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A New Vision for Space Exploration

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President's Message

These are exciting times to be professionals in the space business! Two rovers are at work on Mars, and three orbiters are looking down on them with healthy science instruments. Two people continue to live and work in space, and space systems have become critical to so many facets of our modern lives. The president announced the space exploration vision for NASA and the nation on January 14, and space is once again on the national agenda.

I'm very proud to say that the AAS weighed in with a public statement supporting the president's initiative, but in a way that thoughtfully and professionally commented upon some key elements of the vision that need to be emphasized – and watched – as this process unfolds. This statement was carefully drafted *after* the president spoke, meaning we were closely listening and not simply cheerleading, and then was vetted through our officers and board of directors. I encourage our members to go to the AAS web site to read this statement and know that its wording was arrived upon only after spirited debate and a very balanced process. This is an example of a professional society doing the right thing.

The questions now for our community are: what will happen next, and how will the AAS continue to be a participant and an informed voice in what happens? Of course, the NASA space exploration vision is not the only game in town. The National Oceanic and Atmospheric Administration (NOAA) is working very closely with NASA, other agencies, and the White House in advancing an internationally coordinated plan for global Earth observations – with arguably the most important of those observations coming from space systems. And space systems continue to play a critical role in supporting the defense and intelligence communities.

Will the world's space faring nations "do the right thing" in their investment of precious taxpayer money for space systems to support defense, intelligence, science, and space exploration in the face of growing fiscal challenges? Will businesses and entrepreneurs be able to realize the returns their investors envisioned as their enterprises began? And will the next generation of citizens be inspired to participate in this great enterprise we call the space program and sign up for the math and science courses they need to take? These are all good questions for the AAS to help answer through informed debate.

Enjoy this copy of *Space Times*, and then pass it on. Let's infect others with the importance of the role a true professional society plays in meeting the unique challenges that space presents. As I've said before, this is your Society. I again invite you to get involved. For fifty years now, the AAS has been unique as a professional society, and we are needed now more than ever – in these exciting times.

Jon Malay

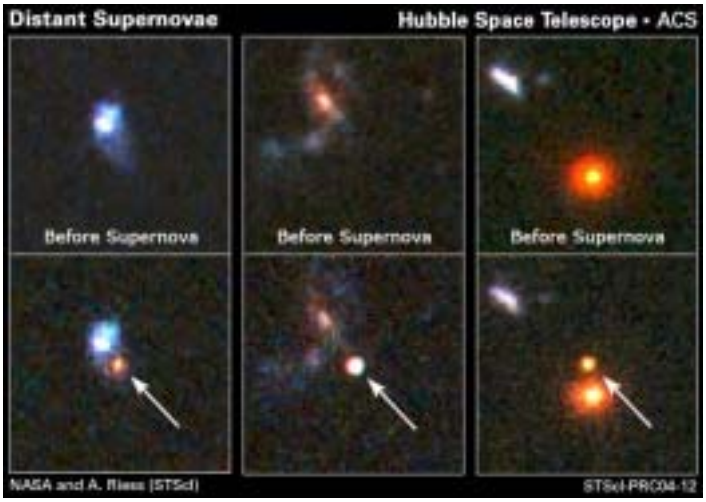
ON THE COVER

President George W. Bush announces a new vision for U.S. space exploration at NASA headquarters in Washington, D.C., on January 14, 2004. (Source: NASA/Renee Bouchard)

New Dark Energy Findings Lend Support to Einstein's Theory

Astronomers using Hubble Space Telescope measurements of distant exploding stars have come a step closer to characterizing an unexplained force, or "dark energy," that appears to be pushing the universe apart.

Adam Riess, of the Space Telescope Science Institute in Baltimore, Maryland, and a team of astronomers have made the first meaningful measurement of the permanence of dark energy. "Right now we're about twice as confident as before that Einstein's cosmological constant is real, or at least dark energy does not appear to be changing fast enough (if at all) to cause an end to the universe anytime soon," Riess said.



Images of three of the most distant supernovae known, discovered using the Hubble Space Telescope. (Source: NASA and Adam Riess/Space Telescope Science Institute)

In 1917, Einstein theorized that some type of "antigravity" force must be responsible for balancing the universe against its own gravity and preventing it from collapsing on itself. He invented the cosmological constant, which he used in his general relativity equations, to account for this repulsive force. How strong, constant, or permanent that force, or dark energy, is has been a mystery to scientists.

Riess and his collaborators used Hubble to find very distant supernovae that exploded when the universe was less than half its current age. The apparent brightness of a certain type of supernova gives cosmologists a way to measure the expansion rate of the universe at different times in the past.

Studies of distant supernovae led two teams of astronomers to discover in 1998 that the expansion of the universe is accelerating. An improved understanding of the nature of dark energy is critical to determining whether the universe will continue to expand or have an entirely different fate.

The source of dark energy, which appears to comprise 70 percent of the universe, is unknown. It could be an unchanging energy percolating from empty space, as Einstein's cosmological constant theorized. An alternative possibility is that dark energy is associated with a changing energy field. This field would be causing the current acceleration—a milder version of the inflationary episode from which the early universe emerged.

If the repulsion from dark energy is or becomes stronger than Einstein's prediction, the universe may be torn apart by a future "big rip," during which the universe expands so violently that first the galaxies, then the stars, planets, and finally atoms come apart in a catastrophic end of time. This idea is very speculative but is being pursued by theorists.

At the other extreme, a variable dark energy might fade away and then flip in force such that it pulls the universe together rather than pushing it apart. This least likely scenario would lead to a "big crunch" in which the universe ultimately implodes.

Even if Einstein turns out to be wrong, the universe's dark energy probably will not destroy the universe any sooner than about thirty billion years from now, the research team said. ■

Corrections

Space Times regrets misspelling author Matt Bille's name in the January/February 2004 issue.

China Targets 2005 for Second Human Space Launch

China has announced plans to launch humans into space for the second time in the nation's history. According to Wang Yongzhi, the chief designer of China's space program, the country will launch Shenzhou 6 sometime in 2005.

Last year, Shenzhou 5 launched the first Chinese astronaut, Yang Liwei, on a twenty-one-hour, solo Earth orbiting mission. The flight made China the third nation in the world ever to send humans into space.

Shenzhou 6 will carry two astronauts into space for a stay of five to seven days to perform additional tests of the spacecraft's capabilities. *Shenzhou* means "divine vessel" in Chinese.

About a dozen candidates, including Yang Liwei, are training for the flight. China has completed development of parts of the Shenzhou 6 rocket system, and tests are underway on the spacecraft system. The precise date of the launch has not been disclosed.

China also formally announced plans to develop docking technology and launch a space laboratory by 2007 to be visited by future Shenzhou missions. The nation ultimately plans to build a national space station. ■

New Space Advocacy Conglomerate Formed

In January, four space organizations—the National Space Society, Satellite Industry Association, Space Foundation, and Washington Space Business Roundtable—announced the creation of the National Space and Satellite Alliance (NSSA).

The NSSA member organizations will coordinate their Washington operations, programs, and activities to provide more unified advocacy of space policy issues and to better serve their members' interests. The NSSA will aim "to marshal the resources of the space and satellite advocacy community to most effectively advance the exploration and development of space, and the utilization of space and satellite systems and technologies."

In 2004, the NSSA will seek to build congressional and public support for the new Bush space exploration plan. In addition, the organization will work with Congress and the White House to implement export control laws that protect national security without unnecessarily burdening industry and will educate policymakers and the public about how satellite systems support homeland security. NSSA also will pursue cooperative efforts in educating and informing the public about space endeavors. ■

Want to Voice Your Views on the President's Exploration Vision?

The President's Commission on Implementation of U.S. Space Exploration Policy, also known as the Aldridge Commission, is soliciting the views of the public. As has been announced in the press, the commission is holding hearings around the country. Interested members of the public are welcome to attend, but, because the commission is charged with producing a report within 120 days, it will not accept oral statements from anyone other than the invited witnesses, unless the meeting notice provides otherwise.

The commission is also accepting written comments from private individuals at www.moontomars.org/notices/contact.asp. If you prefer to send a letter, use the following address. AAS members are encouraged to take advantage of this opportunity and let the commission know how you feel!

President's Commission on Implementation of U.S. Space Exploration Policy
2900 South Quincy Street, Suite 800
Arlington, VA 22206

International Space University Summer Session Program 2003: One Perspective

AAS helps make it possible for aerospace professionals and students to change the way they view the space industry and international cooperation.

by Brandon Jones

Since the summer of 1987, the International Space University (ISU) summer session program (SSP) has provided a forum for professionals and students in the space industry from around the world to assemble and study. The program has two major goals: the completion of an interdisciplinary curriculum and the creation of an international community of people with a common interest in space. Attendee backgrounds range from engineers and scientists to venture capitalists and teachers. These elements combined serve as the basis for a truly life altering experience.

For two years before applying to the SSP, I worked with several program alumni. Hearing them describe the program and share their experiences would make anyone slightly jealous. The opportunity to travel and study in another country for two months was enough to pique my interest, but adding an emphasis on the space industry changed the question from "If I can go…?" to "When will I go?" I took the first opportunity available and attended the 2003 SSP.

In July 107 individuals traveled to Strasbourg, France, the home of the ISU offices and the yearlong ISU Master of Space Studies program. Following orientation, the program officially began with the opening ceremonies, which included a procession of flags from each of the 31 countries represented. Soon after opening ceremonies, it was time to get to work.

Students and faculty of the space systems analysis and design department tour the electrical propulsion test facilities at the University of Stuttgart. (Source: Brandon Jones)

The academic portion of the SSP is broken into three parts. During the first half of the program, the primary element is the core lecture series. Each lecture is devoted to a single topic within one of the nine SSP subjects: space and society, business and management, engineering, information technology and information systems, life sciences, physical sciences, policy and law, satellite applications, and systems analysis and design. Department workshops form the second element of the curriculum. Each student selects one subject for more detailed study; ISU encourages students to select departments that differ from their backgrounds. Department workshops include professional visits to various nearby facilities, experiments, academic exercises, and an individual project selected by the student and the department chair.

Department and lecture workshops provide several opportunities for hands-on application of the topics covered. One workshop demonstrates the difficulties in designing and programming a robot for autonomous exploration, such as a Mars rover. Students in the space systems analysis and design department learn about system design by building a rocket and payload delivery system based on a set of simple requirements, while those in the space life sciences department experience the difficulties of astronaut activities in space while performing an underwater extravehicular activity. Through a multitude of activities, students gain a new appreciation and understanding of many elements of the space industry.

The third part of the SSP is devoted to the team projects. Each student selects one of three team project topics, which in 2003 were "space contributions to climate monitoring and modeling," "lunar missions using ISS capabilities," and "technology mapping of major space agencies." Although the team project provides the opportunity to apply knowledge gained from the department workshops and lectures, the primary purpose of the project is to work with others while overcoming differences in culture and language. It is an amazing event when people from different cultures, who have different ways of approaching a problem or task, find a way to work together. That is what the team project is truly about.

The team project culminates in a final presentation. After four weeks of work, faculty reviews, late nights writing and editing the final report, and countless games of table

tennis to relieve stress, each group gives a final presentation to the complete SSP student body, ISU faculty, and guests. This year, the presentations were broadcast live over the web, with student family members, friends, and ISU alumni viewing from around the world.

Nights at SSP are marked by a series of distinguished panels and other events. Panels included an international collection of astronauts, space policy makers from around the world, and many others. The international aspect of the program was expanded during regular "culture nights," and social events allowed us to sample local cuisine and relax after a hard day of work and study.

The time away from the ISU campus also provides a plethora of amazing experiences, from relaxing in an outdoor café with other students to the occasional early morning jog from France to Germany and back. Students traveled through the Alsatian wine country, relaxed in the hot spring baths in Baden Baden, Germany, and hiked the mountains around Chamonix in the French Alps.

The SSP is more than just the academic program and the two months the students spend together. The intensity and pace of the program creates a bond between the participants that, in my experience, is unparalleled. The accelerated pace of the lectures and the relatively short time to complete the team projects fosters an environment of camaraderie that lasts long after the completion of the program. The term "networking" is often used to describe this aspect of the program, but it is much more.

By the end of the program, the 107 strangers who assembled had become a large extended family. During the closing ceremonies, the students processed out carrying not the flags from their countries but one ISU flag demonstrating the strength of the international community they had created.

Brandon Jones and other students design a rocket for the space systems analysis and design rocket design project. (Source: ISU summer session program staff)

I again thank the AAS for assisting with my attending this wonderful program. Immediately upon returning to the United States, I found my outlook on the space industry had changed. I now have a much broader understanding of the industry, allowing me to participate in new, much more diverse projects. For this and many other reasons, I cannot recommend this program enough. It is designed for people of all ages and cultures; the only requirement is an interest in space. ■

Brandon Jones **works for Odyssey Space Research. He formerly worked for the Titan Corporation.**

International Space University's Introductory Space Course

With the co-sponsorship of the American Astronautical Society (AAS), the International Space University (ISU) is offering its one-week Introductory Space Course April 26-30, 2004, at the University's Central Campus located in Strasbourg, France. The course will be conducted in English.

ISU, the world's leading university completely dedicated to the study of space, presents this workshop to provide an interdisciplinary overview of space programs and activities. The course is specifically aimed at professionals in the aerospace arena who are working in the non-technical areas of management, marketing, finance, law, etc. It is intended to help participants better understand and integrate space science, technology, policy and business perspectives so as to facilitate communications across disciplines in government agencies, aerospace companies and other space-related organizations.

Conducted by ISU's international faculty, the course will utilize lectures, interactive workshops, practical case studies and a challenging hands-on project to expose participants to the interdisciplinary, international and intercultural learning environment of the ISU. Class size will be limited to encourage in-depth group discussion.

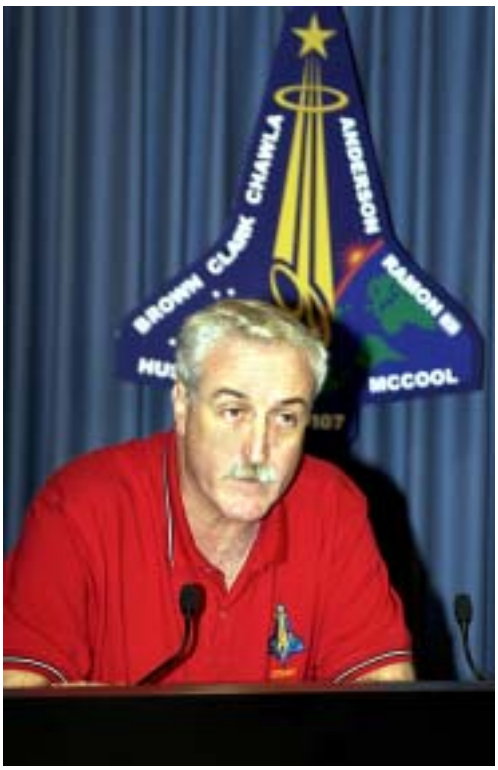
For registration, please contact ISU's Admissions Office at admissions@isu.isunet.edu or online at: http://www.isunet.edu/other_programs/short_programs_intro_sp_course.htm?aas .

A New Space Policy for the United States: Opportunities and Challenges on the Pathway to the Moon and Mars

The new Bush plan for space should be commended for its forward-looking nature—but policymakers should not lose sight of lessons and achievements of the past.

by Frank Sietzen, Jr.

On the morning of Thursday, November 12, 2001, the sun bathed the Grecian columns of the White House North Portico in a brilliant light. Inside, just after 9:00 a.m. senior administration staffers gathered outside the Oval Office, preparing to brief the president of the United States on the latest developments affecting his domestic agenda. On this bright autumn morning, presidential Chief of Staff Andrew Card had assembled then Office of Management and Budget Deputy Director for Management Sean O'Keefe and Bush's policy advisor, Josh Bolten, as well as other senior advisors. At 9:20 a.m., as word flashed to the White House that a commercial airliner had crashed on Long Island, New York, Card led the group in to see President Bush. An hour later, after being interrupted by phone calls from New York officials on the details then known about the crash, the meeting ended. But as the officials filed out, Bush turned to O'Keefe. "Sean, I want a word with you," the president said. Card closed the door and left the two alone. "About this NASA job," Bush told O'Keefe. "Here's what I want you to do…"



Following the loss of Columbia *and crew on their return to Earth, NASA Administrator Sean O'Keefe comments on the tragedy during a press briefing at the Kennedy Space Center. (Source: NASA)*

The marching orders from the forty-third president of the United States to the man who would shortly become the tenth NASA administrator were clear. Not only were the cost overruns then plaguing the International Space Station (ISS) to be stopped but also the whole structure of NASA itself was to be reviewed. Bush told O'Keefe that he had a dim view of the state of the nation's civil space agency. "The place is messed up," Bush said. "I want you to straighten it out." Two days later, Bush announced that O'Keefe would replace Daniel S. Goldin as the nation's civil space chief.

No one would know it for two more years, but that day began a process of renewal at NASA that would lead to a monumental redirection of civil space policy. That direction was triggered not just by the desire of the Bush administration for a reinvigorated space agenda: it would be given urgency and direction by a tragedy that would soon grip the NASA human space flight program.

In early 2002, O'Keefe began to institute a series of management changes and budget restrictions that restructured some of the agency's major initiatives. By early 2003, it seemed as if NASA was in better fiscal shape and had better congressional relations than the agency had in the previous decade.

Then, on February 1, 2003, space shuttle *Columbia* was destroyed and its seven-person crew killed upon return from space on a sixteen-day Earth orbital research mission. The catastrophe, the second shuttle accident in NASA's history, seared the agency and O'Keefe's leadership team. During the first hours following the disaster, O'Keefe spoke with Bush repeatedly and then almost daily. The president made it clear he wanted to get to the bottom of why *Columbia* was lost.

Just days after the disaster, Bush accompanied O'Keefe, senior NASA leaders, and the *Columbia* crew families to the Johnson Space Center in Houston for a memorial service for the fallen astronauts. Aboard *Air Force One* on the journey to and from the event, Bush talked with O'Keefe about the investigation then unfolding. But beyond the quest for the cause of the shuttle accident, the White House began to question the overall direction of the civil space program. Bush's declaration that the space program would continue, whatever the cause of the *Columbia* accident, infused the attention then being addressed to future space policy with a new focus and urgency.

A Search for New Directions

Thus, in parallel to the *Columbia* investigation, a review of space policy options began at the White

House. Initially these were informal discussions about potential options for the nation's space program. Should human space flight continue? What would it cost to replace the shuttles with a completely reusable craft? What was the state of cutting-edge space technologies? What would a human mission to Mars cost—and what would be the risks? Should the shuttle and the ISS be scrapped altogether in favor of a new program?

The Columbia Accident Investigation Board released its report in late August. The administration felt an organized response to the board's criticisms over a lack of policy direction and focus was needed. A formal process began, co-chaired by the National Security and Domestic Policy Councils. The Moon emerged as a logical destination for the next step beyond low Earth orbit, a close-to-home testbed for advanced space technologies that could sustain astronauts on other worlds, such as Mars, asteroids, or even farther objectives.

A consensus formed within the Bush administration that a sustained program of exploration should be the centerpiece of U.S. space policy. To keep the costs of the initiative down, a minimum number of new elements would be required, including a spacecraft that would take astronauts back to the Moon—and eventually on to more distant destinations. This vision of space nonetheless would require difficult choices and sweeping changes within NASA.

By December, the vision was set into a draft Presidential Decision Directive. All was ready for the president to make the final approval. The time came on Friday, December 19, 2003. Surrounded by Vice President Cheney, O'Keefe, and several top officials, Bush saw for the first time the full budget projection for the vision plan and the elements, including human lunar landings and eventual human exploration of Mars, all accompanied by a new generation of robots. "This is more than just the Moon, isn't it?" the president asked Cheney. The room was quiet, then Cheney spoke up. "This is really about going to these other destinations, isn't it?" he asked, looking at O'Keefe. After a time, Bush proclaimed: "Let's do it!" It had been more than ten months since *Columbia* had fallen from the sky. A new space policy had been reached.

President Bush and NASA Administrator Sean O'Keefe affirm their commitment to the new space exploration vision at the president's announcement event at NASA headquarters. (Source: NASA/Bill Ingalls)

Roll Out

On January 14, 2004, Bush visited NASA headquarters in Washington to announce his decision to the nation. "Inspired by all that has gone before, and guided by clear objectives, today we set a new course for America's space program," Bush said. "We will build new ships to carry man forward into the universe, to gain a new foothold on the Moon, and to prepare for new journeys to worlds beyond our own." The first priority was the restoration of the shuttle to safe space flight. Once shuttle missions were again underway, Bush said, their focus would be completion of the ISS. Once that had been accomplished, no later than 2010, the shuttles would be retired. ISS would be redirected to support the human exploration of space.

A new spacecraft called the Crew Exploration Vehicle (CEV)—later dubbed "Project Constellation" by NASA—would be built, Bush said. "This will be the first spacecraft of its kind since the Apollo Command Module." First test flights of the CEV could occur as early as 2008, the same year robotic exploration of the Moon would begin. Then, as early as 2015, but no later than 2020, Americans would land on the Moon to begin testing technologies and making new explorations. The initial landings would evolve into a more extended human presence, Bush posited, saying that following those missions, Mars would be a next destination for the CEV. Existing programs, such as Project Prometheus, NASA's nuclear power and propulsion development initiative, would be folded into the new exploration agenda. It would be an incremental, pay-as-you-go approach. "We'll make steady progress—one mission, one voyage, one landing at a time," Bush said.

Bush called the new space policy "a great and unifying mission for NASA." Within two days of the announcement, O'Keefe began restructuring his agency, establishing a new exploration office. More changes were expected as NASA moved to transform

Bush's vision into a new direction for civil space. But the plan left many questions unanswered as it got underway. What would the CEV look like, and how many elements would it contain? What would be its mission modes to the Moon? What heavy lift launchers would be needed to bring the crew spacecraft elements into orbit? How many of the shuttle's facilities would be converted—or abandoned?

What Is Past Is Prologue?

More than three decades ago, the U.S. civil space program began a transition similar in scope to that which has begun under the Bush doctrine. The evolution of human space flight capability from lunar exploration to low Earth orbit industrialization required virtual abandonment of the Apollo-Saturn architecture then in existence. Little effort was made to craft a bridge from the Moon exploration experience to reusability. Those capabilities and facilities that were not converted from Apollo to the space shuttle first were allowed to atrophy then were abandoned altogether. In that mix were space transportation elements such as the heavy lift afforded by the Saturn V. Instead of becoming part of a national strategy that allowed for conversion into a more affordable launch solution, the Saturns became expensive lawn ornaments at NASA field centers. Two decades later, space program officials lamented the lack of heavy lifting options to assemble Space Station *Freedom*. The world of human space flight had become entirely resident in the shuttle program. It was impossible, as well as politically untenable, to recreate the Saturns that the shuttles were designed by policy choices to replace.

Those policy directions reshaped the nature of U.S. civil, commercial, and military payloads and their planning processes. Nearly every major satellite system then in development was repackaged for the shuttle as its launching system. In some cases, this combination of a reusable vehicle and the presence of a human crew enhanced satellite safety and delivery. On those occasions when a satellite or its booster rockets malfunctioned, the shuttles were dispatched to retrieve them. But in other cases, the forced decision to fly aboard the shuttle—and only the shuttle—added millions of dollars and years of delay to a satellite's timetable. In the aftermath of the 1986 *Challenger* accident, payloads were forced from the shuttle's manifest, in some cases temporarily marooned as the dormant expendable launch vehicle industry was literally resurrected.

With the new space policy, years of technology development in new generations of rocket engines and propulsion systems, conducted first under the Space Launch Initiative and then under the restructured Next Generation Launch Technology program, will be terminated. And the current plan is to make little effort to continue national investments in any type of federally-funded replacement vehicles for the kind of launch and on-orbit servicing capability now resident in the shuttles.

NASA, quick to claim that the Hubble Space Telescope servicing capability was among the shuttle fleet's finest demonstrations of human-machine interface, will abandon such capabilities with the James Webb Space Telescope. The experience gained in three Hubble servicing missions, as well as the development of servicing procedures and tools, will be lost. When and if the U.S. civil space program decides that such a capability is needed again, many of those who pioneered that technology, as was the case with the original lunar explorers a generation ago, will have passed from the scene. All U.S. human space ability will be resident in the variations of the CEV.

Ahead for those in charge of Project Constellation is a similar transition, embedded within is a similar pathway of risk. The retirement of the space shuttle fleet is an irrevocable step that, once taken, would be impossible if not unaffordable to reverse. It includes policy architectures upon which U.S. space capabilities have been centered for a third of a century. Those decisions placed four elements at the center of U.S. human space capability. A large payload bay, plus a dexterous manipulator, human presence, and 100 percent down-mass (the weight of what the

The new U.S. space exploration vision calls for astronauts to explore new worlds, as this artist's conception shows. (Source: Alessandro Gattuso)

shuttles could bring to space could be returned) were considered essential elements to construct large structures in orbit, lift and deploy large spacecraft, or service the same.

Now, embedded in the president's new policy vision and mission is a NASA decision to reverse that previous capability. Crew and cargo will now be separated and human reusable heavy lift abandoned. It is as major a policy redirection as was the 1972 decision to shift all human space capability onto the shuttle system. Like the earlier decision, this step should at least foster some dialog within industry and the space community, for it, too, will be a choice that the nation will live with for decades to come, shaping directions and future choices in space planning that cannot be discerned today. "We are moving from a space-going truck to a series of SUVs (sport utility vehicles)," one NASA official joked. But the form, function, and robustness of that SUV fleet should be a major focus today, not when the steps have already been taken. Had such care been taken with the shuttle decision in the 1970s, the evolution of U.S. human space capability for the past three decades might well have been very different than the architecture that created both opportunity and inflexibility.

None of this is to suggest that the new policy direction is in any way misdirected. The president and his advisors are to be commended for the boldness of their vision and the comprehensive scenario to achieve it. But if the past history of U.S. space policy execution is any guide for the future, visions must be accompanied by political coalitions and the alignment of agile, ever-changing methods to fulfill them.

The space shuttle provides specific capabilities which risk being lost once the vehicle is retired. (Source: NASA)

The political pathway back to the Moon and beyond will be a difficult one to tread. Between now and the first human lunar landings under the early schedules, three presidential elections will be held and six U.S. Congresses will be elected. The political leaders that crafted the Bush plan will have long exited the scene, leaving their hardware handiwork as their legacy. But as we have seen before, hardware is but one element of space policy. The hardest task is not building infrastructure, as difficult as that will be. The true test of any space policy will be the nature and depth of the complex constituencies that will sustain the infrastructure's use. It is a process of renewal and change almost as old as the rocket itself. ■

***Frank Sietzen, Jr.*, is a Washington, D.C., space analyst and lobbyist. He is co-author of *New Moon Rising: The Making of George W. Bush's Space Vision and the Remaking of NASA*, to be published this summer.**

Sustaining the Vision of Exploration

Examining the fates of earlier space policies can provide the implementers of Bush's space exploration vision with valuable "do"s and "don't"s to ensure the new policy's success.

by Jeff M. Bingham

The plethora of "reality" television shows in recent years suggests a fascination, if not a preoccupation, with the notion of survival, or coming out on top, in a fierce competition using both inherent and available external resources to overcome challenges and obstacles.

In a sense, the president's *Renewed Vision of Discovery* is a new contestant in an ongoing policy competition that takes place year after year within the Executive Branch, the halls of Congress, and the hearts and minds of the American public. That competition takes place in each of those three venues and, increasingly, in an international context as well. Furthermore, over an extended period of time, the players in the competition change, as government leadership changes, individual members of Congress come and go, and the public's collective attention is redirected or distracted by other events. Even the rules governing the competition can change over time—sometimes very rapidly, if following a cataclysmic event with wide-ranging social, economic, or policy impacts, such as the September 11, 2001, terrorist attacks.

In a sense, the president's *Renewed Vision of Discovery* is a new contestant in an ongoing policy competition that takes place year after year within the Executive Branch, the halls of Congress, and the hearts and minds of the American public.

What will it take, then, for the president's new space vision to be sustained—to be a "survivor" in the policy "reality" game—and find its eventual expression in the physical reality of human footprints on the surface of the Moon and Mars? As members of the President's Commission on Implementation of United States Space Exploration Policy observed during their first public hearing on February 11, 2004, finding the means to sustain that vision over time is perhaps a greater challenge than identifying the technical means, management requirements, and fiscal resources to carry it out.

An obvious place to look for clues to the answer for that essential question is in past history and experience with major policy initiatives, especially in the realm of space exploration and policy. Reviewing the past twenty years, three such edifying examples immediately come to mind: the National Commission on Space report of 1986, the Space Exploration Initiative announced by President George H.W. Bush in 1989, and the space station initiative begun by President Reagan in January 1984 and still in progress today.

National Commission on Space

The National Commission on Space, chaired by former NASA Administrator Thomas Paine, was inaugurated in 1985. Charged by the Congress to identify the broad range of potential space exploration activities for the subsequent fifty years, the commission developed a report that unquestionably articulated the most far-reaching and ambitious view of space exploration potential ever put forth. It envisioned not only the exploration of the Moon and Mars but also the settlement of the solar system.

Tragically, the report's public release came just two months after the *Challenger* accident. With the space community and the nation preoccupied with the shuttle disaster, it was quietly tucked away on bookshelves. Despite the report's potential for setting the nation on a wondrous course in space, the scenarios presented could not be sustained in the shadow of the recent high-profile space catastrophe. The lesson from this experience is that cataclysmic events can eclipse the most well-intentioned plans.

Space Exploration Initiative

Announced by President George H.W. Bush on the twentieth anniversary of the Apollo 11 lunar landing, the Space Exploration Initiative (SEI) called for a permanent return to the Moon and a human mission to Mars by 2019.

After a disappointing effort by NASA in 1989 to craft an implementation strategy for the vision, the National Space Council, chaired by Vice President Dan Quayle, directed NASA to conduct an outreach program to solicit academic, corporate, governmental, and public views on ways to implement the president's vision. The White House asked retired General Tom Stafford, former Apollo astronaut and Apollo-Soyuz mission commander, to establish a team to review the inputs and "syn-

thesize" them into a set of potential mission architectures to carry out the initiative. Those systematic approaches, along with a series of recommendations for the necessary supporting infrastructure, were summarized in the final report of the Synthesis Group, *America at the Threshold: America's Space Exploration Initiative*, submitted to Quayle and the National Space Council on May 3, 1991.

Within a matter of weeks after the report was issued, SEI was described as being "dead on arrival" on Capitol Hill. Despite some organizational efforts within NASA, including establishment of a headquarters exploration office and an extensive planning structure at Johnson Space Center, within two years most of that structure and planning activity had been dismantled.

It has become almost axiomatic to attribute SEI's demise to cost, despite the fact that the Synthesis Group did not provide a cost estimate for its proposed architectures. Indeed, any given architecture is virtually impossible to place a cost on because it is not, in fact, a program in and of itself: it is really a vision that offers program options. Only when a specific program option is selected can its cost be estimated.

Extremely rough estimates of the potential long-term cost of sending humans to the Moon and Mars had been prepared in 1989 as part of NASA's "Ninety-Day Study." Those estimates, which ranged from $300 billion to around $500 billion over a thirty-year period, were not included in that study's final report because they, too, had no foundation in actual program options and had been overestimated and inflated by adding huge "reserves" to account for the uncertainties. Nevertheless, the huge numbers surfaced in unofficial sources and were bandied about in the trade press and in some quarters within the Congress.

SEI's failure was a matter of allowing the primary identifying feature of the initiative to become the myth and fear of potential high cost rather than its true intent of priming the discussion of possible program alternatives. The policy sustainment lessons from SEI can be found, in part, in understanding how that misperception arose.

First, the Synthesis Group had made no effort to address the growing concerns within the Congress about the potential cost by explaining the spurious nature of the figures that had been floating around since NASA's study. Nor was there any effort to explain that the Synthesis Group's purpose was to define a range of options and a context in which the administration and the Congress could consider them.

Also, the enormous influx of inputs from those who participated in the outreach program was simply absorbed into the synthesizing activity. It was not used to demonstrate the vast potential constituency for SEI—the kind of constituency that can get the attention of policymakers and help lift a vision beyond the vagaries of the annual appropriations processes and into the realm of a societal imperative.

Finding the means to sustain that vision over time is perhaps a greater challenge than identifying the technical means, management requirements, and fiscal resources to carry it out.

Space Station

In today's environment, the space station has become the poster child of a stagnant, limited, dead-end space policy. It is viewed by many as proof that NASA has become lost in space, with no vision for the future, smothered by cost overruns and program misman-

President George H.W. Bush announces the Space Exploration Initiative in the company of Apollo 11 astronauts. The announcement took place at the National Air and Space Museum in Washington, D.C., on July 20, 1989. (Source: NASA)

The International Space Station as it appears today, taken from STS-113, December 2, 2002. (Source: NASA)

agement. Such dismissal of the space station not only is a disservice to the dedicated, capable individuals and organizations that have and are creating and operating it but also overlooks what may be the most valuable source of information for determining how to sustain the president's new space vision.

The space station became a formal initiative twenty years ago. It has survived through five Administrations, ten Congresses, and twenty appropriations cycles despite enormous criticism and debate over its mission and relevance, numerous changes in its mission and design, and annual attempts in the Congress to kill it since 1992. Yet, there it is, orbiting Earth, as a living example of a policy initiative that is being turned into a reality. There are very specific reasons for the space station's survival, which should be examined, evaluated, and understood in any effort to craft the means of sustaining the new Bush initiative.

After a "near-death" experience in 1993, when the station survived by a single vote in the House of Representatives, it was clear that something had to be done to increase its chances for survival. In the near-term, that began with direct interaction among the highest levels of the administration and NASA with individual members of Congress to foster support for the station.

Over the longer term, an active and aggressive coalition of efforts that included NASA, industry, scientists, space advocacy organizations, and members of Congress and their staffs was established. Those efforts expanded information sharing about the challenges—and solutions—facing station development and identified themes regarding the station's purposes to energize interested and affected constituents in support of those themes. Major criticisms and concerns in opposition to the station were directly confronted and addressed.

As the time approached for congressional consideration of "killer amendments," the ongoing efforts were consolidated into a coordinated effort that anticipated and addressed—well in advance of the debate—all of the major issues and, once the debates began, responded quickly to criticisms as they arose. These and other activities led to ever-increasing margins of support for the space station in the Congress, with almost four-to-one margins by the time the first element was launched in 1998.

* * *

The failures and successes of these cases provide a clear message: addressing the mechanics of government policymaking and developing a broad national—and international—constituency for the vision are the essential twin pillars upon which the "survival" of the president's exciting new initiative will rest. ■

A former NASA member of the Synthesis Group, *Jeff Bingham* currently is special assistant for historical activities in the office of the administrator at NASA headquarters. This article represents his personal views and is not a statement of NASA or administration policy or views.

Report on the AAS 50th Annual Meeting

Speakers and panelists at the national conference universally confirmed that the event's theme holds true today: "The Dream is Alive!"

by Rick W. Sturdevant

The AAS National Conference and Fiftieth Annual Meeting, which occurred November 18-19, 2003, at South Shore Harbour Resort in League City, Texas, gave attendees reason to celebrate past accomplishments and to anticipate future adventures in space. Dedicated to the "Columbia 7" astronauts, the conference focused in large measure on inspiring, preparing, and enabling today's young people to become the successful space adventurers of tomorrow. Many teachers already in the Houston area for the National Space Biomedical Research Institute Teacher Academy Project swelled the ranks of AAS conference attendees and provided a level of audience enthusiasm missing from many recent meetings.

On Tuesday, November 18, William Gerstenmaier, International Space Station (ISS) program manager at Johnson Space Center (JSC), delivered an inspiring keynote address to open the conference. Developing the theme "The Journey Continues," he challenged listeners to compare the ISS project to the Wright brothers' pursuit of powered flight a century ago. Pointing out the complexities of both endeavors, he emphasized the importance of an environment that cultivates the intellectual understanding needed to break knowledge barriers and that excites the next generation to press even further into the unknown. Focus on solutions, he told everyone, and not on what you lack.

Roald Sagdeev, Distinguished Professor of Physics at the University of Maryland and recipient of the Carl Sagan Memorial Award for 2003, pondered what Sagan would be advocating and doing if he was alive today. He would call for a national vision for space, Sagdeev said, and would champion bigger, more diversified science aboard the ISS as well as in deep space. He would be in the vanguard of those seeking innovative, even revolutionary propulsion technologies such as solar sailing, electric drives, and nuclear systems. Sagan, according to Sagdeev, was first to understand that space exploration is not necessarily the same thing as space research. He would continue to encourage international cooperation and would remain a vocal critic of weapons in space.

Those who attended Tuesday's luncheon heard SpaceX founder Elon Musk explain how his launch company, using his earlier brainchild, PayPal, as a model for rapid growth with reliability, set out in 2002 to develop the low-cost Falcon semi-reusable launch vehicle. He touted the Falcon's avionics architecture, which relies on both inertial and Global Positioning System capabilities, as better than that of other small launchers. To minimize the risk of failure, SpaceX reduced the vehicle's number of engines and stages. Unveiled in early December 2003 at the National Air and Space Museum, the Falcon is scheduled to launch its first payload, the Navy's *TacSat-1*, in early 2004.

The conference's first formal sessions occurred Tuesday afternoon. Panelists in Session 1 examined from various perspectives "The Quest for Assured Access to Space." Andrew Algate, recently the lead architect for NASA's long-term space transportation strategy, emphasized the advantages of a robust, flexible, discovery-driven, stepping-stone approach to development of future space transportation systems compared to the high-risk, limited-vision, technology-driven, single-mission focus that characterized the Apollo era. Retired Air Force Major General Michael Kostelnik, NASA deputy associate administrator for space station and shuttle programs, spoke from a near-

2003 Carl Sagan Memorial Award recipient, Dr. Roald Sagdeev, with Jon Malay and Dr. Franklin Chang-Diaz. (Source: AAS)

Walter Cunningham, awards banquet guest speaker. (Source: AAS)

term perspective and outlined the process and problem solving—technical, organizational, and cultural—needed to ensure the shuttle's successful return to flight following the *Columbia* tragedy. Patrick McKenzie from Lockheed Martin described his company's efforts to develop and build at credible cost and in reasonable time a safe vehicle that would have met NASA's need for an Orbital Space Plane before being proposed for termination in NASA's 2005 budget. The final presenter, Peter Diamandis from the X Prize Foundation, predicted that competition in a market-driven industry will produce a new generation of private spaceships for the twenty-first century.

Next door to the above gathering, Session 2 addressed the historical evolution "From Aeroplanes to Spaceplanes." Jon Rogers, a self-styled "spaceship archeologist," staged a fascinating *tour de force* to show how advances in "hard" science fiction over the course of the twentieth century presaged the technology of actual spaceships. Stephen Justice, an engineer at Lockheed Martin's Skunk Works, pondered how "tolerance of failure en route to success" enabled visionaries working on Project Oxcart to build an airplane—the SR-71 Blackbird—capable of flying at the edge of space. Coming from the Center for Space Science in Fountain Valley, California, T.A. Heppenheimer lectured on the problematic nature of scramjet physics as related to the X-30 National Aerospace Plane project of the late 1980s and early 1990s. To conclude the session, I discussed the remarkable, trailblazing contributions of the X-15 research program to winged aerospace flight.

Tuesday's final session offered "International Views of the Future in Space." Masato Koyama, director of the Japan Aerospace Exploration Agency (JAXA) office in Washington, D.C., discussed the reasons for JAXA's formation on October 1, 2003, and its "pivotal" activities. He described how the Kibo module, Japan's first manned space facility, will aid those activities once it is connected to the ISS. David Wyn-Roberts, head of the European Space Agency (ESA) office in Houston, asserted that European human space flight is based on Europe's contributions to the ISS and that a European human space transportation capability is the key to ensuring an adequate European role in future deep-space exploration. Both individuals assumed that human explorers would expand significantly their presence in space during the twenty-first century.

A closing speech by Michael Mott, Boeing's vice president and general manager for NASA systems, stirred everyone's spirit. Formerly a Marine test pilot, Mott supplied a "checklist" to permit problem solving among aerospace professionals working at twenty-first-century speeds. Among the most critical items on his list were the following: (1) determine where you are going and how you are going to get there; (2) remember the power of commitment, as well as the difference between commitment and technology; (3) focus on accomplishment, not on taking credit; (4) have realistic expectations; and (5) rely on teamwork. He offered the following words to aerospace professionals pondering how to advance in space: "If not illegal, immoral, or unethical, it might be worth trying." Hardship strengthens us, Mott observed, and competition reveals our weaknesses. He added: "When you have nothing left to give, find another 10 percent."

Session 4 on Wednesday morning examined Mars exploration and the search for life signs. After moderator Frank Jordan from the Jet Propulsion Laboratory outlined the "rather massive invasion of Mars" that is occurring in the first decade of this new century, NASA's James Garvin compared photographs of similar features on Earth and Mars. As for answering the question of whether water ever existed on Mars, he postulated that "the answer is in the rocks," perhaps those now being studied by the rovers *Spirit* and *Opportunity*. Everett Gibson from JSC updated attendees on meteorite ALH 84001 research and concluded that no single, non-biological process exclusively explains all the data that otherwise suggest that microorganisms once inhabited the rock from Mars. Augustin Chicarro from the European Space Agency explained how, before the news of *Nozomi*'s disappointing fate, the Japanese probe and ESA's *Mars Express* would have allowed for observation of Mars simultaneously from two differ-

ent orbital perspectives: one polar and the other equatorial. Finally, Franklin Chang-Diaz, director of the Advanced Space Propulsion Laboratory at JSC, detailed technical progress toward a Variable Specific Impulse Magnetoplasma Rocket (VASIMR) thruster that possibly could be tested on the ISS in three years and used for human missions to Mars.

A stimulating media roundtable followed, with *SpaceDaily.com* columnist John McKnight, CNN news anchor Miles O'Brien, and CBS news space consultant William Harwood sharing thoughts about the business of reporting space activity. McKnight proclaimed that a new space age is dawning because information technology makes possible a data flow that fosters creativity by flattening hierarchical structures. O'Brien opined on the general public's confusion about the ISS mission and the difficulty of turning something technical into an understandable story that holds people's attention. Harwood added that a story must be compelling to generate interest. He humorously admitted that "most reporters are idiots" and theorized that the level of their expertise or knowledge is inversely proportional to the number of people in their audience. He bemoaned the "dumbing down" of the news for a mass audience but confessed that this phenomenon is fundamentally a cultural rather than a journalistic problem. All agreed that stories about people rather than things have the highest positive resonance with an audience.

Following a luncheon presentation by Marine Lieutenant Colonel Art Tomassetti on the Joint Strike Fighter program, conference participants returned to the main hall for Session 6 on "Military Human Space Operations." Brigadier General Richard Zilmer from Marine Corps headquarters delivered an informative briefing on how the demand for extremely rapid deployment of expeditionary forces anywhere around the globe led to issuance in July 2002 of a "universal needs statement" for a Small Unit Space Transport and Insertion Capability (SUSTAIN) around 2030. Naval reserve officer and Boeing shuttle program manager Steve Oswald confessed the Navy lags woefully behind the Marines with respect to human space operations, and Air Force Colonel Joe Squatrito guardedly described his service's involvement as "much closer to the dream end of the spectrum." The real question for the Air Force and other services is not whether military human space operations will become a reality but when that will happen.

The conference's last session on "Space in the Classroom" generated perhaps the most interest among those who stayed for the full two days. Moderated by NASA associate administrator for education Adena Loston, the panel included representatives from both formal and informal learning venues. Loston explained how NASA seeks through its educational programs to touch various communities of learners with the twin goals of inspiring the next generation and engaging the public to help share and shape the NASA mission. Rene Flores, a middle school teacher at San Antonio's Christa McAuliffe Academic Academy, described how inclusion of space-related material across the curriculum has encouraged students, many of whom were considered "at risk," to engage in higher-level thinking. As a result, performance scores have improved for the entire school. "We don't just shoot for the stars," said Flores, "we reach them." Chad Rowland, a student in the University of Michigan's College of Engineering, revealed how the extracurricular Everest Project to build a crewed Mars rover is helping members of the student team learn about aspects of engineering they would not necessarily get in the classroom. Using university facilities and backed by over forty corporate sponsors, the rover team began its design work in 2000 and plans to complete the three-phase project in 2008. The team also has endeavored to include elementary and secondary classes through an educational outreach effort.

Additional emphasis on "informal learning" outside the classroom came from Terri Gipson and Anthony Docal. Gipson, from the St. Louis Science Center, outlined recent improvements in the Center's facilities and exhibits that inspire and nurture natural curiosities in both children and adults. By "layering the experience" through multiple learning approaches, the Center and its McDonnell Planetarium strive to stimulate understanding of science and technology in the community. Docal, president of nonprofit Orbit Education, Inc., which is associated with Georgia Tech's Center for Education Integrating Science, Mathematics and Computing, touted learning in our own homes and marveled at how the internet, CD-ROMs, and DVDs have enhanced learning in all environments. He encour-

Dr. Trevor Sorensen, one of six new AAS Fellows for 2003. (Source: AAS)

aged use of the new NASA web portal, which captures roughly 2.5 million web pages and aims to meet the needs of various audiences. Information technology is rapidly equalizing rural, suburban, and urban people's access to learning experiences.

Wednesday night's AAS awards banquet was a proper conclusion to a wonderful conference. Reminiscing on forty years of association with space flight, former astronaut Walter Cunningham predicted that five hundred years from now one event from the twentieth century will be remembered: humanity's first landing on the Moon, because it was a dangerous, spiritually uplifting adventure that placed all humankind on a new plateau. Reflecting on the implications of Russian participation on the ISS, the first Chinese human space flight, and loss of the shuttle *Columbia*, Cunningham questioned whether America is prepared to pay the price of embarking on new adventures in space. He asserted, contrary to the findings of the Columbia Accident Investigation Board, that NASA has changed with the times and that change, particularly change based on politics, is what contributed to the present crisis in culture. Perhaps the future of NASA's human space flight program would be better if today's astronauts had the influence, authority, and "positive independence" they possessed during the Apollo era.

Former astronaut Walter Cunningham predicted that five hundred years from now one event from the twentieth century will be remembered: humanity's first landing on the Moon...

Newly elected AAS President Jon Malay concluded the evening with presentation of the 2003 awards. Sally Ride earned the Space Flight Award, and the STS-107 *Columbia* crew—Richard Husband, William McCool, Kalpana Chawla, David Brown, Laurel Clark, Michael Anderson, and Ilan Ramon—posthumously received the Flight Achievement Award. George Mueller, presently CEO of Kistler Aerospace, accepted the Lloyd V. Berkner Award for outstanding contributions to commercial utilization of space technology. The W. Randolph Lovelace II Award went to elliptical constellation designer John Draim, and the Dirk Brouwer Award went to David Dunham. Stephen Johnson won the Eugene M. Emme Astronautical Literature Award for his book *The Secret of Apollo: Systems Management in American and European Space Programs* (2002). A highly deserving Buzz Aldrin accepted the John F. Kennedy Astronautics Award. Finally, Malay announced the selection of six new AAS Fellows: Thomas Gavin, G. Thomas Marsh, Horace Ngan, Richard Obermann, Trevor Sorensen, and Robert Stevens. ■

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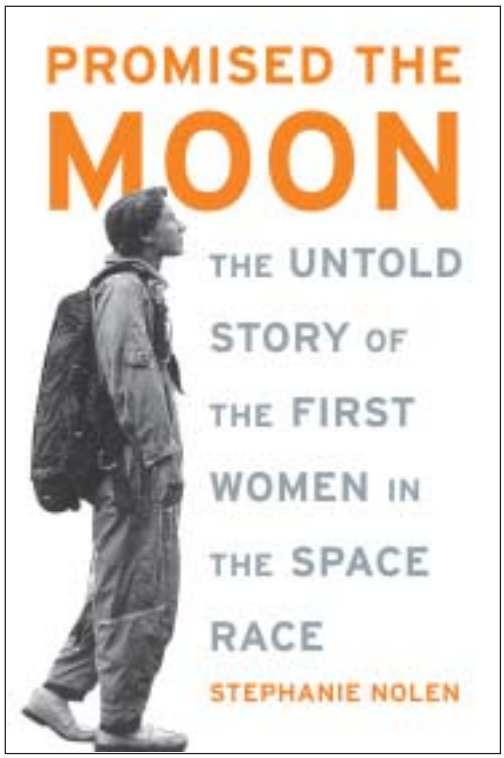
Promised the Moon

Reviewed by Alison Fortier

Promised the Moon: The Untold Story of the First Women in the Space Race, by Stephanie Nolen. New York: Four Walls Eight Windows, 2003. 356 pages. ISBN: 1-56858-275-7. $22.95.



They called themselves FLATs—Fellow Lady Astronaut Trainees. Never formally recognized by NASA, this remarkable group of women trained to be the first females to voyage into space. In *Promised the Moon*, Stephanie Nolen tells their story in an attempt to bring them the recognition they deserve but never won.

On Valentine's Day, 1960, Jerrie Cobb, a world-record-setting female pilot, arrived at the Lovelace Foundation in Albuquerque, New Mexico, to undergo testing for space travel. Dr. Randy Lovelace, an advisor to the newly created NASA, had designed the tests to help the agency select the Mercury 7 astronauts. Lovelace suspected that women might withstand better than men the stress and solitude of space travel. Without any NASA direction or funding, he recruited Jerrie for medical evaluation. From isolation chambers to vertigo tests, Jerrie passed the rigors of Lovelace's regime, and the call went out for additional female volunteers.

Beforehand, the 13 women who became the FLATs were, as Nolen characterizes them, extraordinary figures "who ignored traditional roles, defied convention, and broke through barriers." In her book's most inspiring passages, the author conveys how these women, many of whom transported military aircraft to U.S. forces overseas in World War II but lost prospective commercial piloting jobs to men returning home after the war, seized other opportunities to keep flying. Jerrie Cobb took an assignment ferrying single-engine aircraft to Peru alone. Wally Funk landed a job as a flight instructor in Oklahoma, teaching recreational flying to servicemen from Fort Sill. B Trimble Steadman opened her own flight school and at age 24 became CEO of Trimble Aviation. Jan and Marion, the Flying Dietrich Twins, flew in college; after graduation, Jan became chief pilot for Cessna.

But as *Promised the Moon* reveals, the most formidable challenge the FLATs faced was convincing government leaders that they were fit to fly into space. Nolen unveils the opposition to women astronauts that the FLATs endured—from NASA management, from Vice President Lyndon Johnson, from the Mercury astronauts. The author summarizes their sentiments: "Space was the domain of astronauts, and astronauts were men." Even Jackie Cochran, the heralded female aviator who sponsored Lovelace's work with the FLATs, spoke against female space flight in a Congressional hearing, determined to retain her fame in the aerospace sphere.

Despite extensive petitioning, the FLATs could not change minds in NASA, the White House, and Congress. Nolen's narrative shows that for all of their tenacity and hope that the United States would trump the Soviet Union with the first female space flight, the FLATs witnessed the United States lose this opportunity: on June 16, 1963, the Soviets launched a young textile-worker-turned-cosmonaut named Valentina Tereshkova into space.

These pioneers finally saw their goal achieved but only several years later by other women. NASA accepted its first six female astronauts in 1978. Nolen notes that the FLATs most admired not Sally Ride, America's first female in space, but Eileen Collins, a decorated Air Force officer and the first female space shuttle pilot. Collins had read about the FLATs and invited them to Cape Canaveral on February 3, 1995, when she flew *Discovery* into space. Eight of the surviving FLATs were there to see her fly.

If there is a failure in Nolen's book, it is that she does not complete the story by describing more fully the thread between Jerrie Cobb and Eileen Collins. Yet, she accomplishes her goal of writing a compelling history of a remarkable group of women that not only dreamed of going into space but worked to make it a reality. The determination these women showed, despite the obstacles and setbacks they faced, should be an inspiration to all. ■

***Alison Fortier* is an AAS board member.**

Bush Space: Misfocus on Ends, not Means

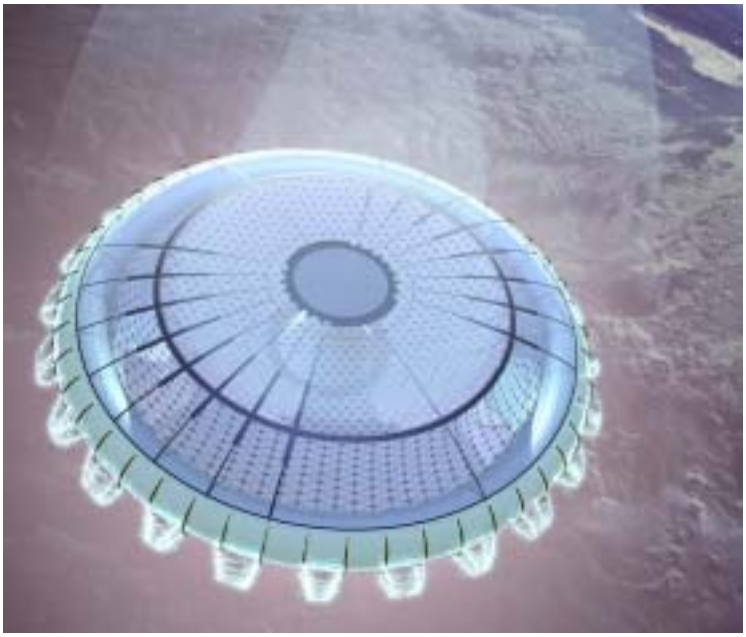
The Bush administration needs to focus on reducing the cost of access to orbit in order to maximize the nation's ability to explore and use space. Ground-based delivery systems could offer the solution.

by Jonathan Coopersmith

President Bush's recently announced space policy has provided the first coherent framework for humans in space since Apollo. This new policy, a welcome advance over previous efforts, is actually quite conservative conceptually, a restatement of Von Braun's 1950s proposal, which increases its chances of achieving its technical goals. Apollo's dash to the Moon was an outstanding technological accomplishment, but left nothing to build on. Because this is not a race, NASA can take a more methodical approach to creating a permanent human presence in space. But by not focusing on reducing the cost of reaching orbit, the administration has forfeited the opportunity to truly increase access to space exploration and exploitation.

Most criticism has addressed the cost and lack of financing for this program. But two basic questions have yet to be addressed: Is this the right vision? And if so, is this blueprint the best way to accomplish these goals?

Unfortunately, the new administration policy does not address the basic challenge of space travel. The major factor restricting the exploitation and exploration of space is the high cost to reach Earth orbit. Many arguments, such as debates about robotic versus human flight and conflicting priorities for exploration, would lose their divisiveness if the per-kilogram cost of launching spacecraft shrank from today's $10,000-$20,000 to $200 or less per kilogram of payload.



The Microwave Lightcraft in this conceptual image would deliver a payload to orbit using power transmitted via microwaves beamed from either a ground station or an orbiting solar power satellite to the lightcraft. (Source: NASA)

Clearly, sending astronauts to Mars is a more inspiring and captivating goal than reducing launch costs. Yet drastically reducing the cost of reaching orbit might be the federal government's greatest contribution to space exploration and exploitation by transforming the economics of operating in space. Not only would the president's space initiative benefit: so would researchers and businesses that could previously not afford extensive space operations.

High launch costs are caused by our reliance on rockets. While technological marvels, existing and proposed new generations of rockets will not significantly reduce the per-kilogram cost to reach orbit.

Are there alternatives to rockets? Ask any participant at the Second International Symposium on Beamed Energy Propulsion in Sendai, Japan, or the Second International Space Elevator Conference in Santa Fe, both held last fall, and the answer will be a resounding, "Yes: ground-based systems." While more radical technologically, these systems have far more potential to drastically reduce the cost of reaching orbit and thus transform space operations.

Ground-based systems keep the launching mechanisms on Earth and only send the spacecraft into space. A wide range of options exists, including electromagnetic launchers, laser and microwave propulsion, and space elevators. Most of these systems proposed would initially send tens or hundreds rather than thousands of kilograms into orbit per launch. Later generations would handle larger payloads, including people.

Ground-based systems initially will reach only low Earth orbit and geostationary orbit with smaller payloads than the heavy-lift launch vehicles considered necessary for lunar and Mars missions. This may mean a reliance on Earth-orbiting rendezvous of cargo vessels and construction of interplanetary ships, a scene familiar to any reader of science fiction and space speculation since the 1950s. Who knows? A space station might even become the staging ground for future missions.

Some of the ideas are not new: Arthur C. Clarke proposed the electromagnetic launcher in 1960 and Arthur R. Kantrowitz first proposed laser propulsion in 1972. What is new are recent developments in these technologies. Lasers and microwave generators are far more efficient and more powerful than a few decades ago. Space elevator advocates herald carbon nanotechnology as possibly providing the needed lightweight and ultrastrong material for a space elevator.

The growing international interest in these launch technologies far outpaces the available funding, a standard problem. U.S. government funding of these approaches has been modest at best, reflecting the domination of the rocket community. The U.S. Air Force and Strategic Defense Initiative Organization have funded the Lightcraft Technology Demonstrator at Rensselaer Polytechnic Institute. NASA's Advanced Space Transportation Program at Marshall Space Flight Center was exploring some concepts, but the latest incarnation of the program has severely restricted its interests.

As part of the new space policy, the president and Congress should direct NASA to research and develop at least one ground-based system. This mandate would put NASA back into an area it does so well, research and development, while laying the foundation for a major expansion of human and robotic entrance into space a decade or two hence. Although lacking the deep pockets of the Departments of Defense and Energy, NASA should direct this research because it is the U.S. civilian space agency. Public and private use of a ground-based system will occur earlier than if the military developed it.

The biggest issue is funding. NASA probably cannot afford the administration's new space program within the administration's proposed budgets. Developing a ground-based system will add billions more. Some of this money should come from the Energy and Defense Departments, two probable users, but an increase in NASA's budget will be needed.

The time and the large sums needed to develop such a system mean that no private firm can independently take on such a task. This long-term project is the type of program that the federal government, unconstrained by the need to show short-term profits, can and should do. The failure of several firms over the last decade to develop reusable launch vehicles is stark economic proof.

Such a massive investment has an important historical precedent. In the 1950s, the Air Force, Army, Navy, and nascent NASA spent over $10 billion developing the boosters that evolved into the first generation of

Tregenna Myrabo of Lightcraft Technologies, Inc., prepares a laser-propelled lightcraft for launch at White Sands Missile Range in New Mexico. The lightcraft, weighing 50 grams and made of ceramic materials, was boosted by a laser beam to an altitude of seventy-one meters in October 2000. (Source: NASA)

American launch vehicles. Many billions more were spent in the 1960s scaling up these rockets and making them reliable enough to launch astronauts safely. Adjusted for inflation, the equivalent amount today would be over $40 billion.

Reaching further back to the first "A" in NASA, for aeronautics, the military and NASA's predecessor, the National Advisory Committee for Aeronautics, played important roles in funding the development of airplane engines and airplanes. The results included a vibrant commercial aviation industry. Could a similar space industry result from reliable, low-cost access to space?

Policymakers must be honest and recognize the high cost of developing these new systems. The reason Apollo came in without the cost overruns that have plagued so many space projects was NASA Administrator James Webb's insistence on doubling his engineers' estimates before submitting them to President Kennedy. Webb also insisted that Kennedy and the Congress approve in principle the financial resources he thought necessary.

By not trying to drastically reduce the cost of reaching orbit, the administration is forfeiting the chance to truly open up space exploration and exploitation. Low-cost access to space will not only mean less expensive launches for government missions but also enable others – businesses, researchers, entrepreneurs – to view space as an opportunity and not something to be experienced vicariously. ■

Jonathan Coopersmith **is associate professor of history at Texas A&M University.**

Grand Vision for NASA, or Unfunded Mandate?

Without a cost estimate for the president's new vision, the administration and Congress cannot truly embrace the investment.

by Walter Cunningham

It was wonderful to see President Bush identify himself with NASA and announce a new charter and grand vision for the agency. For any grand plan of exploration to succeed it must be championed at the highest levels. The president's plan can provide the focus NASA has been missing for a long time. The plan, however, did not sound like it had much input from engineers and operational types.

I want to see an American standing on Mars or one of its moons in the worst way, but it won't happen in my lifetime. If it takes a return to the Moon to eventually get a Mars mission funded, I enthusiastically support it. My two favorite rationales to justify exploring our solar system are:

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1. A commitment to return to the Moon and go on to Mars will do what exploration has always done: feed the human spirit. A passion for discovery and a sense of adventure has always driven America forward. These deeply rooted qualities spur our determination to explore new scientific frontiers and spark our can-do spirit of technological innovation. The continued leadership of our world depends on our enduring commitment to science, technology, research, and learning.
2. Space exploration is a research and development "engine of change" that benefits sectors far removed from the space industry. The engineering capability developed in space initiatives is employed in a variety of activities across the economy. Without the research and development necessary to maintain an edge, America's position as the world's leading economic power will be in jeopardy.

Whether it is advances in fire fighting technology, sewage recycling, communications, medical technology and instrumentation, manufacturing, agriculture, hurricane forecasting, or educational technologies, what NASA initially developed for astronauts in space has found its way into daily commerce. Space technology improves our quality of life on Earth in ways that are transparent or unknown to most people.

Any great exploration is a risky undertaking, involving political, technical, human, and economic risks. The *political risk* rests squarely on the shoulders of President Bush because there is no huge constituency clamoring to send humans to Mars. According to a recent poll, a majority of Americans would rather spend money on domestic needs.

I believe we have the *technical risk* well in hand. We first went to the Moon thirty-five years ago, and our current technology is such that only the cost and will to go keep us from having a Mars program today. Yes, it may be faster, safer, and better executed if it is pushed farther into the future, but a human mission to Mars is much more feasible today than was a manned landing on the Moon when President Kennedy announced it forty years ago. Ten years later, "man on the Moon" was history. President Kennedy enunciated a simple vision, and then the engineers and scientists determined how to do it right.

The *human risk* is great at a time when risky activities are not acceptable to a large segment of our population. For many, human space flight will always be extravagant and illogical. Historically, there have always been those who opposed fording the next river, crossing the next sea, or traveling beyond the next ocean. Can anyone remember those who tried to fly the Atlantic before Charles Lindbergh? We celebrate successes after the fact, and conveniently forget the failures which are important to the effort.

There is a difference between a risky activity, such as the Apollo missions or a shuttle launch, and reckless activity, as when we continued to launch shuttle missions after we knew the external tank was regularly shedding insulation. In a risky activity, we can quantify the payoff or benefits, compare it to other known and estimated risks, and determine the cost/benefit ratio. In reckless activity, risks are unmeasured and unknown, and payoffs are ill defined and ephemeral.

Space is inherently dangerous: it is the most hostile environment ever explored by humans. But there are benefits to be derived from exploring and utilizing space. It is NASA's job to reduce the risks until the anticipated benefits are judged to exceed them and then get on with the program. Astronauts will accept reasonable risks associated with meaningful objectives in which they truly believe.

The new initiative avoided any mention of the *economic risk* in returning to the Moon and going on to Mars. Money is the real obstacle! Without clarification and commitment to the cost, the new vision for NASA is little more than an unfunded mandate. We cannot go into space on the cheap. The five-year funding to support new exploration activities—$1 billion in new money and $11 billion squeezed out of NASA's current projected funding—is woefully inadequate.

It is not difficult to estimate the cost of the lunar portion of this grand adventure. The Apollo program cost

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$25 billion, equivalent to about $125 billion in today's dollars. Lunar exploration will be at least as difficult as and no less costly than it was in the 1960s. NASA may be more experienced today and armed with better technology, but it is also more bureaucratic with less efficient management. If we are optimistic, we can assume it could be done for the same cost today. Realistically, we could return to the Moon for $125-150 billion (about twice what Americans spend on alcohol each year).

I believe we can not only afford this amount, but it will be well worth the investment. Now is the time to make such a commitment, but not at the cost of current programs.

The first casualty of the return to the Moon initiative is the 2005 servicing mission for the Hubble Space Telescope. The Hubble may not "contribute to completion of the International Space Station (ISS)," as NASA says, but its contribution to scientific knowledge may well exceed that of the ISS.

Abandonment of the Hubble is as much a consequence of NASA's reaction to the *Columbia* disaster as it is the new initiative. Regarding his decision to cancel the Hubble servicing mission, NASA Administrator Sean O'Keefe had this to say: "It was one based on risk exclusively." He describes a shuttle flight to Hubble as "a one-of-a-kind, unique, very different and riskier mission… that's not a risk that I could deem to be an acceptable one." He is talking about the world's greatest flying machine after spending two years making the shuttle system even safer! It only gives credence to those critics who say the ISS exists as a destination for the shuttle, and the shuttle exists to service the ISS.

Can an organization unwilling to accept the risk of flying a truly great spacecraft in familiar Earth orbits accept the inherent risks of landing humans on the Moon, let alone of sending them to Mars? Of greater concern, is NASA merely reflecting society's growing desire for a risk-free existence? That attitude would never have gotten us to the Moon in the first place and made us the world leader in human space flight. NASA was founded to explore the unknown, evaluate the risks versus gains, and take calculated risks to move our society forward.

It will be another great loss if the space shuttle is "retired" by 2010, long before we have an adequate replacement. The shuttle is the only vehicle capable of carrying to and from the ISS the biological and engineering equipment to perform research essential to future space goals.

Historically, NASA has enjoyed a symbiotic relationship with Congress whereby NASA over-promises on results and low-balls the cost of new programs, which allows Congress to fund the program. When the under-funded program is, inevitably, late and over budget, NASA is mercilessly criticized by Congress and the public. It would be nice, just once, to see Congress endorse a program based on realistic expectations and honest cost estimates from NASA.

Gus Grissom, famous for the remark "No bucks, no Buck Rogers," would understand the picture perfectly. Without a commitment for adequate funding, NASA's new vision of our destiny is just another unfunded mandate. ■

Walter Cunningham **flew on Apollo 7, the first manned Apollo mission, and is author of** ***The All-American Boys*** **(ibooks, July 2003).**

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www.astronautical.org

January 23–27, 2005
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Copper Mountain Resort
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