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AAS Celebrates Its 50th Year

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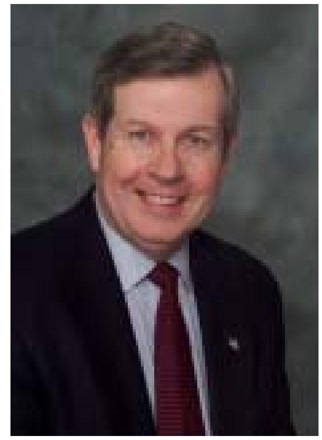
President's Message



As I write these remarks, sitting here on a summer-like day in Northern Virginia, I'm watching NASA TV's streaming webcast of the long-awaited Gravity Probe B launch countdown at Vandenberg Air Force Base, a mission which will verify two extraordinary predictions of Albert Einstein's general theory of relativity. I just replayed yesterday's launch of the Expedition 9 crew to the International Space Station (spectacular), peeked at the latest pictures coming back from *Spirit* and *Opportunity* on their now-extended missions (amazing), checked the latest satellite image from NOAA (encouraging), read the national news headlines (depressing), and noted the stock prices of my company and our major competitors (blah). That I did all this on the internet while eating my lunch is no great surprise—we have this kind of access to information almost all the time. But it's easy to take for granted the technology that makes all this possible. It's easy to take for granted that there are dedicated and talented people out there who build and launch rockets, who design and fabricate spacecraft and instruments, who operate ground systems, who do research on applications and technology, and who do all the other things that it takes to be a spacefaring world.

Over the past fifty years, the AAS has counted among our members the individuals, companies, and organizations who grew up in the space age and rose to the challenges that space presents. This special issue of *Space Times* is a fitting tribute to the Society and its members. I hope you'll join me in celebrating the achievements of the American space program and those of our fellow spacefarers in the international community. Together, we've already kicked off this anniversary year in spectacular fashion. Our Guidance and Control Conference in Colorado and Goddard Memorial Symposium in Maryland were huge successes with great agendas and sold-out registrations. The AAS was formally recognized for our fiftieth anniversary at the Goddard Memorial Dinner in Washington and at the National Space Symposium in Colorado Springs. And planning is well underway for a Space Law Workshop in June and our Annual Meeting and National Conference in November. The AAS is as relevant and active today as it ever has been in the past fifty years. This is a great time to be a member of such a great organization.

This is also a great time to *become* a member! If you or your company are not individual or corporate members, please join us as we embark on our next half-century. Information on membership is available on our web site (www.astronautical.org) or by calling the AAS office at (703) 866-0020. If you're already a member, please get involved. Let us know how you'd like to serve or how we can serve you better. The space age is taking an exciting turn toward exploration and revolutionary new applications. The AAS isn't going along for the ride… we're leading the way.

Upper level winds have just caused a scrub of today's launch, and my lunch break is over. Let's get back to work—together. Another launch opportunity—many, many opportunities—and the next fifty years lie ahead for the AAS.

Jon Malay

ON THE COVER

A Redstone missile sits on the launch pad at Cape Canaveral, Florida, on May 16, 1958. The first Redstone was fired at Cape Canaveral on August 20, 1953, three months before the founding meeting of the American Astronautical Society. Developed by the Army Ballistic Missile Agency under the direction of Dr. Wernher von Braun, the Redstone was the first major rocket development program for the United States. Redstone became the "reliable workhorse" for America's early space program and was utilized as the first stage in the Jupiter-C rocket, which launched the first American satellite, *Explorer 1*. (Source: NASA)

Goddard Memorial Symposium Proves a Huge Success

by Jim Kirkpatrick

Chilly temperatures, wind, and rain did nothing to curb the overwhelming response to AAS's forty-second Goddard Memorial Symposium, held March 16 and 17 at the Greenbelt Marriott in Greenbelt, Maryland.

Jon Malay of Lockheed Martin Corporation and president of the AAS provided opening remarks and introductions, and Goddard Space Flight Center Director Al Diaz presented the keynote address before a crowd of over three hundred. "We broke all past attendance records this year," Malay said. "Our theme, 'Exploration: To the Moon and Beyond,' really hit the mark."

During six intense sessions, speakers candidly addressed topics that encompassed all components of the new exploration vision. Roger Launius, formerly of NASA and now with the Smithsonian National Air and Space Museum, provided his take on why NASA should go back to the Moon. According to Launius, the rationale for returning to the Moon is simple: it is only three days from Earth and is an excellent test bed for science and technology. "Although we didn't go to the Moon for scientific reasons…we got a lot of science out of the Apollo missions," Launius told the audience.

James Garvin discusses results from the Mars rovers. (Source: NASA/Goddard Space Flight Center)

Goddard geophysicist Paul Lowman, Jr., explored what America learned from Apollo. According to Lowman, we learned that the Moon is predictable, stable, and survivable if we go properly prepared. He told the audience that we learned a lot about the geological evolution of the Moon and can now compare planetary aspects of this body with others within our solar system. Wendell Mendell from the Johnson Space Center provided his views on the potential of future lunar exploration, while David E. Smith, chief of Goddard's Laboratory for Extraterrestrial Physics, discussed considerations for a lunar orbiter in 2008.

James Garvin, NASA lead scientist for Mars exploration, invigorated the morning session on day two with an overview of the current Mars program and latest results from the Mars rovers. Garvin said it is imperative to explore Mars because it is the nearest planet with evidence of past life, and the scientific data we are now analyzing are helping us to better understand Earth.

According to Garvin, the six integrated science instruments aboard the rovers are providing researchers with incredible data. What have we found out so far? Among other things that the sand on Mars is a hundred times finer than anything found on Earth—data that are seemingly mediocre but in fact very important because the fine sand sticks to everything. Garvin stressed that future human explorers, their spacecraft, and their instruments will need to deal effectively with this issue. Garvin also stated that although the baseline mission for the two rovers was originally ninety days, NASA now thinks that it can extend the mission to 250 days or more under the proper conditions. "So stay tuned," Garvin said. "More good stuff is coming!"

Congressman Nick Lampson (D-Texas) was the distinguished luncheon speaker on day one. Lampson is the new ranking member for the House Space and Aeronautics Subcommittee. According to Lampson, "This [space] program has to be ours. Space exploration leads to advancement in science and medicine, bettering the lives of all U.S. citizens." He also stressed that we have to find a way to adequately fund programs such as health care as well as space exploration. Lampson ended his talk with a challenge for the audience members to start talking to their neighbors and help shape their attitudes. Lampson totally embraces the president's vision for space exploration, stating, "We've all experienced a higher standard of living because of the advancements in the space program."

Joining the impressive group of speakers from Goddard were key officials from NASA Headquarters, including new Associate Administrator of the Office of Exploration Systems Craig Steidle; Associate Administrator of the Office of Biological and Physical Research Mary Kicza; Director of Project Prometheus and Nuclear Systems Alan Newhouse; Director of the Sun-Earth Connection Division Richard Fisher; plus John Mankins from the Office of Exploration Systems and Jitendra Joshi from the Advanced Human Support Technology Program. Other Goddard presenters included James Webb Space Telescope Senior Project Scientist John Mather and Space Architect representative Rud Moe.

Ian Pryke, senior fellow at the Center for Aerospace Policy Research, George Mason University, provided a non-U.S. view of international cooperation in the new exploration vision, while Franceska Schroeder, partner at Pillsbury Winthrop LLP, looked at space lift legal issues. James Crocker, vice president of Civil Space Systems at Lockheed Martin Space Systems Company, energized the audience with his look at exploration capabilities of America's industrial base. Riccardo Giacconi, president of Associated Universities, Incorporated, was the distinguished luncheon speaker on day two and provided his thought-provoking views on the serious challenges of executing President Bush's vision. Finally, Robert Sackheim, chief engineer of propulsion at the Marshall Space Flight Center, reviewed the evolution of heavy lift launch systems.

Day two concluded with a special student session that focused on space exploration career perspectives for future scientists and engineers. Vigdor Teplitz, chief of University Programs at Goddard, moderated a panel that included NASA Director of Higher Education Brad Weiner, Goddard astrophysicist Tali Figueroa, Goddard aerospace engineer Melissa Vess, and Goddard electrical engineer Tracee Jamison.

Undergraduate and graduate students from the University of Maryland-College Park, Morgan State University, The Johns Hopkins University, Howard University, Southeastern University, The Catholic University of America, University of Kansas, and the College of Notre Dame (Maryland) attended the student session, which covered career discussions in the Earth science, space science, and engineering fields.

The consensus of those who attended this year's Goddard Symposium can be summed up as follows: the right theme with the right speakers at the right time! ■

***Jim Kirkpatrick* is the AAS executive director.**

ABOVE: *Al Diaz delivers the keynote address. (Source: NASA/Goddard Space Flight Center)*

BELOW: *Rep. Nick Lampson (D-TX) speaks at the March 16 luncheon. (Source: NASA/Goddard Space Flight Center)*

Note: All of the presentations from the Goddard Symposium can be accessed and downloaded from the AAS web site: www.astronautical.org.

The Early Years of AAS: What the Experts Were Saying about Space

Talks bounding with optimism and vision were the standard at AAS meetings in the early decades of the space age.

by Jim Kirkpatrick

In keeping with its objective to provide a forum for the presentation, discussion, investigation and development of support for matters relating to space, the AAS has continuously sponsored meetings, symposia, technical conferences, workshops, and seminars over the past fifty years. During its early years, the Society gained the reputation—held to this day—of hosting forward-looking events in which speakers envisioned a future where human space flight within the solar system would be commonplace. It is interesting to note that audiences of six or seven hundred people were not uncommon during this timeframe, a reflection of the wide interest in space exploration and anticipation of exciting things to come.

On the occasion of the Society's fiftieth anniversary, a review of the AAS's library of conference proceedings provides insights into what scientists, engineers, and space professionals were talking about in the 1960s and early 1970s. Overall, there were at least as many "hits" as "misses" in conference speakers' predictions of what was ahead in space flight and exploration. If there is one common thread, it is that most speakers were guilty of being too optimistic about where the space program would be at the dawn of the twenty-first century. Although the timing of their predictions might have been off by a few decades or more, many of the specifics as to future technology were right on the mark.

Dr. Wernher von Braun explains the Saturn system to President John F. Kennedy at the Cape Canaveral Missile Test Annex. (Source: NASA)

Solar System Exploration

With the *Spirit* and *Opportunity* rovers currently providing high-resolution images of the Martian surface, it is easy to forget that up until the late 1960s, many scientists still believed that there might be intelligent life on Mars, based on observations from Earth-based telescopes. In 1960, Wells A. Webb and James A. Harder discussed design of a Mars probe based on the available evidence of life, which indicated the possibility of canals and changing seasons on the planet: *In this paper we have set forth evidence that points to the probability of the existence of past or present intelligent life on Mars. We…think every reasonable person will agree that the chance is sufficiently high that we should instrument our probe so it will detect manifestations of intelligence if they do, in fact, exist. The value of cultural contact, should it be effectively and peacefully made with an extraterrestrial society, is certain to give ample reward for our effort.*

Philip Bono, also interested in reaching Mars, discussed the feasibility of launching an eight-man scientific mission to the planet in 1971: *It is recognized that this mission could be performed far more efficiently with a nuclear propulsion system. However, it appears certain the liquid propellant engines will be capable of propelling* *manned vehicles long before their nuclear counterparts…The vehicle configuration described* [a three stage oxygen-hydrogen propelled rocket with a glider vehicle for landing on Mars and returning to Earth] *is technically sound and does fulfill its intended purpose—it has the capability of landing man on Mars within the next decade.*

The Soviets, flush with the success of Sputnik and Gargarin's orbital flight, were looking forward to a multitude of human space flight accomplishments. In 1964, the USSR Ministry of Defense published the following predictions for the Soviet space program, which were discussed at an AAS conference focused on international issues:

- 1964-65: A soft landing on the Moon of an automatic station;
- 1966-67: Flight of a manned spaceship around the Moon;
- 1967-70: Creation of a manned space station with a crew of three to five men;
- 1968-70: Landing of a man on the Moon;
- 1972-75: Creation of a large manned space station with a crew of thirty to fifty men;
- 1975-80: Flights to Mars and Venus of manned spacecraft with a return to Earth; and
- 1980-90: Landing of men on Mars.

The Apollo 11 Saturn V space vehicle awaits liftoff with astronauts Neil A. Armstrong, Michael Collins, and Edwin E. Aldrin, Jr. (Source: NASA)

Of these seven ambitious goals, the Soviets accomplished the soft landing on the Moon (Luna 9 in 1966) and creation of manned space stations (Salyut in 1971 and Mir in 1986), although not in the timeframes specified.

Speaking at the Goddard Symposium in 1967, Arthur C. Clarke foreshadowed the basis of the new U.S. space exploration vision: *The Moon will be the testing ground for almost all our techniques of planetary probing and surveying. We are immensely lucky in having such a body so close at hand.*

Clarke closed his 1967 talk with a forward-looking comment often echoed today by proponents of a vigorous space program: *I am a little tired of the complaint "Why should we go to the planets when there is so much to do on Earth?" There was plenty to do in Europe when Columbus left it—there's still plenty to do there. But the opening up of a new world did more to revive the stagnant European culture and economy that any internal action could possibly have done.*

Satellite Applications

While it was Clarke who in 1945 established the principles of communication with satellites in geostationary orbits, Joseph L. Goldstein had keen foresight forty years ago when he stated: *High-powered satellites will soon make it possible to bring television and voice into home receivers, at first through community antenna ground stations and later through direct broadcast. What policies will best optimize the interests of local stations if anyone, almost any place, can tune to dozens of channels instead of only to the relatively few now within line of sight of his rooftop antenna?* What Dr. Goldstein envisioned as dozens of channels is actually hundreds now offered via cable, direct television broadcasting, and satellite radio.

Robert S. Cooper and William N. Redisch saw the future of mobile telephones: *With satellite communications, a new era could be opened up; that is, the same way that one can now*

A full Moon is outdazzled by the lights of the gantries below on "Missile Row" in 1965, as they stretch north along the shoreline of Cape Canaveral Air Force Station. (Source: NASA)

communicate from almost any location via telephones in a fixed location, one should be able to communicate from any mobile location to any other location with the same ease and economy as in the fixed service.

The Fourth Goddard Memorial Symposium in 1966 was devoted to looking ahead to the year 2001. Edward C. Welsh made a number of predictions, including the advent of video teleconferencing and the Internet: *The time will come when we will not gather together in meetings. Rather, programs will be announced in advance and then those interested will simply tune in and, via direct broadcast, get the oral message as well as the visual picture without leaving their offices or their homes…On what might be called "color picture walls," installed in all modern offices and homes, there will be available, on electronic command selected displays, study and research data from central automated computerized libraries, business information from world centers and conferences, entertainment, and educational programs.*

Although Dr. Welsh had amazing foresight for technological advances, he offered a statement about the future of public debate on the value of the space program that was, unfortunately, way off the mark: *One thing I can predict with great confidence: the debate on the worthwhileness of space technology and space exploration—still continuing on the part of those of little vision—will have disappeared completely within a decade or so. The benefits will have become so obvious and the potential so exciting that even the most near-sighted will be aware of the rich space harvest.*

Finally, Senator Frank E. Moss extolled the value of the Global Positioning System (GPS): *There is a type of communications satellite that offers an unprecedented array of benefits to mankind. It's called the NAVSTAR GPS. I have already sent a letter to* [Administrator] *Jim Fletcher requesting NASA to consider investigating the possible non-defense applications of NAVSTAR, to include a national air traffic control system and an aircraft collision avoidance system. I certainly hope the other agencies, especially the Department of Transportation, will take a serious look at how NAVSTAR could revolutionize the method of finding the answer to an ancient question "Where am I?"* Senator Moss passed away in 2003, but he lived to see today's wide non-military applications of GPS, including emergency rescue services, personal GPS receivers, and popular navigation systems such as OnStar.

Space Transportation

Predictions of advances in launch and space flight technology were less accurate. During the Apollo program, some envisioned a continuing role for the Saturn rocket. Robert F. Freitag, speaking in 1965, said: *The Apollo spacecraft…provides the nation with a precursor to its first space station. And the Saturn V will provide the launch vehicle power necessary to carry out whatever programs the national interest may dictate for many years to come.* On the contrary, the operational use of the Saturn V ended with the launch of Skylab in 1973.

In 1966, Wesley A. Kuhrt, too, missed the marked, overestimating our progress in propulsion technology and space flight: *By the year 2000, we will be in a technical and financial position to travel extensively throughout the solar system. The propulsion systems for space travel will represent highly advanced products of the technology developed in the 1960s. Gas-core fission systems will play a dominant role in manned transportation throughout the inner solar system. The economy of the United States will support extensive space exploration without any neglect of other important areas of government interest. In short, by the year 2000 man will have taken a giant step into space, and will not be limited in space activities by propulsion technology.*

Just as many saw a bright future for the Saturn vehicle after Apollo, Robert S. Kraemer envisioned an ambitious role for the space shuttle. Speaking at the Goddard Symposium in 1975, he said: *With an appropriate Interim Upper Stage (IUS), we look forward to many Shuttle-launched planetary missions, like the proposed Mariner Jupiter Orbiter.* Today, expendable vehicles are the planetary mission launch mechanisms of choice. At the AAS Annual Meeting in 1976, Senator Moss added: *The shuttle is aimed at economy—its reusability, its huge payload capability, its simplification of the launch process, and its retrievability. Yet it's the economy of the space shuttle that is going to slash the price of the admission ticket to space.*

Conclusion

Predicting what lies ahead for the U.S. space program, and space exploration in general, is still a key focus of AAS events. Progress and the future are always of interest to space professionals and enthusiasts, since those who are passionate about space are generally also optimistic about what tomorrow has in store. As L. Eugene Root stated in 1965: *Combining, as the space program does, the best talents in management, in engineering, and in science, with the most modern facilities available, the net result is the production of progress*. And, as Hubert Humphrey told an AAS audience while he was vice president of the United States: *Even if we could not point to a single immediate dollar return from the space program, we must continue, for that is man's history, as well as our destiny.*

However, as evidenced by today's debate on the future direction of the space program, the road ahead will not be easy. The late Charles Sheffield, speaking at the AAS Annual Meeting in 1977, put it this way: *In terms of our current understanding of the universe, there is no "royal road" to space. Unless some other civilization comes to see us, and tells us the easy way to do it (and that would be at best a mixed blessing), we'll have to do it the hard way. It will be the usual mixture: some inspiration, a lot of hard engineering, a lot of pushing both for and against by special interest groups, and an overall stimulus that ranges from the desire to make money, to the desire to understand the heavens.* AAS will continue to provide a forum for those who are "doing it the hard way." ■

"Even if we could not point to a single immediate dollar return from the space program, we must continue, for that is man's history, as well as our destiny."
—Hubert Humphrey

Jim Kirkpatrick is the AAS executive director.

A Historical Perspective of the American Astronautical Society: The First Five Years, 1954-1958

by Ross Fleisig

The Founding Years: 1954-1956

As with almost all of society's innovations, new ventures are started when corresponding needs become apparent. So it was for the American Astronautical Society. James Rosenquist and Hans Behm met in April 1952 at a meeting of the Staten Island Interplanetary Society. They believed that manned space flight would develop as a logical progression of the high-altitude research aircraft and rocket-propelled missiles of that day and, moreover, that this development would advance man's knowledge and civilization. As serious interest in the Staten Island group waned, Rosenquist and Behm agreed in September 1953 to actively pursue the formation of a national space flight organization. Support of this goal grew as additional people joined these two men as AAS founders.

Another belief shared by this founding group was that established national societies that were engaged in the field of aeronautics and rocketry did not adequately address space flight science nor technology from either mission-oriented or systems development viewpoints, perhaps because certain influential leaders of these societies associated space exploration with science fiction or the lunatic fringe. This view, though myopic, was possibly conditioned by the fact that certain fundamental technical problems, such as rocket propulsion at significantly high levels of thrust and heat shields for crew protection during reentry, were still to be solved before manned space flight could be deemed a feasible enterprise.

Ross Fleisig (center) receives AAS corporate member dues from Dr. W.L. Barrow, Sperry Gyroscope research vice president (right). Herbert Harris, Sperry air armament manager, looks on. (Source: AAS)

Attention to the formation of AAS shifted from Staten Island to Manhattan in New York City, where support was obtained from the Hayden Planetarium/American Museum of Natural History. On November 5, 1953, Rosenquist and Behm invited 150 people to "the first meeting of an American counterpart to the British Interplanetary Society." On November 20, 1953, about thirty-two persons attended this meeting at which an organizational committee was formed to prepare the constitution, select a name for the new organization, and establish an agenda for its founding meeting. This founding meeting occurred on January 22, 1954, where, with thirty-seven people present, the name—American Astronautical Society—was chosen, the draft constitution was adopted, and officers and directors were elected. Hans Behm and James Rosenquist were elected president and recording secretary, respectively. A certificate of incorporation in New York State was issued on February 17, 1954.

Through hard work and dedication on the part of Rosenquist and Behm, supported by a small number of additional people, the AAS was founded. The momentum created by this group would carry AAS through 1954 and 1955. During 1954, four lecture meetings were held. The last, on December 3, held at the Hotel Shelbourne in New York City, was designated the First Annual Meeting. It featured Dr. Wernher von Braun, who spoke on the lessons he had learned in the development of space flight hardware. By July 1954, sixty-four members had joined the AAS. In the next month, the International Astronautical Federation (IAF) admitted the AAS as a member society. On April 15, 1955, the New York Section was constituted as the first AAS regional section.

Between the New York Section and the national organization, the AAS held six meetings in 1955. At the last of these meetings, the Second Annual Meeting, held on December 1, 1955, at the American Museum of Natural History and the Hotel Edison in New York City, technical papers were given by Dr. Wernher von Braun, Dr. S. Fred Singer, Andrew G. Haley, and Dr. Ernst Stuhlinger, as well as other prominent people who were active in astronautics development. The first AAS Space Flight Award was presented to Professor Hermann Oberth, a pioneer in the field of space flight.

The AAS program in these early years included publications as well as lectures and annual meetings. *The Journal of Astronautics*, published in the fall of 1954 and four times in 1955, contained technical papers, news of the Society, book reviews, abstracts, astronautical news and notes, and advertisements. Other AAS publications included proceedings of the Annual Meetings and technical paper preprints.

My own interest in the AAS started in early 1955, when I attended several very informative and stimulating technical meetings. Because of my engineering experience in the development of aircraft and missile guidance and control systems, I was genuinely interested in the AAS program. Most of the officers and directors whom I met at these meetings were dedicated and serious-minded professional people. Although few of the AAS founding group were actually contributing to astronautical sciences and technology, the group members were sincere in their desire to discuss bona fide space flight proposals and to attract qualified scientists and engineers to their forums. I joined the AAS in the fall of 1955.

H.E. Weihmiller, chairman of the AAS New York Section, welcomes guests at the Honors Night Dinner. To his left, moving clockwise, are Major General Otis O. Benson, Jr., Major David G. Simons, and Austin N. Stanton. The identity of the woman at left is unknown. (Source: AAS)

During much of 1956, further growth in the AAS was retarded by strife within the Society's management. Serious issues surfaced relating to *Journal* policy as well as to the conduct of the Society's business. The Society's internal problems caused a sharp polarization of views. Throughout much of this period, I did not personally become involved in the conflict by actively taking sides or signing any of the accusatory memoranda or letters that were circulated. At the September 26, 1956, board of directors meeting, I was appointed to serve an unexpired term as director-at-large, replacing a director who had resigned because of illness.

The battle of words continued. The intensity of this situation was manifested by the resignation on November 28, 1956, of a majority of the board of directors. I chose to remain on the board and was elected AAS president for 1957. I firmly believed that the AAS should and could perform a worthwhile service and that the Society would weather its storm.

The Maturation Year: 1957

On January 1, 1957, the new board of directors assumed responsibility for the management of the AAS. At the first meeting of this directorate on January 18, 1957, I described the state of the Society and reviewed the problems that the AAS would face in the coming year. Following a full and frank discussion by the directorate, it was agreed that the major objectives for 1957 would be to stabilize the Society's business operations, plan a program of AAS activities, and implement the plan vigorously. Moreover, in each of these areas, [I as] the president solicited each director's proposal and views so that actions taken by the board would be based on the will of the majority. Unanimous agreement was reached on a key point: the board's conduct during 1957 must reflect a real team effort to revitalize the Society. Through a mature directorate, the AAS could regain its momentum to grow as a professional organization that could truly serve astronautics.

Fourth Annual Meeting participants from left to right: George R. Arthur, Norman V. Petersen, Col. Paul A. Campbell, Saunders B. Kramer, and Ross Fleisig. (Source: AAS)

In a matter of weeks after the first board meeting, a comprehensive program of activities was unanimously adopted by the directorate. On February 11, 1957, a letter was sent by [me as] the president to every AAS member describing the program and naming the director appointed to chair the committee responsible for each activity. These program activities, as well as other business operations of the Society, were conducted by officers and directors with whatever help they could arrange from their own company organizations and other AAS members. Because no paid secretariat or staff was available, the board members volunteered much of their own time to support the Society's program of technical activities and business operations.

While a casual observer might conclude that this mode of support would limit the growth of AAS, the opposite, in fact, turned out to be the case. The main reason for the AAS succeeding in its planned activities was that the officers and directors were dedicated to furthering AAS growth. Individual board members who interfaced with the scientific and engineering community reflected sincere enthusiasm for the AAS program of activities. Moreover, most of the board members were professional managers in the aerospace or electronics industries. These people understood the status and potential of astronautical developments. With motivation and skill, the 1957 AAS board performed well as a team meeting its goals.

Throughout 1957, nine board meetings were held. At each meeting, in addition to reviewing AAS business operations, each director responsible for one of the five program activities reported on his committee's progress. On May 2, 1957, the first meeting of the AAS San Francisco Regional Section was held. Efforts were also undertaken to form new regional sections in Washington, D.C., and Los Angeles. On December 23, 1957, a provisional charter was issued to the AAS Washington Area Section.

One of the 1957 highlights that I recall is my attendance at the Eighth Congress of the IAF, October 6-12, 1957, in Barcelona, Spain. AAS delegates to past IAF Congresses had been Society directors or officers. Two days before the start of the 1957 Congress, [I as] the president received a call from the director who had planned to represent AAS at the meeting. He advised that he would not be able to attend. Because it was not possible for any other board member to serve as AAS delegate on such short notice and because I decided that it was important for AAS to be represented, I quickly rearranged my schedule and flew to Spain. My report of the Eighth IAF Congress was presented to the AAS membership in *The Journal of Astronautics*.

What made the Eighth IAF Congress unique among astronautical symposia was that *Sputnik*, the first artificial satellite of the earth, had been launched by the USSR on October 4, 1957, two days before the Congress started. This event heightened worldwide interest in space flight and Congress activities. Its impact on AAS growth would be sustained for many years.

The Growth Year: 1958

During 1958, five board meetings were held. Because four of the directors were from the Southwest or Far West, the board decided to convene less frequently than in 1957. Additional management tasks would be undertaken by the executive committee, which was empowered by the board to transact much of AAS business. The committee consisted of the president, treasurer, and recording secretary, all of whom resided in the New York metropolitan area. The board concerned itself mainly with Society policy and long-range planning.

The 1958 AAS program goals were established to significantly enhance the Society's growth. These included: two national meetings annually; increased individual and corporate membership; formation of additional regional sections; and continuation of the publication of the *Journal*, proceedings, and preprints.

The AAS held its Fourth Annual Meeting January 29-31, 1958, at the Engineering Societies' Building and Midston House in New York City. Considerable national interest was generated at this meeting because of the two recent space flight experiences: the successful Soviet launch of *Sputnik 1* into Earth orbit on October 4, 1957, and the U.S. Vanguard failure on the launch pad on December 6, 1957. I, as the meeting program chairman, and many other AAS officers, directors, and members contributed much energy and time to make this meeting an unqualified success. Over six hundred people registered for the technical paper presentations.

The Honors Night Dinner on January 30 was attended by over two hundred people. Dr. Wernher von Braun was the recipient of the 1957 AAS Space Flight Award but was not able to attend since he was at Cape Canaveral for the launch of the *Explorer 1* satellite atop the Jupiter C launch vehicle. Austin Stanton accepted the award in his place, and *Explorer 1* was successfully launched into earth orbit three days later. Thirteen new fellows were announced, including Dr. von Braun. The executive officer of the American Association for the Advancement of Science (AAAS) announced that the AAS had, on December 30, 1957, become an affiliate of the AAAS. On April 25, 1958, an article written by me appeared in *Science*, the AAAS journal, in which I described AAS objectives, programs, publications, regional sections and corporate membership.

To point up the national character of the AAS, the board decided to hold the Fifth Annual Meeting in Washington, D.C., in December 1958, in conjunction with the 125th meeting of the AAAS. Technical sessions for this meeting covered satellite mechanics and space exploration; upper atmosphere research and re-entry mechanics; space vehicle design; rockets and satellites; guidance and instrumentation; and man's environment in space. Over seven hundred people registered for these sessions!

A new feature introduced at the Fifth Annual Meeting was the AAS guest lecture in the astronautical sciences. Dr. Hugh L. Dryden, NASA Deputy Undersecretary, gave the first lecture entitled: "Space Exploration and Human Welfare." At the 1958 Honors Night Dinner, the AAS Space Flight Award was presented to Professor James A. Van Allen, and nine new AAS fellows were announced. Because of the enthusiastic participants, prestigious guests, and large attendance, the Fifth Annual Meeting was judged a tremendous success.

As a result of the successful space flights of the Sputnik, Explorer, and Vanguard satellites in 1957 and 1958, U.S. interest in astronautics burgeoned. This, together with the AAS's expanded program of national and sectional meetings, led to a significant increase in AAS membership in 1958. The AAS was the only U.S. technical society dedicated exclusively to astronautics. Moreover, AAS programs, which stressed space-mission analysis, space systems development and the space sciences (including man's environment in space), appealed to an increasing number of scientists and engineers who were entering the astronautics profession in 1958. AAS membership grew from four hundred to almost seven hundred during 1958. An upsurge in corporate members also occurred, with Republic Aviation Corporation, Space Corporation, Kearfott Company, The Martin Company and Sperry Gyroscope Company signing on.

Two years later, the United States initiated the very successful Apollo manned lunar flight program. Without a doubt, AAS meetings during the early 1950s helped to mold the thinking of U.S. space program policy decision-makers for many years to come. ■

Reproduction of the 1957 AAS Space Flight Award. (Source: AAS)

Ross Fleisig **joined AAS in 1955 and served as third president from 1957 through 1958. Now retired, he enjoyed a fifty-five-year career as a specialist in systems engineering, flight dynamics, and guidance and control hardware and software development. This article was excerpted from an essay he wrote for a history workshop at the 1979 AAS Goddard Memorial Symposium on the occasion of the Society's twenty-fifth anniversary.**

After the X Prize

The X Prize is within reach of enterprising space vehicle developers. After it is won, how can entrepreneurs cash in on the ultimate frontier?

by David Boswell

Last year on December 17, the one-hundredth anniversary of the Wright brothers' original powered flight, *SpaceShipOne* became the first privately financed passenger-carrying vehicle to break the sound barrier. In April 2004, in another test flight, *SpaceShipOne* reached speeds over Mach 2.

Scaled Composites, the company that is developing *SpaceShipOne*, made this flight as part of its preparation to win the X Prize, a $10-million award that will go to the first private organization that launches three people into sub-orbital space and then does it again within two weeks. This prize is styled after the numerous competitions and awards offered in the early part of the twentieth century that helped jump-start the commercial air transportation industry. Perhaps the most famous of these was the Orteig Prize, a $25,000 award that Charles Lindbergh won by making the first non-stop flight across the Atlantic.

More than twenty other teams are competing for the X Prize, and it is possible that one of them will win it by late 2004 or early 2005. The hope is that these teams will form the beginning of a successful private space industry, fueled initially by paying tourists who want to experience a glimpse of space in sub-orbital flights. As the industry matures, entrepreneurial companies will pioneer other business opportunities.

If we may be less than a year away from the successful conclusion of the X Prize, the obvious question is: What will come next? More specifically, what other business opportunities might exist beyond short flights into sub-orbital space? And what role will private industry play in space exploration now that our government funded space program has a new mandate to send humans beyond Earth orbit to return again to the Moon and then venture on to Mars?

Government as a Near-Term Supporter

In its 2005 budget, NASA announced a new program of annual prizes that it is calling Centennial Challenges. These prizes seek to foster creative solutions that will advance the capability to explore the solar system. Potential prize categories include very low-cost robotic missions, life detection sensors, and advanced rover systems. NASA is modeling these challenges after the early twentieth-century aviation prizes and more recent contests such as the X Prize.

These new prizes should provide additional stimulus for private industry by offering incentives to develop new space systems and services. NASA can then benefit from these new technologies by using them to help meet the nation's exploration goals. NASA also will benefit by making possible the creation of solutions that would not nor-

SpaceShipOne, shown here being raised to launch altitude by carrier plane White Knight*, is a lead contender for the X Prize. (Source: Scaled Composites)* mally be created through its existing procurement processes.

The government is helping to foster the private space industry in other ways, such as by providing support to expendable launcher manufacturers. Under the assured access to space program, the Air Force is providing almost $200 million in assistance in its 2005 budget to Boeing and Lockheed Martin to keep both the Delta 4 and Atlas 5 launchers operational. The European Space Agency has also recently announced that it is providing a similar level of assistance to the Arianespace launch consortium to keep the Ariane rocket a viable player in the world market.

A space elevator could be used for transporting people and payloads between Earth and space sometime in the future. This space elevator concept is depicted from a geostationary transfer station, looking down the length of the structure towards Earth. (Source: NASA)

Prizes and government investment provide assistance to emerging industries, but they can't sustain business forever. The aviation industry was established through contests and through government incentives, but airlines today make their money through the services they offer, not prizes. The same thing will happen in space. So how will companies make money in space after winning the X Prize or the Centennial Challenges?

Current Situation

There are certainly companies focused on making money in space today through satellite manufacturing and operations, launch vehicle production, and other services for government and commercial customers. In fact, the space industry has existed as long as the space age. Companies have made money by selling equipment or services to space agencies conducting their own missions. As NASA prepares to return to the Moon and Mars, more business opportunities will be available for the private space industry.

So if companies are making money in space today, what is the purpose of the X Prize and the Centennial Challenges? When talking about these contests spurring on the emergence of the space industry, it would be more correct to talk about the emergence of a *self-sufficient* and *profitable* space industry. The goal is to help businesses—particularly new ones, without histories of winning government contracts—develop revenue sources that are separate from government funded space programs.

The state of the expendable launch market is a perfect example of the current situation in the space industry. Delta, Atlas, Ariane, and other expendable rockets need government subsidies because there isn't enough demand to keep all of the available launchers in business. There were approximately sixty launches in 2003—about the same number as in 2001 and in 2002—but still not enough to make producing expendable launchers a profitable business.

The launching business needs something to spur the demand for its services. Simply put, there would be more launches if there were more reasons to launch things into space. Space tourism and other markets being pioneered by the entrepreneurs working to win these contests may create the increase in demand that is needed for the emergence of a mature space industry. The high level of interest in space tourism shows that at least one new market likely exists for launch services.

Return on Investment

It should be possible to get a rough idea of how the space industry will mature by looking at the potential return on investment of a variety of possible missions. Since the bottom line for any private company is profit, missions that generate money are of interest to private companies. In contrast, the bottom line for any government funded space program is science, so NASA judges the value of missions by a different measure of success.

For example, what is the scientific return of placing someone into Earth orbit? NASA learns much about the effects of weightlessness on humans by conducting experiments on the International Space Station (ISS), but it learns very little in the process of getting people there. The economic value is clear, however. NASA pays a certain price to launch astronauts to the ISS. A price for a ticket has also been established by the first space tourists, who paid $20 million each for a ride to orbit and a brief stay on the ISS.

In another example, the *Spirit* and *Opportunity* rovers have provided a return on investment by finding evidence that liquid water once flowed on the surface of Mars. The scientific value of proof of a shallow, salty sea at Meridiani Planum is enormous, although this dis-

The Soyuz spacecraft and launch vehicle are one of only three means available in the world today for humans to access space. (Source: NASA)

covery yields no practical economic value.

It is therefore reasonable not to expect to see privately funded planetary probes in the near future. A clear incentive nonetheless exists for the space industry to develop and market orbital launch services and to explore other business opportunities in space.

Orbital Flights

The next logical step beyond sub-orbital flight is orbital flight. The flights needed to win the X Prize follow a ballistic path that goes up and then comes right back down without going high enough or fast enough to achieve orbit. Sub-orbital flights can still be used as a stepping stone to orbital flights, though. After all, that's how NASA did it. The first two Mercury flights in 1961 were sub-orbital trips that reached space but not orbit. It was on the third Mercury flight that John Glenn became the first American to orbit Earth.

The gap between the two types of flight is not trivial. Sub-orbital flights need to reach an altitude of at least 100 kilometers; to reach this height they need to be going about Mach 4. In comparison, the space shuttle flies about twice as high above Earth and at twenty-five times the speed of sound. Orbital flights have taken place for over forty years now, so there is no question of whether a private company could build an orbital vehicle. The important question is whether a company could build one that earned more money than it took to develop and operate.

Ignoring the technical aspects of how this could be done, let's see if there are any business motivations for private companies to build orbital vehicles. Currently, few options exist for carrying people into orbit—the American shuttle, the Russian Soyuz, and the Chinese Shenzou. The Shenzou has only been used once for human space flight so far. The shuttles are currently grounded and are also scheduled for retirement when ISS construction is complete. NASA's next vehicle capable of taking crews into space has also not yet been determined and will almost certainly not be available by the time the shuttles stop flying. This leaves the Soyuz, which has already been used to launch the first two paying space tourists and will soon launch a third.

With such a small number of options, the orbital launch services market looks like an ideal market for the private space industry. If a private company was able to offer an orbital vehicle that could compete effectively with existing or proposed government developed launch options in terms of cost and safety, then the opportunity would be enormous. NASA doesn't build the cars it uses to get the astronauts from their homes to the launch pad, so there is no reason why the agency couldn't buy orbital launch services from a private company if doing so was a better deal than building its own vehicles.

Of course, NASA would not be the only entity interested in commercially available orbital launch services to get astronauts to the ISS or into orbit. Other countries could be interested in sending people into space without needing to develop their own space infrastructure. Dennis Tito and Mark Shuttleworth have also shown that individuals are willing to pay to get into orbit. A commercial vehicle could also possibly be used for super-fast passenger travel and package delivery on Earth.

Beyond Earth Orbit

Looking further out, are there any opportunities for private space industry beyond Earth orbit? If we are interested in sending humans back to the Moon and to Mars, would it make sense for private companies to take us there? Are there any business opportunities for companies on the Moon or Mars that would make going there worth their investment? We have sent humans to the Moon and robotic probes to Mars, so we have some idea about the returns from these missions. So far the value gained has been mainly scientific rather than economic.

Some people have suggested that there is an economic reason for going to the Moon. The Moon has an abundance of helium-3, an isotope that is extremely rare on Earth. Helium-3 also has the potential to be used as a fuel for fusion reactors and may become the main energy source for the twenty-first century, but right now this is a very theoretical market. Funds are being spent on research, but commercial fusion reactors still exist only in science fiction. There are other resources beyond Earth orbit, though, that do have an existing market.

Asteroid mining might be the ideal opportunity for the space industry. Although most asteroids are grouped within the asteroid belt between the orbits of Mars and Jupiter, there are others much closer to home that either intersect Earth's orbit or that orbit nearby. Although asteroids would no doubt have scientific value, they hold an almost unbelievable wealth of metals. Some estimates suggest that even average-sized asteroids contain trillions of dollars' worth of iron, nickel, cobalt, platinum, and other metals.

Of course, getting to an asteroid, mining the metals, and then getting them back to Earth has never been done and would be a huge undertaking. Because of the potential return, though, it is conceivable that private companies might send prospecting probes to asteroids to start the process of setting up a future mining mission. Although sending a crew to an asteroid would be within the abilities of NASA if the agency was prepared to send people to the Moon or Mars, the scientific value wouldn't be nearly as compelling a reason to go as the economic value.

Lunar mining, shown in an artist's conception here, may prove to be an economic boon for prospective entrepreneurs. (Source: NASA/Pat Rawlings)

Space Elevator

Looking even further out into the growth of the private space industry, it is possible that a commercial company will make the investment to turn the concept of a space elevator into a reality. Getting to space is currently very expensive. Launch costs run several thousand dollars per kilogram. With a robust private space industry we can assume that innovation, competition, and improved efficiency will lower these existing costs to some degree, but it is possible that rockets will never be as safe and cheap as they need to be to make a profit. If this is the case, then someone will try to get to space some other way.

Again, let's ignore the technical aspects of how a space elevator could be built and focus on the business reasons for why a company would want to try to build one. Cost of reaching space is a major incentive for why a company would want to build a space elevator, but it is not the only one. Other benefits that an elevator would have over existing rocket-based launch options include the ability to bring payloads down from space and lift fragile payloads into orbit.

The space shuttle is the only vehicle currently capable of bringing a massive payload down from space intact. The shuttle is set to be retired soon, and any future orbital, crew-carrying vehicles that are built by NASA or private companies will almost certainly be much smaller and have less capability to bring payloads down from orbit. If asteroid or helium-3 mining ever becomes a reality, there will need to be some way to get these resources down to the surface of Earth—something for which an elevator would be well suited.

An elevator would also be well suited for constructing a solar power station located in orbit that beams power down to Earth. As our energy needs increase, this may become the most attractive power generating option available to us. Rockets produce considerable vibration during launch, and payloads must be able to handle the stress of launching, so it simply might not be feasible to place acres of delicate solar panels into orbit using conventional methods. A space elevator, though, would produce very little vibration and could lift fragile payloads into orbit.

The Future

It is very exciting to watch the competition for the X Prize. Whatever the future may hold for the private space industry, the world will be a different place once a team wins the prize. Space will no longer be limited to astronauts and large government programs. The space industry has a long way to go before it matures to the level of the aviation industry today, but it will have taken one big step closer.

Setting up additional prizes may help get the space industry off the ground, but building a sustainable presence in space requires real business opportunities for companies. The good news is that it seems that space is filled with them. Some of these possible opportunities may be a long way away, but they will provide the ultimate prize for the people willing to go after them. ■

***David Boswell* (davidwboswell@yahoo.com) has written articles about space and other technology issues for the online publications *The Space Review* and the *O'Reilly Network*.**

15th AAS/AIAA Space Flight Mechanics Meeting

January 23-27, 2005

Copper Conference Center, Copper Mountain, Colorado

The fifteenth annual AAS/AIAA Space Flight Mechanics Meeting will be held at the Copper Conference Center at Copper Mountain, Colorado, January 23-27, 2005. This event is cosponsored by the American Astronautical Society (AAS) and the American Institute of Aeronautics and Astronautics (AIAA). The meeting is organized by the AAS Space Flight Mechanics Technical Committee and the AIAA Astrodynamics Technical Committee. The conference location is situated in the middle of the Colorado Rocky mountains in the ski resort community of Copper Mountain, about 75 miles from Denver International Airport. Participants are strongly advised to make their lodging arrangements well in advance to take advantage of the incredible group rate offered by the resort. Papers are sought from all areas of astrodynamics, including but not limited to:

- Orbital dynamics, perturbations and stability
- Orbit determination and tracking
- Spacecraft guidance, navigation and control
- Trajectory design and optimization
- Earth orbital and planetary mission studies
- Attitude dynamics, determination and control
- Low thrust mission and trajectory design
- Satellite constellations and formation flying
- Dynamics and control of large space structures and tethers
- Artificial and natural space debris
- Trajectories about libration points
- Asteroid and Non-Earth Orbiting missions
- Probability of Asteroid Earth Collisions
- Rendezvous/proximity operations missions

Updated and additional information on the conference will be posted at the AAS Space Flight Mechanics Committee website: http://www.space-flight.org.

Information for Authors

Papers will be accepted on the basis of extended abstracts. These abstracts should consist of

1. A cover page containing the paper title as well as the name, affiliation, postal address, telephone number, fax number, and email address of each author. This page shall also indicate the corresponding author, who will be the point of contact for all communication from the technical chairs.
2. The text of the extended abstract, with a length of 500-1000 words and containing supporting tables and figures. The extended abstract shall provide a clear and concise statement of the problem addressed and the results obtained. Submissions without extended abstracts will not be considered.
3. A condensed version of the abstract (100 words maximum) to be included in the printed conference program.

We encourage submissions to be made by email. Acceptable document formats are PDF (the preferred method), Word , or ASCII. For Word files, use only the standard installation fonts. Avoid using symbols and Greek characters in the short abstracts. All material should be sent to each of the Technical Chairs. Notification of acceptance will be sent to the authors via email by November 1, 2004. Author instructions will be sent by email and also placed on the website, http://www.space-flight.org. Final manuscripts are required at the time of the meeting. Authors are required to supply their session chairs with a copy of their paper and a short biography of the presenter before the meeting. A **no paper-no podium** rule will be in effect for all presentations. Authors whose papers are not available in printed form at the time of the meeting will not be allowed to present their paper.

Special Sessions

Proposals are solicited for appropriate special sessions, such as panel discussions, invited sessions, workshops, and mini-symposia. Potential special session organizers should submit a proposal to the Technical Chairs. For a panel discussion, this proposal should include a title of the discussion, a brief description of the topics to be discussed, and a list of the speakers and their qualifications. For an invited session, workshop, or mini-symposium, the proposal should consist of the title of the session, a brief description (approximately 500 words), and the extended abstract and short summary for each talk to be included in the session. The following special sessions have been suggested.

Open Astrodynamics. This panel discussion will focus on the application, development, distribution and implementation of astrodynamics information. There may be a related special session if there are enough relevant papers. The overall goal is to determine what is needed to stimulate a cooperative environment in the astrodynamics community that allows organizations to efficiently share data, resources, and ideas. The potential benefits of polices and their impact to the overall astrodynamics community will be discussed. Related to this is the observational data (SSN, JPL, other) that could be shared for research activities. Another example is the need for the satellite regulatory agencies to standardize an approach to avoid interferences between systems. Each panel participant should bring suggestions to the table from their perspective (data owner, investigator, developer, contractor). They should identify the people in their organizations that make decisions on data sharing – or who can authorize data release. Contact: Felix Hoots/Paul Cefola, phone: (703) 506-5931 / (781)-981-5723.

Novel Lunar and NEO Mission Design and Analysis. This session seeks a discussion on the following topics:

1. Long-duration human missions to the Moon, Mars, and beyond.
2. Circumnavigation and rendezvous missions to comets and NEOs using single or multiple satellites.
3. Mission design and analysis for high risk missions with significant payoffs.

Contact: Rao Vadali, phone: 979-845-3918.

Breakwell Student Travel Award

The AAS Space Flight Mechanics Technical Committee also announces the John V. Breakwell Student Travel Award. This award provides a maximum of $1000 to cover travel expenses for U.S. and Canadian students planning to attend this con-

The Secret of Apollo: Systems Management in American and European Space Programs

The Secret of Apollo: Systems Management in American and European Space Programs, by Stephen B. Johnson. Baltimore: The Johns Hopkins University Press, 2002. 304 pages. ISBN 080186898X. $41.50.

One might think that over thirty years after the last successful human landing on the Moon there would be little left about the Apollo program to elicit scholarly interest. Fortunately, Stephen B. Johnson was not dissuaded by the voluminous literature on the subject.

Rather, the associate professor of space studies at the University of North Dakota chose to view the Apollo program from a new perspective, seeking to find the organizational tools which allowed the United States to fulfill John Kennedy's challenge to put a person on the Moon by the end of the 1960s. The result of his work is *The Secret of Apollo: Systems Management in American and European Space Programs*. The book received the American Astronautical Society's 2002 Eugene M. Emme Award.

In his book, Johnson examines how the U.S. government built on the principle of configuration management to create an environment in which highly complex missile and space systems could be constructed. He then delineates the crucial process by which George Mueller, who became head of NASA's human space flight in 1963, transferred that principle to the agency's Office of Manned Space Flight, leading to the implementation of the organizational technique known as systems management. This concept allowed civilian and military program managers to coordinate large-scale technology development.

After describing the impact that systems management had on the Apollo program, Johnson makes telling comparisons with the lack of success experienced by the Europeans until they mastered this concept. Along the way, Johnson uses other space projects, such as the series of robotic spacecraft developed by the Jet Propulsion Laboratory, to illustrate the significance of the breakthrough that systems management represented.

Drawing on a wealth of primary and secondary sources, *The Secret of Apollo* covers familiar territory but does so from a different, and important, vantage point. This groundbreaking study represents a masterful analysis of how America's early missile and space programs led to a bureaucracy of high-tech innovation for both human and robotic space flight. ■

Reviewed by *Donald C. Elder III*, professor of history at Eastern New Mexico University.

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ference. Further details and applications may be obtained at http://www.space-flight.org.

Warning - Technology Transfer Considerations

Prospective authors are reminded that technology transfer guidelines have substantially extended the time required for the review of abstracts and completed papers by private enterprises and government agencies. These reviews can require four months or more. It is the responsibility of the authors to determine the extent of approval necessary for their papers to preclude late submissions and paper withdrawals.

All material (cover page, abstracts) should be sent to each of the **Technical Chairs**:

Dr. Michael Gabor (AAS Technical Chair)
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Schriever AFB, CO 80912-7200
719-567-8185 (voice)
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Mr. Prasun Desai (AIAA Technical Chair)
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8 Langley Boulevard, MS 365
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757-864-2986 (voice), 757-864-8671 (fax)
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For other questions regarding the conference, please contact the **General Chairs**:

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The Space Frontier Paradigm: Correcting a Misleading View of Space as the New West

To understand the true nature of the space frontier, we must turn not to the classic Old West but to hostile frontiers more suited to science than settlers.

by David West Reynolds

Space as "New West"

Wernher von Braun's space exploration manifesto in *Across the Space Frontier* (1952) established space as a frontier in the American consciousness. The identification of space with the classic Western frontier has carried potent associations for Americans. The Old West presented a tough proving ground for the American spirit, filled with challenge for the pioneers and prospectors but holding the promise of glory, gold, and a prosperous California paradise once civilization had been established.

Space as the "New West" grew into a paradigm that has influenced space policy debate and engagement strategy in minds all the way up to that of the NASA administrator. It was Dan Goldin who said, "Send out the Conestoga wagons!"

This painting by space artist Chesley Bonestell illustrates the expansion of San Francisco by the construction of giant barges, a twenty-first century version of Holland's famous land-reclamation practices. Such a grandiose project as this would be far more economically viable for expanding population capacity than would space colonies, as this floating city would cost per capita only a tiny fraction of the expense undertaken to build the International Space Station. (Copyright: Bonestell Space Art. Used with permission.)

The West, like other such "classic" frontiers before it, offered three principal advantage factors that made classic frontier development so productive:

- **Settlement land** for building homesteads, ranches, farms, and towns for burgeoning populations;
- **Natural resources** suitable for profitable development through mining, logging, ranching, and agriculture; and
- **Economic opportunity for infrastructure builders**, such as the creators of the Transcontinental Railroad that allowed settlers and developers to easily and affordably gain access to the frontier.

Space has been emphatically positioned as the sequel, the New West, on the grounds that it offers the same opportunities as the Old. Advocates see in space:

- **Settlement "land"** in the form of space colonies in Earth orbit. These are seen as the frontier towns of the Space Age, forerunners of the San Franciscos of the future.
- **Natural resources suitable for profitable development**, such as flawless crystals manufactured in microgravity, solar energy beamed to Earth from satellites, and helium-3 mined on the Moon as fuel for advanced nuclear power plants. These are the harvests and ores of the New West.
- **Economic opportunity for infrastructure builders.** The space shuttle was positioned from its inception as being a solution to easier and cheaper access to space. The investment in this infrastructure would open the space frontier to development, making the shuttle the equivalent of the Transcontinental Railroad into the West. The International Space Station (ISS) has also been promoted as a materials science platform, making it a mining town in the High Sierras of orbit.

Failure of the New West Paradigm

Unfortunately, the environmental and logistical challenges of space render it critically different from the classic Western frontier. The basic reality of extremely high expense makes space incapable of offering the benefits of engagement with a traditional frontier and renders the New West paradigm dangerously misleading.

Space is too expensive to furnish suitable settlement area, and the costs of reaching and obtaining its resources far outweigh the gain to be made in obtaining them. Although it is a technological wonder, the space shuttle completely failed at its primary mission to dramatically reduce the cost of accessing space. The materials science function of ISS has also failed to attract industrial investment.

In its pitch for investing in the space shuttle, NASA distorted data regarding the economics of space development to make the data fit the paradigm, rather than allowing the paradigm to arise from an interpretation of the data. The *a priori* reasoning of the failed space shuttle and ISS projects has caused decades of lost opportunity and has eroded public and Congressional support. This was the result not of Machiavellian intentions to deceive but of a firm belief in a paradigm that turned out to be false.

Space as a Hostile Frontier

Unlike the classic Western frontier, space presents a hostile, deadly environment that requires human explorers to equip themselves with elaborate protective clothing and specialized shelters. Space is also an environment barren of virtually everything needed by explorers to sustain themselves: unlike Lewis and Clark, space travelers cannot easily "live off the land." These factors can be overcome with sophisticated modern technology, but they cannot be overcome without prodigious expense.

Conditions most closely approaching the challenge of functioning in space are found on Earth in two environments: at the poles and in the sea.

Like spacecraft, space stations, and proposed lunar bases, underwater vehicles and habitats face tremendous engineering challenges and an extremely hostile pressure environment. They must contain their own air and sealed life-support systems to provide breathable atmosphere.

Under relatively shallow waters, commercial operations such as oilrigs can operate profitably, but only government and military-sponsored expeditions can hope to penetrate the greatest depths. Deep-sea mining schemes such as manganese nodule recovery are periodically promoted, but, like often-promised lunar commercial projects, none ever come to anything. Such operations are simply too expensive to be practical.

Polar explorers face a similarly barren environment. Working at the South Pole requires extensive logistical preparation, complete supply provision, and special protective clothing for survival. Antarctic science station habitats such as the geodesic dome of the Amundsen-Scott South Pole Station bear more than a passing resemblance to proposed lunar bases because many similar considerations apply to both hostile frontiers.

Antarctic and undersea science missions have shown that an isolated and expensive base in a hostile environment can return a steady stream of scientific data and discover phenomena of global significance like the ozone hole, making it a worthwhile scientific and prestige asset for the United States. This suggests that a space facility such as a lunar base could be a similarly productive enterprise, if approached with realistic expectations focusing on science rather than imagined profitable industrial applications.

The Hostile Frontier paradigm suggests clearer perspectives on a range of space policy issues.

Like the oceans and the poles, space does not offer land suitable to accommodate burgeoning populations. The orbital colony illustrations offer exciting and attractive visions,

Established by the U.S. government, the Amundsen-Scott South Pole Station supports scientific research that can be carried out nowhere else. This facility is isolated by winter weather conditions, must be supplied from distant locations, and is constructed to withstand temperatures reaching -83 degrees Centigrade. In respects such as logistics, operation, and isolation, this base exists on a hostile but scientifically exciting frontier analogous to that of space. (Source: P. Roberts/Climate Monitoring and Diagnostics Laboratory/NOAA/ Department of Commerce)

The Navy's TEKTITE I sits beneath the waves near St. John Island. This sea base sustained aquanauts on a sixty-day mission in 1969. Underwater laboratories have supported coral reef research not possible for scientists based on the surface, much as a lunar base would support unique research on the Moon. The engineering and economic challenges of creating and operating underwater habitats provide perspective on operating facilities in the hostile frontier of space. (Source: NOAA/Department of Commerce)

but they are economically naive in the extreme. If expanding populations need more room, it will be far more economical to house them on Earth than in space. The harshest and least desirable environments on Earth—the poles, the Sahara, the ocean surface—are vastly more hospitable and economically advantageous than the best locations in space.

Space tourism has also been proposed as both a goal and an economic engine for the development of space and space colonies. While there is now a steady stream of tourists visiting Antarctica, elite tourism has never been construed as a legitimate justification for the expense of U.S. Antarctic operations. There are tourist submarines around the world and even a few underwater restaurants and hotels, but neither polar nor undersea tourism is economically substantial enough to drive technology advancement, and we should not expect space tourism to be different.

Space industry advocates claim that planetary bodies may harbor valuable natural resources, but such sentiments again arise from the enthusiasm of the New West paradigm rather than a realistic evaluation of the Hostile Frontiers. The uncollected manganese nodules at the bottom of the sea and the undisturbed coal and oil beneath the glaciers of Antarctica remind us that in a Hostile Frontier the expense of recovery can easily outweigh the rewards of the resource on the market. With the staggering expense of even small space ventures, we must accept that it will not be profitable to exploit resources in space without quantum technology advancements.

Realistic Expectations

The failure of space to deliver the same goods that the West once did has been blamed on poor NASA leadership, faulty government policies regarding commercial space development, and even a failure of the American spirit. NASA has committed its share of errors, but our worthy space agency is not to blame for the fact that space is a Hostile Frontier rather than a New West. It is only to blame for promoting this false paradigm and raising inappropriate expectations.

In the face of uncharted territory, appropriate metaphors can provide the guidance of experience to debate and decision-making. Metaphors can help people reduce a problem to its essentials and can aid in explaining issues to Congressional officials in terms that they can appreciate and understand. Inappropriate metaphors, or false paradigms, can lead to people getting carried away with ideas that do not actually make rational sense. If NASA had understood that it was trying to build a Transcontinental Railroad underwater, so to speak, it might have had clearer and more accurate expectations for the space shuttle program.

The Hostile Frontier paradigm is easily applied for the purpose of gaining basic perspective on an issue. Generically speaking, if an idea makes sense for undersea or polar exploration, it might make sense for space exploration. If it doesn't make sense for undersea or polar exploration, it probably won't make sense for space exploration. To illustrate:

- **Is colonization a sensible idea?** Not underwater, nor in the polar ice…and not in space, either. All such environments could be colonized using high technology, but all are wildly expensive, and space is the most expensive of them all. Classic frontiers attracted settlers with cheap land. Space will be economically suitable for settlement only when it becomes cheaper to build in than earthly territories.

- **Will elite tourism play a significant role in frontier development?** Its arrival has neither changed the cost of Antarctic logistics nor advanced the technology of deep-sea exploration in spite of the widespread use of scuba apparatus for shallow-water tourism. We should expect tourism in low Earth orbit to take advantage of space technology developments—as it has already begun to do—but not to drive space technology or provide significant new tools for space exploration.

- **Should private industry develop the frontier?** Industry has limited opportunities to profitably develop a Hostile Frontier in the face of the heavy expenses. The satellite business can be seen as the equivalent of oilrigs in relative shallows. Going farther into a Hostile Frontier takes a public commitment based on science and exploration rather than commerce. Government must lead exploration in space just as it does in the oceans and Antarctica.

- **Should operations be turned over to private industry?** Critics have blamed NASA for the high cost of space access, but no one blamed the Navy logistical system for the high cost of getting people into and out of the U.S. science stations in Antarctica. Privatization is not the cure to the inherent high cost of operating in space and should not be recklessly adopted.

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- **Must we choose between inexpensive robotic probes and costly human explorers?** High technology allows remotely operated vehicles to carry out economical undersea exploration, yet human presence in the deep sea has not been made obsolete. Submersibles such as *Alvin* still carry scientists to examine deep-sea vents or to view the *Titanic* with their own eyes because there remain irreplaceable aspects of human presence on the frontiers of exploration, even when those frontiers are hostile and expensive. Advanced probe technology similarly supports space exploration: remotely operated vehicles economically conduct space science, from the interplanetary *Voyagers* to the Mars rovers. And yet no probe can completely replace the multifaceted perception, problem-solving ability, and ability to inspire that human explorers offer. In space, as in the seas, exploration will be approached best with a combination of robot and human explorers, using robots for work they can carry out and reserving humans for exploration missions for which they are uniquely suited.

- **Should we stage long-distance exploration from bases on the Hostile Frontier?** A lunar base has been suggested as a staging point for planetary exploration, but we don't stage major oceanic expeditions from undersea habitats when home harbors provide infinitely more advantage. Specialized Hostile Frontier habitats, cramped like submarines, are destinations, not stepping-stones. It will always be easier to do as much work as possible on Earth before setting out into space. Apollo demonstrated that orbital rendezvous operations performed to enable exploration beyond low Earth orbit do not require a space station as a staging point.

- **Should we construct our specialized habitats at home or in the Hostile Frontier?** Anything is cheaper to build back home than on a Hostile Frontier. The U.S. Navy Sealabs were constructed in dry-dock, where all expenses were lower and logistics easier. By contrast we are assembling the ISS in space. This mode maximizes logistical expenses and compromises design. The Skylab space station illustrates the advantages of the Sealab approach and the correct paradigm. Skylab was built like a Sealab, on Earth in "dry-dock," and launched pre-assembled at a fraction of the cost of the ISS. Skylab's integral design was so much more efficient that it gave its crews a higher per-capita ratio of productive work hours than does ISS, which requires that crew members spend most of their time on maintenance.

Space policy must stand or fall on what the Hostile Frontier really offers. Space advocates should not be beaten down by critics into offering false promises of the benefits of exploring the space frontier. Setting expectations based on the illusion of the New West paradigm causes Congressional and pubic disappointment and harms the stability of the U.S. commitment to space. Instead, space advocates should learn to argue on the basis of what space really does offer, be bold enough to make that case, and be skilled enough to make it well.

Space is a Hostile Frontier. But like the undersea and Antarctic frontiers, space remains well worth our engagement, offering opportunities for fascinating science, engineering challenge, and adventure for the national spirit. It is worth substantial government investment to pursue all these aims. But we must have clear and appropriate expectations for the space frontier if we are to make rational and intelligent decisions about how to approach this frontier and best employ our national energies. ■

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UPCOMING EVENTS

AAS Meeting Schedule

June 29–30, 2004
***International Space Law Workshop**
Doubletree Paradise Valley Resort
Scottsdale, Arizona
www.astronautical.org

August 16–19, 2004
***AIAA/AAS Astrodynamics Specialist Conference and Exhibit**
Rhode Island Convention Center
Providence, Rhode Island
www.aiaa.org

November 16–17, 2004
AAS National Conference and 51st Annual Meeting
Pasadena Hilton
Pasadena, CA
www.astronautical.org

January 23–27, 2005
***AAS/AIAA Space Flight Mechanics Winter Meeting**
Copper Mountain Resort
Copper Mountain, Colorado
www.space-flight.org

February 2–6, 2005
28th Rocky Mountain Guidance and Control Conference
Beaver Run Resort and Conference Center
Breckenridge, Colorado
www.aas-rocky-mountain-section.org

March 29–30, 2005
43rd Goddard Memorial Symposium
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