this policy announcement was headed by the Space Operations Mission Directorate (SOMD) and included an early contributor to strategic planning of US space endeavors—John Frassanito. Frassanito's NASA design and engineering team credits include Skylab, the International Space Station, Lunar inflatable habitats, Reusable Launch Vehicles, Crew Exploration Vehicles, First Lunar Outpost, technical support for Earth to orbit (ETO) transportation, the Space Exploration Initiative, and, now, the Vision for Space Exploration.

This policy announcement was, in part, one of the outcomes of the Columbia accident. The Columbia Accident Investigation Board (CAIB) found that NASA had no clear, defining mission to focus the agency's activities. Without a defined mission, no one knew how long the Space Shuttle would fly. Without a known service life for the Shuttle, it was difficult to determine what investment strategies the nation should make with respect to our space program.

The CAIB finding prompted the White House to establish the VSE, which used multiple teams working independently on the policy formation process. John Frassanito & Associates (JF&A) worked on one team for four months, supporting this formation process.

JF&A worked on various mission designs, the locations and characteristics

and the benefits to the nation all had to be incorporated within a policy framework.

A big part of JF&A's contribution was via the firm's Strategic Visualization® process, an integral part of the VSE planning process that, ultimately, provided many of the images and animations that the President used for his announcement. These visuals were broadcast on televi-

“With Strategic Visualization(r) JF&A captures the ideas and contributions of individual members of a working group and converts them to a visual vocabulary that supports the planning process.”

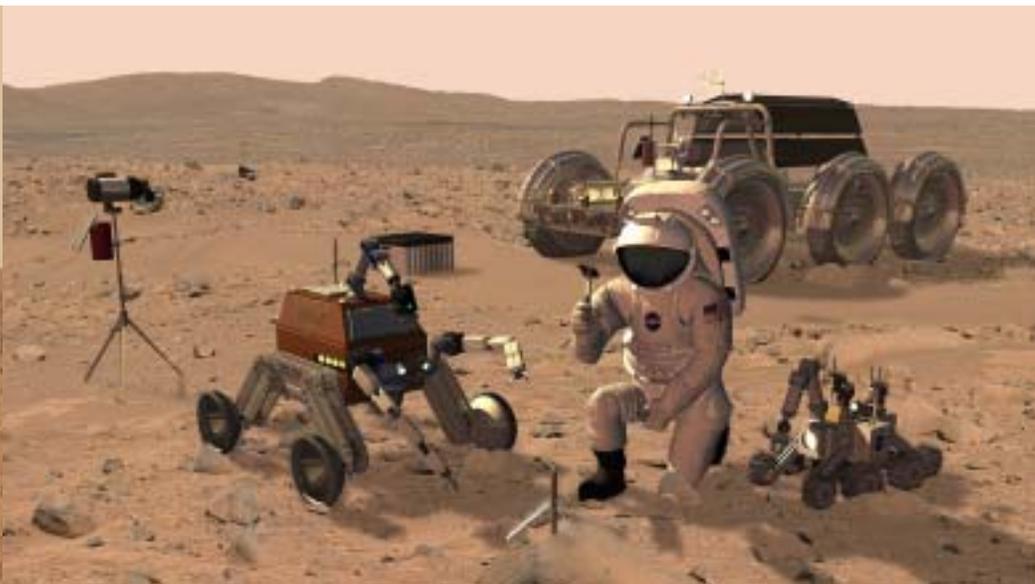
of Earth, Lunar, and Martian venues, and the articulation of the benefits in terms of the key imperatives of the policy—national security, economics, and science. These three tenants of the policy were inspired in part by Theodore Roosevelt's concept of a Blue Water Navy—a policy that eventually established the United States as the dominate world presence. JF&A also provided technical support in developing the elements on which to base the VSE mission, particularly for space transportation aspects, rationale and benefits, historical perspective, as well as many other aspects of the policy basis.

In addition to being technologically viable, the major elements of the mission designs had to be explained in a non-technical, compelling way. The locations and characteristics of various venues, the international partner participation,

mission around the world, posted on the NASA and industry websites, and reprinted in national and international publications.

NASA first used JF&A's Strategic Visualization® process for exploration planning and management support in 1989 during “The 90-Day Study on Human Exploration of the Moon and Mars.” The JF&A staff worked with the different engineering teams on a conceptual exploration plan, capturing their ideas in sketches, then posting them on a “planning wall.” Each team could see what the other teams were doing and how their ideas fit with their own team's work. Notes, annotations, and yellow “stickies” registered comments and problems; changes were made on the sketches, and then reposted on the wall. Some resulting concepts of that Study (http://history.nasa.gov/90_day_study.pdf) laid a





foundation for the planning going into and coming out of the Vision for Space Exploration

With Strategic Visualization®, JF&A captures the ideas and contributions of individual members of a working group and converts them to a visual vocabulary that supports the planning process. JF&A condenses volumes of data into powerful images that clearly com-

are distributed within a virtual network. Consequently, computer animation and other digital techniques provide an efficient means to communicate top-level technical information among team members.

Furthermore, once the team has developed a sound mission design, STRATEGIC VISU-

“Since the President’s 2004 announcement, Frassanito has continued to support the Exploration Systems Mission Directorate (ESMD) at a number of levels including the Administrator’s rollout of the Exploration Systems Architecture (ESAS), the Lunar Reconnaissance Orbiter, the Crew Exploration Vehicle project, the Constellation program, and other program elements.”

municate missions, technologies, and plans to engineers and managers as well as the general public. Now the “planning wall” is behind the firewall of NASA’s websites, and JF&A’s NASA presentations are used for everything from Congressional briefings, broadcast television, and magazine articles to high-level technical exchanges and publications worldwide.

“Strategic Visualization and Space Exploration,” a paper by NASA’s Douglas Cooke and John Frassanito, noted the historical role of visuals in space exploration:

NASA teams, such as the NASA Exploration Team (NEXT), utilize[d] advanced computational visualization processes to develop mission designs and architectures for lunar and planetary missions. One such process, STRATEGIC VISUALIZATION®, is a tool used extensively to help mission designers visualize various design alternatives and present them to other participants of their team. The participants, who may include NASA, industry, and the academic community,

ALIZATION® is used to communicate that concept to the general public. This is a vital step that Dr. Wernher von Braun used to enhance public support for space exploration. In 1952, for example, Chestly Bonestell and others working under the direction of Dr. von Braun, created the Collier’s Magazine series of eight articles known as ‘the Collier’s space program.’ Unlike previous works of science fiction, these articles were based on rigorous science and technology. Virtually every aspect of space flight was considered: astronaut training, space stations, lunar expeditions and missions to Mars. Space exploration was greatly advanced as a national priority when Collier’s presented the American public with a bold and feasible vision of excursions to Moon and other planets.

Since the President’s 2004 announcement, Frassanito has continued to

support the Exploration Systems Mission Directorate (ESMD) at a number of levels including the Administrator’s rollout of the Exploration Systems Architecture (ESAS), the Lunar Reconnaissance Orbiter, the Crew Exploration Vehicle project, the Constellation program, and other program elements. The firm archives and updates a library of current architectures in 3D formats that it provides to its NASA clients as part of its services so, when a new component or mission is under development, the project team has the tools at hand to help do the job.

John Frassanito is a New York-born industrial designer who trained at Art Center in Los Angeles and, after graduation in 1968, worked as part of the famed Raymond Loewy and William Snaith design team on the interior concepts for Skylab, America’s first space station launched in 1973. A co-founder of Datapoint Corporation in 1969, Frassanito later began his own design firm designing products for companies such as Scott Paper, Texaco, Sani-Fresh, Daniel Industries, General Foods, and EMI Corporation. Since 1985 he has been a strategic planning, mission and spacecraft design consultant to NASA engineering, scientific and planning teams for the Agency’s future space missions, making those scientific visions come alive for specialists and the general public alike.

JF&AI’s work in Strategic Visualization for the space program has been recognized in major public exhibitions including the Art Institute of Chicago and, currently, The Intrepid Aircraft Carrier Air, Sea, and Space Museum in New York City, as well as in general public and technical journals such as *Popular Science Magazine*, *Aviation Week*, *Space News*, *Men’s Magazine*, and in the book *Space Architecture, The Work of John Frassanito & Associates for NASA* by John Zukowsky. ■

Keitha Nystrom is a Houston-based writer with a focus on harsh environment technology and operations for offshore, subsea, and space industry trade publications.

AAS Events Schedule

November 1–2, 2006

***AAS/AIAA Seminar**

“Contributions to Space Exploration: Global Objectives, Plans, and Capabilities”

George Mason University

Arlington, Virginia

703-866-0020

www.astronautical.org

*See page 14
for details!*

November 14–15, 2006

**AAS National Conference and
53rd Annual Meeting**

“The Human+ Machine Equation”

Pasadena Hilton

Pasadena, California

703-866-0020

www.astronautical.org

*See pages 12-13
for details!*

January 28–February 1, 2007

***AAS/AIAA Space Flight
Mechanics Winter Meeting**

Hilton Sedona Resort & Spa

Sedona, Arizona

703-866-0020

www.space-flight.org

February 3–7, 2007

**30th AAS Guidance and
Control Conference**

Beaver Run Resort

Breckenridge, Colorado

703-866-0020

www.aas-rocky-mountain-section.org

**AAS Cosponsored Meetings*

March 20–21, 2007

**45th Robert H. Goddard
Memorial Symposium**

*“Sputnik to Orion: Perspectives,
Opportunities, and Future Directions”*

The Inn & Conference Center by Marriott

University of Maryland University College

Adelphi, Maryland

703-866-0020

www.astronautical.org

May 16–18, 2007

***11th International Space Conference
of Pacific-basin Societies (ISCOPS)**

“Space Exploration for the 21st Century”

Beijing, China

703-866-0020

www.astronautical.org

*See pages 15-16
for details!*

August 19–23, 2007

***AAS/AIAA Astrodynamics
Specialist Conference**

Mission Point Resort

Mackinac Island, Michigan

703-866-0020

www.space-flight.org

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Utah State Univ. / Space Dynamics Lab.

Virginia Polytechnic Inst. & State Univ.

Women in Aerospace

Wyle Laboratories

2nd Space Exploration Conference

The Boeing Company, the National Aeronautics and Space Administration (NASA), and the American Institute of Aeronautics and Astronautics (AIAA) are pleased to announce that registration is open for the 2nd Space Exploration Conference, which will be held at the George R. Brown Convention Center, Houston, Texas, 4-6 December 2006. Please join us as a united space community to implement the Vision for Space Exploration.

Register online at <http://www.aiaa.org/events/exploration>



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