NOVEMBER/DECEMBER 2004

SPACE TIMES

THE MAGAZINE OF THE AMERICAN ASTRONAUTICAL SOCIETY

ISSUE 6 | VOLUME 43

The Future of Space Exploration Awaits Us

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SPACE TIMES is published bimonthly by the American Astronautical Society, a professional non-profit society. *SPACE TIMES* is free to members of the AAS. Individual subscriptions can be ordered from the AAS Business Office.

PERIODICALS

SPACE TIMES, magazine of the AAS, bimonthly, volume 43, 2004—$80 domestic, $90 foreign
The Journal of the Astronautical Sciences, quarterly, volume 52, 2004—$155 domestic, $170 foreign
The publications listed above can be ordered from the AAS business office.

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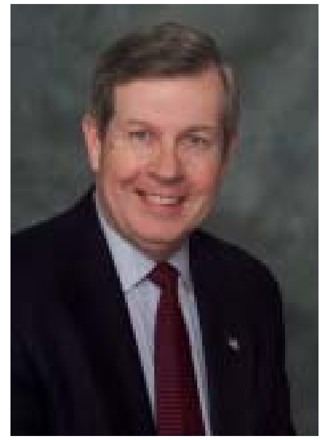
American Astronautical Society

6352 Rolling Mill Place, Suite 102
Springfield, VA 22152-2354 U.S.A.
Phone: 703-866-0020 Fax: 703-866-3526
aas@astronautical.org www.astronautical.org

President's Message



The birthday party is over, but we're still smiling. In 2004 the AAS celebrated its fiftieth birthday, and it's been an exciting year. It has been my privilege to serve as president through a year in which we can look back at some real highlights. First, there were some wonderful acknowledgements of our golden anniversary by our fellow professional organizations, including formal recognition by the Space Foundation at the National Space Symposium in Colorado and by the National Space Club at the annual Goddard Memorial Symposium in Washington. I was proud to stand up and acknowledge these salutes on behalf of our members and of all those whose vision in creating the AAS back in 1954 continues to bear fruit.

And what of these fruits? Our meetings in 2004 were well attended—selling out in fact—and we are again gaining not only in membership but also (most importantly) in relevance as a professional society. There may never have been a more important time for the AAS to provide a voice for the professionals, companies, and organizations committed to astronautics—the collective *we*. *We* are building and operating the space systems to support our brave warfighters in Iraq, Afghanistan, and worldwide. *We* are building and operating the operational environmental satellites that save lives and protect the property of our citizens. *We* are operating rovers and orbiters on and around Mars and dozens of robotic scientific and commercial satellites in near-Earth and deep space. *We* are working to return the space shuttle to safe flight and to keep the International Space Station operating so humankind can continue permanent habitation off the planet. And *we* are responding thoughtfully and professionally to the national vision for space exploration outlined by President Bush and debated throughout the year. Indeed, *we* of the AAS have had an exciting year and face some real challenges in the future.

Looking toward that future, the recently elected AAS volunteer officers and directors will not be standing still. I'm pleased to report two very significant developments which will be important to the society. First, through the leadership of our executive vice president, Mark Craig, and a dedicated team, we enter 2005 with a new AAS Strategic Plan and Implementation Plan. You'll be reading about the details of this important development in the next issue of *Space Times*. Also, on November 11 the AAS and the Students for the Exploration and Development of Space (SEDS-USA), an organization of undergraduate and graduate student chapters around the country (and affiliated with SEDS chapters in several nations), signed an MOU for mutual cooperation. This AAS-SEDS alignment will provide benefits to both groups, but for the AAS we will have a new and important opportunity to welcome into our professional society many more of the young professionals who will become part of that collective *we* who will be moving into the second half-century of the work of the AAS.

In closing the books on 2004, let me make one last request. If you're reading this and you're not yet a member of the AAS, please join us. If you are an AAS member, please come to our meetings and bring colleagues, submit papers to *The Journal of the Astronautical Sciences* and *Space Times*, and write to us at members@astronautical.org to let us know what you think, how we can serve you better, and how you'd like to get involved. The next fifty years have already begun. Where we are when we reach one hundred years of the space age depends on all of us today.

Jon Malay

ON THE COVER

Totality ends during the October 27 lunar eclipse as the Man in the Moon pokes his head back out into the sun's light. This seven-second exposure was taken at the prime focus of a Celestron twenty-eight-centimeter telescope using a Fuji FinePix S2 digital camera at 9:47 p.m. Mountain Standard Time. (Source: Jimmy Westlake)

From the Past to the Future: Core Challenges for Space Flight at the Turn of the New Millennium

Following the vision of a pioneering rocket scientist, the United States has spent some fifty years chasing increasingly ambitious goals in space. Progress over the next half century requires the nation to overcome some significant hurdles.

by Roger D. Launius

Introduction

On March 16, 1926, a reclusive Robert H. Goddard launched the world's first liquid-fueled rocket at Auburn, Massachusetts, which only traveled thirteen meters in two and a half seconds. This event could appropriately be characterized as the "Kitty Hawk" of space exploration and the beginning of what would eventually become one of the most significant endeavors of the twentieth century. In the years since, humanity has faced and overcome many challenges in space flight. We have journeyed outward with robot avatars as vanguards of humanity and have visited every planet of the solar system, save Pluto. Our astronauts have gone to the Moon and opened astounding possibilities for future settlement. For all of humanity's success, however, many of the challenges of the next half century in space mirror those wrestled with in the last fifty years. Using historical understanding as a departure point, I shall offer some comments on the possibilities available for the next fifty years in space flight.

The von Braun Paradigm

Much of what has passed for space policy since the beginning of the space age might best be characterized as political scientist Dwayne A. Day called it, the "von Braun paradigm," named for the handsome German émigré. Beginning in the 1950s Wernher von Braun called for an integrated space exploration plan centered on human movement beyond this planet and involved these basic ingredients accomplished in this order:

1. Deploy Earth orbital satellites to learn about the requirements for space technology that must operate in a hostile environment.
2. Conduct Earth orbital flights by humans to assess the possibility of exploring and settling other places.
3. Develop a reusable spacecraft for travel to and from Earth orbit, thereby extending the principles of atmospheric flight into space and making space operations routine.
4. Build a permanently inhabited space station as a place from which to observe the Earth and launch future expeditions.
5. Undertake human exploration of the Moon with the intention of creating Moon bases and eventually permanent colonies.
6. Undertake human expeditions to Mars and eventually colonize the planet.

Wernher von Braun (right), then chief of the guided missile development operations division at the Army Ballistic Missile Agency in Redstone Arsenal, Alabama, receives a visit from Walt Disney (left) in 1954. In the 1950s, von Braun worked as a technical director for three Disney television films about space exploration. Von Braun's integrated plan for exploring the solar system has energized American efforts in space since its conceptualization. (Source: NASA, photo no. GPN-2000-000060)

Von Braun espoused these ideas in a series of *Collier's* articles over a three-year period in the early 1950s, each with striking images by some of the best artists of the era, and later in a classic set of three Disney television programs. The von Braun paradigm has cast a long shadow over American efforts in space for over fifty years, conjuring powerful images of people venturing into the unknown to make a perfect society free from the boundaries found on Earth and representing a coherent and compelling definition of American ideals in space. In many respects von Braun's vision of space exploration served as the model for U.S. efforts in space through the end of the twentieth century.

NASA accepted this paradigm as the *raison d'être* of its programs beginning in 1959, and it doggedly stayed with it throughout the latter twentieth century. It drove the United States to develop the space shuttle as a means of achieving routine access and prompted an international consortium of nations to build a space station to achieve a permanent presence in space. Only through the achievement of these goals, space advocates insist, will a vision of space exploration that includes people venturing into the unknown ultimately be realized.

Kennedy's decision to race the Soviets to the Moon in the 1960s fundamentally altered the von Braun paradigm. Specifically because of Apollo, NASA lost the rationale for a space station, viewed by everyone both then and thereafter as critical for the long-term exploration and development of space. As soon as Apollo succeeded, however, NASA went back to the paradigm and has followed it to the present. The last element of the von Braun paradigm required human expeditions to Mars, something that is still very much on the agenda. Wernher von Braun envisioned huge armadas of what looked like V-2 rockets flying to Mars and a crew of more than one hundred staying on the surface for more than a year. While NASA has not done that, and will not do so anytime soon, preparations have been underway for a long time using robotic spacecraft.

President John F. Kennedy delivers his historic message to a joint session of Congress, on May 25, 1961, declaring that "this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth." Shown in the background are Vice President Lyndon Johnson (left) and Speaker of the House Sam T. Rayburn (right). Does the United States still have the political will to engage in bold space exploration ventures? (Source: NASA, photo no. GPN-2000-001658)

Core Challenges for the Future

While other analysts might differ with my list, I would suggest that there are five core challenges for those engaged in space flight in the twenty-first century, and they are either directly related or a logical follow-on to twentieth-century challenges. Each may be traced far back in the history of the space age, and all have served as perennial issues affecting all outcomes involving an expansive future beyond this planet.

Challenge #1: Finding the political will to support an aggressive space flight program. At a fundamental level, it is the most critical challenge facing those who wish to venture into space in the coming century. It is even more significant than the technological issues that also present serious challenges. Since most space activities—and virtually all of the large ones—have been sponsored by governments, policymakers must first agree that the expenditure of funds for exploration is in the best interest of the nation. Without political will, discovery and exploration cannot take place.

An expansive program of space exploration rarely has been consistent with many of the elements of political reality in the United States since the 1960s—especially given the high cost of such an endeavor. Numerous questions now abound—particularly in light of President Bush's promulgation of a space exploration policy—concerning the need for aggressive exploration of the solar system and the desirability of colonization on other worlds. A vision of aggressive space exploration, wrote Dwayne Day,

> implies that a long-range human space plan is necessary for the nation without justifying that belief. Political decision makers have rarely agreed with the view that a long-range plan for the human exploration of space is as necessary as, say, a long-range plan for attacking poverty or developing a strategic deterrent. Space is not viewed by many politicians as a "problem" but as at best an opportunity and at worst a luxury.

Of course, there are visions of space flight less ambitious than the von Braun paradigm. Aimed at incremental advances, these include robotic planetary exploration and even limited human space activities. Most of what is

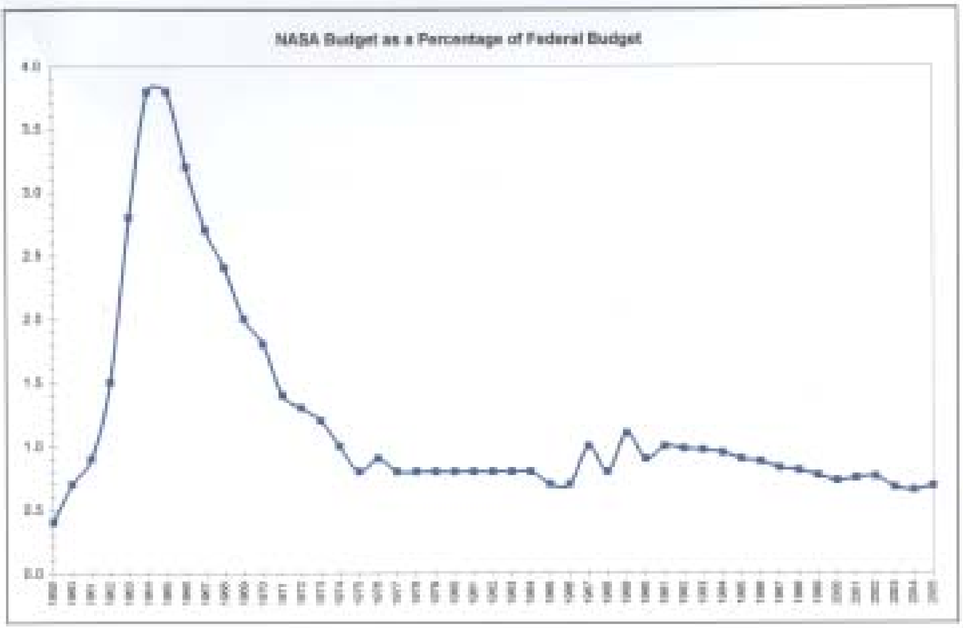


Figure 1. NASA budget as a percentage of the federal budget, 1959-2005.

presently underway under the umbrella of NASA in the United States and the other space agencies of the world falls into this category. Yet, these only moderately ambitious space efforts also raise important questions about public policy priorities and other fiscal responsibilities. At present the NASA budget stands at only about three-quarters of one percent of the federal budget. As shown in Figure 1, with the exception of a few years in the mid-1960s as NASA prepared for Apollo flights to the Moon, stability has been the norm as the annual NASA budget has incrementally gone up or down in relation to a one-percent benchmark in the federal budget.

Challenge #2: Developing multifaceted, inexpensive, safe, reliable, and flexible access to space. Pioneers of space flight believed that humans could make space travel safe and inexpensive. They gained confidence by watching aeronautical engineers develop jetliners that moved people through the air within forty years of the Wright brothers' first flight. Despite years of effort, however, the dream of cheap and easy space access has not been attained. Costs remain particularly high.

Since the beginning of space flight more than forty years ago, those who have sought to travel into space have been, in essence, "between a rocket and a hard place." The enormous release of energy made possible through the development of chemical rocket technology allowed the first generation of launch vehicles to free humanity and its robots from the constraints of Earth's gravity. It allowed the still exceptionally limited exploitation of space technology for all manner of activities important on Earth—communications, weather, global positioning and navigation, and a host of other remote sensing satellites—to such an extent that many individuals in the United States today cannot conceive of a world in which they did not exist. This same chemical rocket technology made possible human flight into space, albeit for an extremely limited number of exceptional people, and the visiting of robotic probes from this planet to our neighbors in the solar system.

These launch capabilities have been enormously significant, and overwhelmingly positive, developments. They have also been enormously expensive, as have been sustained efforts to reduce the cost of space flight. One concept is to use rocket propulsion and, with new materials and clever engineering, to make a launcher that is not only recoverable but also robust. Another concept is to use air-breathing launchers and thus employ the potentially large mass fractions that air breathing theoretically promises. There are other options still.

Most launch vehicle efforts throughout the history of the space age, unfortunately, have committed a fair measure of self-deception and wishful thinking. A large ambitious program is created, hyped, and then fails as a result of unrealistic management, especially with regard to technical risk. These typically have blurred what should be a bright line between revolutionary, high-risk/high-payoff research and development efforts and evolutionary, low-risk/marginal-payoff efforts to improve operational systems. Efforts to break the bonds of this deception may well lead in remarkable new directions in future launcher development efforts. Only once that happens will humanity be able to escape the netherworld "between a rocket and a hard place."

Challenge #3: Developing smart robots to explore the solar system. Humans can travel throughout the solar system in ways unimagined by the first pioneers: that is, by not physically going at all. Using the power of remote sensing, humans could establish on all the planets and their moons a virtual presence through which those of us on Earth could experience these sites without leaving the comfort of our homes. Humans might not progress naturally toward the colonization of Mars in this scenario, with extensive exploration by robotic machinery taking place. As a result, the human dimension of space flight could take on a less critical aspect than envisioned by most space flight advocates.

One of the unique surprises of the space age that opened with Sputnik in 1957 has been the rapid advance in electronics and robotics that made large-scale space flight technology without humans not only practicable but also desirable. This has led to a central debate in the field over the role of humans in space flight. The president's vision for space exploration announced on January 14, 2004, recognizes the significance of robotic exploration to pave the way for future human efforts. Indeed, more may be accomplished in the short run without human presence in these expansive space exploration missions. Clearly, if scientific understanding or space-based applications or military purposes are driving space flight as a whole, then humans flying aboard spacecraft have little appeal. Their presence makes the effort much more expensive because once a person is placed aboard a spacecraft, the primary purpose of that spacecraft is no longer a mission other than bringing the person home safely. But if the goal is human colonization of the solar system, then there are important reasons to foster human space flight technology.

This debate has raged for decades without resolution. It is reaching crescendo proportions in the first decade of the twenty-first century as the International Space Station (ISS) is coming online and discussions of future efforts beyond the station emerge from the public policy nether land. Scientist Paul Spudis observed in *Scientific American* in 1999: “Judicious use of robots and unmanned spacecraft can reduce the risk and increase the effectiveness of planetary exploration. But robots will never be replacements for people. Some scientists believe that artificial intelligence software may enhance the capabilities of unmanned probes, but so far those capabilities fall far short of what is required for even the most rudimentary forms of field study.” Spudis finds that both human and robotic explorers will be necessary. “The strengths of each partner make up for the other’s weaknesses,” he writes. “To use only one technique is to deprive ourselves of the best of both worlds: the intelligence and flexibility of human participation and the beneficial use of robotic assistance.”

Challenge #4: Protecting this planet and its species. The twenty-first century may well prove to be the most difficult for humanity since the Renaissance. During this century humans will face three great environmental challenges: overpopulation, depletion of resources (particularly fossil fuels), and environmental degradation. Without space-based resources—especially remote sensing satellites that monitor Earth—humans will not be able to control these trends.

Humans can use space as a place from which to monitor the health of Earth, maximize natural resources, and spot polluters. By joining space with activities on the ground, humans have a fighting chance to protect the environment in which they live. Using space to protect Earth will be as important to twenty-first century history as Moon landings were to the twentieth. At the same time, humans will confront the consequences of environmental degradation in space. Orbital debris, derelict spacecraft, and satellites reentering the atmosphere have already created hazards around Earth. Proposals to strip mine the Moon and asteroids make many people blanch: how dare humanity, having fouled the Earth, destroy the pristine quality of extraterrestrial bodies? The environmental movement will expand into space.

All of these issues–the use of space for monitoring Earth, environmental degradation in space, and biological contamination–promise to create a new perspective on space exploration. As a result, humans in the twenty-first century will witness the greening of space.

Challenge #5: Sustaining human exploration and development of space. As an early step, the creation of a permanently occupied space station, something that has long been a critical component in space architecture, is presently underway. In the post-Cold War era, the United States, the former Soviet Union, and several other nations have joined to realize the long-held vision of a space station in Earth orbit. This relationship made the ISS a reality in 2000 when the first crew set up residence aboard the craft. With this accomplishment, the spacefaring nations of the world intend that no future generation will ever know a time when there is not some human presence in space.

The air-breathing, hypersonic X-43C, part of NASA’s Hyper-X series of flight demonstrators and shown in this artist’s rendering, is expected to accelerate to a maximum potential speed of more than 8000 kilometers per hour and could undergo flight testing as early as the year 2008. Will it revolutionize the way we gain access to space, or will it be another stillborn program similar to the National Aerospace Plane and X-33? One thing is certain: without access to space, America will be unable to explore anything beyond. (Source: NASA, photo no. X-43-0202010)

Of course, there are people in the United States, including some high officials, who would seek to prematurely disentangle the nation from its involvement in the ISS. Thinking that the station may not provide the payoff that was originally envisioned, they would foolishly "cut and run" from the endeavor before its potential is even fully fathomed. It is important for the United States to remain a firm partner in the ISS and use it as an integral part of a long-term strategy for exploration.

Fulfilling the Paradigm

Using the space station as a base camp, humanity may well be able to return to the Moon and establish a permanent human presence there. It is no longer hard to get there: all of the technology is available to land and return. Such an endeavor requires only a modest investment, and the results may well be astounding. Why return to the Moon? This is a critical question, especially since humans have already "been there, done that." There are six compelling reasons:

1. It is only three days' travel time from Earth, as opposed to the distance to Mars of nearly a year's travel time, allowing greater safety for those involved.
2. It offers an ideal test bed for technologies and systems required for more extensive space exploration.
3. It provides an excellent base for astronomy, geology, and other sciences, enabling the creation of critical building blocks in the knowledge necessary to go farther.
4. It extends the knowledge gained with the space station in peaceful international cooperation in space and fosters stimulation of high-technology capabilities for all nations involved.
5. It furthers development of low-cost energy and other technologies that will have use not only on the Moon but also on Earth.
6. It provides a base for nuclear weapons that could be used to destroy near-Earth asteroids and other threats to Earth.

From the Moon, the last step in the von Braun paradigm is a human mission to Mars, but the task is awesome. A majority of Americans does not support human missions to Mars and never has. Consistently, only about 40 percent of those polled have supported human missions to Mars, as shown in Figure 2. In that climate there is little political justification to support an effort to conquer Mars.

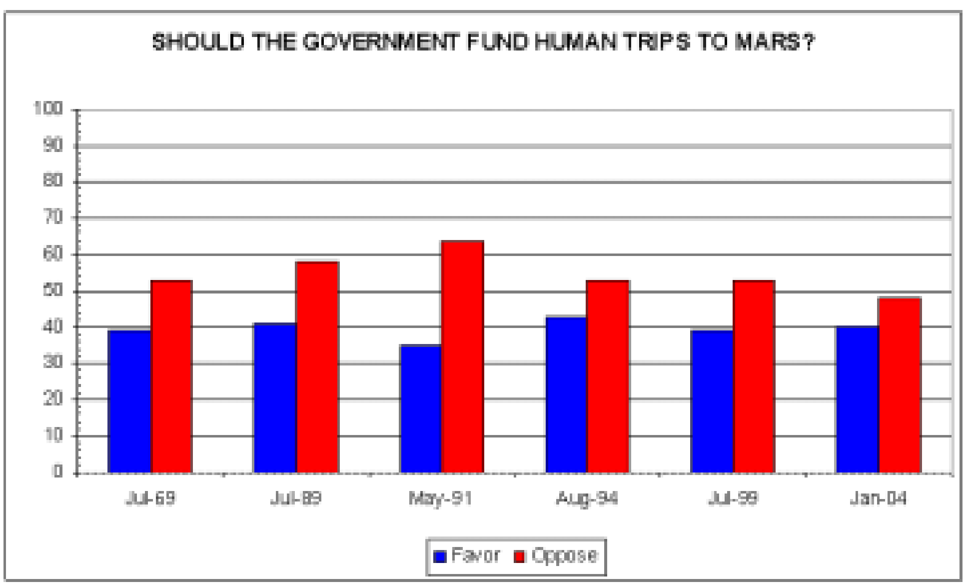


Figure 2. Percentages of people in favor of and opposed to U.S. government-supported human trips to Mars. Data reflect the results of multiple polls, all of which asked people for their opinions on the subject using slightly different wording.

Of course, the United States could send human expeditions to Mars. There is nothing magical about it, and a national mobilization to do so could be successful. But a human Mars landing would require a decision to accept enormous risk for a bold effort and to expend considerable funds in its accomplishment for a long period. Using Apollo as a model, addressed as it was to a very specific political crisis relating to U.S./Soviet competition, anyone seeking a decision to mount a human expedition to Mars must ask a critical question: To what political, military, social, economic, or cultural challenge, scenario, or emergency would the best response be a national commitment on the part of the president and other elected officials to send humans to Mars? In addition, with significantly more failures than successes, and half of the eight probes of the 1990s ending in failure, any mission to Mars is at least an order of magnitude greater in complexity, risk, and cost than returning to the Moon. Absent a major surprise that would change the space policy and political landscapes, I doubt we will land humans on Mars before the mid-twenty-first century.

Conclusion

Since the dawn of the space age, humanity has developed the capability to move outward in a third great age of discovery and exploration. In so doing it has followed with rare deviations a set of stepping stones aiming toward a permanent presence in Earth orbit, on the Moon, and at Mars. In the process much has been accomplished, some tragedies have occurred, and several challenges remain.

Who knows what transforming discoveries will be made in the first part of the twenty-first century that will alter the course of the future? Humans may well discover extraterrestrial life, or detect an Earth-like planet around a nearby star, or discover some heretofore unknown principle of physics. Virtually any forecasts made are possible, but none are guaranteed. Only one feature of space exploration is inevitable: something unexpected will occur. Space is full of achievements, disappointments, and surprises. By going into space, humans learn what they do not know. Properly conducted, this effort may foster a hopeful future. ■

Roger D. Launius **is the chair of the space history department at the Smithsonian Institution's National Air and Space Museum. He is former editor of *Space Times*.**

Two explorers on Mars stop to inspect a robotic lander and its small rover in this artist's conception. This stop also allows the crew to check out the life support systems of their rover and space suits within walking distance of the base. Will this scene become reality in the first half of the twenty-first century? (Source: NASA, photo no. S95-01408)

28th Annual AAS Guidance and Control Conference

Feb 5-9, 2005
Breckenridge, Colorado

The 28th annual AAS Guidance and Control (G&C) Conference will be held at the Beaver Run Resort in Breckenridge, Colorado, February 5-9, 2005. We have worked hard to put together another exciting and educational program for this year's conference. In addition to the traditional conference sessions of **"G&C Advances"** and **"Recent Experiences,"** we will be presenting **"Robotic Exploration," "NASA's New Vision and the Next-Generation Challenges in GN&C,"** and **"When things Go Bump"** (about single-event effects). To increase technical content, we have also added a special tutorial session titled **"University Work on Precision Pointing and Geolocation Technology Enhancement."** Further details are at http://www.aas-rocky-mountain-section.org.

Our traditional G&C Storyboards session is re-titled as **"Technical Exhibits"** and will include hands-on demonstrations of state-of-the-art simulation, analysis, and visualization tools available to GN&C engineers. As usual, this will provide attendees the unique opportunity for one-on-one interaction with industry, national laboratory, and academia representatives and will provide exposure to state-of-the-art guidance and control technology. This is accomplished in a setting unique to our conference and is traditionally attended by all conference attendees. **Family members and significant others are welcome to participate!** The conference will open with the Saturday evening banquet, including a nationally known speaker that is sure to entertain all.

Come join us in the Colorado Rockies for four days of learning from world leaders in Guidance and Control. The exciting atmosphere, state-of-the-art technical innovation, and lessons-learned make it an exceptional experience. The conference format blends world-class technical presentations with ample time for recreation, family and group activities, and social gatherings in an authentic mountain community. The conference offers special discounts on lodging, ski tickets, ski lessons, and rental equipment, so be prepared for an experience that will keep you coming back year after year.

For more information, please contact Bill Frazier or Lis Garrat:

Bill Frazier, Conference Chairperson, Ball Aerospace
Phone: 303-939-4986; Email: wfrazier@ball.com

Lis Garrat, Conference Coordinator, Ball Aerospace
Phone: 303-939-6916; Email: lgarrat@ball.com

For early conference registration and to reserve lodging for the conference, please visit our website.

Prospective authors: please contact one of the session chairpersons for information.

The Legal Environment for Space Tourism in the United States

SpaceShipOne's successful flights proved that the technology to support passenger space flights is not just the stuff of science fiction. A clear legal regime, however, is equally critical for space tourism to evolve into a viable industry.

by Howard Trace

Space exploration finds itself at a crossroads. Until recently, only governments have had the capacity to send humans beyond Earth's atmosphere, but all that has changed. In October, Scaled Composites claimed the Ansari X Prize and proved that private enterprise has the ability to create sub-orbital transportation. The next step is orbital flights, and that is a big step. Before that can occur in the United States, the nation's leaders must examine and define its legal regime for private human spaceflight—or risk missing out on the economic benefits this nascent industry has the potential to yield.

Although the U.S. government issued licenses to X Prize participants, these licenses only covered experimental testing and the launch of non-human cargo. In order to compete in the global space market, the United States needs to be proactive in handling private human space flight. The fact that there is no U.S. legal framework for private human space flight could influence the development of the industry.

Three specific issues are at the heart of this discussion. Liability represents the single most important problem that needs to be overcome because of the potential financial influence. Two other issues, regulation and jurisdiction, are interrelated but important in their own rights. How the United States chooses to cope with these issues could potentially impact the future of human tourists in space for generations.

The White Knight *turbojet aircraft climbs over the Mojave Desert with* SpaceShipOne*, the first private, piloted vehicle to reach an altitude of over one hundred kilometers. (Source: Scaled Composites, LLC)*

The Need for a Legal Regime

Several international treaties and principles impact the privatization of human space flight. U.S. participation in these agreements imparts certain responsibilities on the U.S. government in its handling of private human space flight.

The most important international document of space law is the 1967 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, also known as the Outer Space Treaty. Article VI of this treaty outlines the responsibility of nations for all launch activity: "States Parties to the Treaty shall bear international responsibility for national activities in outer space…whether such activities are carried on by governmental agencies or by non-governmental entities….The activities of non-governmental entities in outer space…shall require authorization and continuing supervision by the appropriate State Party to the Treaty." The responsibility that nations bear in outer space activities was clarified further in the 1972 *Convention on International Liability for Damage Caused by Space Objects*, also known as the Liability Convention:

"A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft flight." Under international law, nations bear liability for outer space activities; it is left up to nations to decide whether to develop municipal laws to require that the parties conducting the launch share liability. The Commercial Space Launch Act of 1984 and subsequent amendments to this legislation is the U.S. municipal law that addresses how the U.S. government shares launch liability with launching parties within its borders and with U.S. entities launching abroad.

During the early 1980s, the United States was embroiled in a debate over how to handle rocket launches. NASA was able to make the case for the U.S. government to adopt a "one shuttle" launch policy, which required all U.S. civil, military, and commercial payloads to launch on the space shuttle. The military quickly realized that the shuttle would not be able to handle the workload of all U.S. launches and pushed for the reinstatement of expendable launch vehicles, which had achieved their past launch needs. At the same time, President Ronald Reagan began advocating a commercial rocket launching capability for the United States.

The commercial aspirations of the president were realized in the Commercial Space Launch Act of 1984. This law had the effect of codifying how the United States would handle commercial outer space activities, establishing an Office of Commercial Space Transportation in the Department of Transportation to regulate commercial launches. However, this legislation did not address private or commercial human space flight. In fact, Title 14 of the Code of Federal Regulations originally stated that the Office of Commercial Space Transportation would conduct "evaluation of license requests for *unmanned* launches." The act was amended in 1988 and 1998, removing the word "unmanned" from the Code of Federal Regulations, but Congress did not take the next step to address the particular concerns of human space flight.

One of the benefits of opening space travel to the public is that passengers will be able to view Earth as they have never seen it before. In this artist's conception, space tourists get a glimpse of a magnificent storm brewing over an ocean. (Source: Alessandro Gattuso)

While human space flight is currently in the process of privatization, it already has been commercialized. That is, passengers have paid for trips into space aboard state-owned rockets. The first commercial flight was sold by the Soviet Union and occurred in December of 1990 when Toyohiro Akiyama of the Tokyo Broadcasting System paid $11 million to spend a week aboard the *Mir* space station. Over a decade later the Russian Space Agency took two more paying passengers into space. In April of 2001, American Dennis Tito paid $20 million for a flight aboard a Soyuz spacecraft to the International Space Station (ISS) for a six-day stay; one year later, South African Mark Shuttleworth took a similar flight. These trips were accomplished through the U.S. firm Space Adventures.

Getting Tito and Shuttleworth to the ISS was difficult because flying non-professional astronauts aboard the ISS required an agreement by NASA and the other international partners. Tito's flight was a focusing event that allowed the ISS partners the opportunity to create guidelines for future paying visitors to the ISS.

The impact that paying passengers can have on the future of human space flight can easily be seen in the numbers: the budget of Russia's space program is only around $150 million per year, so a tourist flight can augment that budget by more than ten percent. If the ultra-rich can help subsidize an entire country's space program, it would seem that people interested in shorter, suborbital flights would be able to have a similar impact on the emerging private industry. Space Adventures is already booking suborbital flights, believing that the company will be able to offer flights beginning in 2006.

These flights, however, will not be taking place from the United States but from Russia. Without a clear regime of liability, regulation, and jurisdiction by the U.S. government, the future of private human space flight remains unclear. A look at the current status of these issues nonetheless reveals that regulated private human space flight could be a distinct possibility.

Liability

One of the most critical issues regarding private human space flight is directly related to the possibility of liability claims for those flights. Liability covers a number of areas, including third-party liability, passenger liability, and the government's liability under the Outer Space Treaty regime; a related issue concerns how the insurance industry could react to liability claims. These interrelated types and issues of liability pose a significant obstacle to the possible expansion of human space flight to the private sector. The success of private industry will depend upon a flexible legal regime associated with all aspects of liability in human space flight.

Liability must be considered because it directly relates to the international responsibilities of the United States, which is ultimately responsible under the 1972 Liability Convention for all launches that it conducts or that occur from its territory. This means that the U.S. government would bear the burden under the Convention of any space-related accident incurred by a private or commercial entity without some provision for that entity to share in this burden.

The United States has made provisions in its municipal laws to account for this situation. Federal law transfers liability to private launch entities, requiring those seeking commercial launch licenses to secure insurance or otherwise demonstrate that they have adequate financial resources to cover a launch accident affecting third parties or government property. The maximum liability insurance coverage required under U.S. law is $500 million for third-party claims and $100 million for U.S. government property damage. This provision only partially protects the government: the law states that the government will pay the difference on any claim that exceeds the amount of insurance required, up to $1.5 billion.

The U.S. government has protected itself from undue financial burden should a liability claim be filed under the Liability Convention, but how might this need change with the privatization of human space flight? Government liability and claims would be covered by the current liability regime. However, third party and passenger claims will likely need attention.

> If the ultra-rich can help subsidize an entire country's space program, it would seem that people interested in shorter, suborbital flights would be able to have a similar impact on the emerging private industry.

Since the dawn of space flight there has never been a third party injury in the United States due to a commercial launch. With no third party claims for the space launch industry, it seems unlikely that there would be a need to significantly increase the liability requirements that are currently in place for unmanned vehicles. However, getting the space tourism market to become cost effective will require many more launches than current unmanned industries. A study by Boeing found that development of a commercial orbital vehicle would cost $16 billion and would have to conduct flights with fifty passengers eight hundred times per year for three years at a cost of $150,000 per ticket to break even. If these estimates prove true, the costs associated with obtaining liability insurance of more than half a billion dollars for each launch to cover third-party and government claims would prove insurmountable for the burgeoning industry.

Passenger claims also will need to be considered. Current U.S. laws are silent on liability for passenger claims. Two definitions have emerged for those people who would pay for a ride on an orbital or suborbital space flight. The first considers them to be thrill seekers who understand the risks involved in what they are undertaking. The second looks at them in a fashion similar to people who purchase a ticket for an airline: they believe there is an ordinariness to the flight that affords them a fair amount of safety. The first view has emerged as the primary way people who purchase a ticket on a private space flight will be treated, at least in the near future. In order to define their involvement, the term "space flight participant" is used, as opposed to the term "passenger," which to some implies an understanding of safety that space flight cannot yet provide. How the government and insurance industry cover liability of space flight participants will have a profound effect on private space flight of humans. If participants are unable to obtain insurance for themselves, the number of people willing to pay thousands or even millions of dollars to fly into space will be significantly reduced.

Liability could prove to be a very heavy burden on private human space flight. The way these flights will likely differ from traditional unmanned flights is in the frequency that will be required in order to sustain the industry. It may prove impossible to hold private human flights to the same liability standards as unmanned flights. Establishing liability insurance requirements is only the first step in establishing a legal regime that will allow this new market to flourish. A system of regulations must be developed and administered under an agency that can effectively reduce the risk of losses and assure the safety of space flight participants and third parties.

Regulation and Jurisdiction

While a stable, clear regulatory regime is critical to the success of private human space flight entrepreneurs, regulation also has proven to be one of the most daunting aspects for operation of private and commercial space flights in the United States. From launch to reentry to environmental impact, an almost insurmountable amount of preparation is required for a launch in the United States or by a U.S. entity abroad. Examining the current state of commercial space transportation regulation will show the impracticality of the current system for private space flights involving humans.

How much regulation is necessary? The section of the Code of Federal Regulations dealing with launch licenses has almost forty parts not including regulations on launch sites or reentry. Regulations need to ensure public safety but not at the expense of overburdening either the applicants or the agency that carries out the regulation. The Commercial Space Launch Act of 1984 established the Office of Commercial Space Transportation within the Department of Transportation as the agency responsible for issuing licenses for commercial launches, including suborbital rockets. Congress extended this authority in 1988 to include reentries of reusable launch vehicles. In 1995 this office became known as the Office of the Associate Administration for Commercial Space Transportation (AST) when it was transferred to the Federal Aviation Administration (FAA), which has much more than space flight to worry about. Current commercial launch licensing requirements require years of preparation and millions of dollars to complete. Perhaps a less involved regulatory and liability regime, like the one in Russia, could serve U.S. human space flight entrepreneurs better.

For a launch in Russia, only proof of insurance and governmental notification are required for operations. Russian law also states that the Russian Federation retains jurisdiction over any manned space flight registered in its territory, including anyone trained in Russia or onboard a Russian spacecraft, unless otherwise specified by international treaty. The least that the United States needs to do in regard to human space flight is to codify the obligations of jurisdiction set forth in international law. This would ensure that launches from the United States are handled under U.S. law and would help prevent international disputes regarding jurisdiction. Being one of only three countries with the capability to send humans into space, the United States needs to address not only its international responsibilities but also the protection of its citizens and an industry that could significantly increase U.S. technological prestige. Clearly there are simple models upon which to work, but a balance must be attained so that the creation of an easier licensing regime does not compromise safety of passengers or third parties.

A second regulatory issue is how private launchers will be categorized and whether they will continue to fall within the realm of licensing or whether they will need to be moved into a process of certification similar to what is done for aircraft. At least for the time being, suborbital launchers will continue to be categorized as rockets subject to licensing and not certification. Although current AST regulations appear to favor not subjecting suborbital launch vehicles to the same certification process that is required for airplanes, at least in the near term, some believe that AST is not the proper place for some types of space vehicles to be regulated. There have been discussions within FAA, Congress, and the industry concerning the possibility of transferring responsibility for private human space flight to the FAA Associate Administrator for Regulation and Certification, which has more experience with dealing with flight safety issues.

FAA Administrator Marion Blakey presents a plaque to Burt Rutan (left) and Paul Allen (center) in recognition of their X Prize competition victory. Currently responsible for regulating non-human U.S. commercial launches, the FAA is likely to be the designated authority to oversee private human launches if and when legislation in support of commercial human space flight is signed into law. (Source: Jeff Foust)

Political will is at the crux of a legal and regulatory regime for private human space flight. Legislation that would provide this framework has passed Congress and awaits President Bush's approval. (Source: Washington, D.C., Convention and Tourism Corporation)

Commercial and private launch companies endured a long struggle concerning who would be responsible for regulating this sector of U.S. space commerce. Before the Commercial Space Launch Act, the Departments of Commerce and Transportation competed for this responsibility, and even after being given the task, the Department of Transportation eventually moved commercial space activities to the FAA. As private entities approach the threshold of offering space flights, either orbital or suborbital, to those with the financial wherewithal to afford a flight, there could be a need to again evaluate which agency is best suited to regulate, license, and possibly certify these vehicles as being safe to fly.

If it does nothing else, the United States must establish that it has authority to regulate private human space flight—launch, reentry, and in-orbit operations alike—and it must empower a specific agency to enforce those regulations while ensuring that the regulation is not overly burdensome.

Conclusion

Establishing a legal regime for private human space flight is a complicated issue that impacts the launch providers who are attempting to create the technology and vehicles that will carry Americans to the edge of, or even into, outer space. The U.S. government is also directly involved in this issue because of its ratification of international treaties that relate to space flight. The 1967 Outer Space Treaty and the 1972 Liability Convention make the U.S. government directly responsible for all launches from its territory. This responsibility carries with it the obligation to regulate the launches that are undertaken by non-governmental entities. The X Prize spurred private and commercial ventures to seriously investigate human space flight. At the time of publication, current U.S. municipal law is lacking in regulating these endeavors; at time you are reading this article, however, this shortcoming may have already been remedied.

Just before adjourning for the year, the Senate approved the Commercial Space Launch Amendments Act of 2004 (House Resolution 5382). This legislation, which already had been approved by the House and has been sent to President Bush for signature into law, would give AST the authority to license private suborbital human space flights carrying passengers and also make it easier for companies to flight-test experimental vehicles. Reflecting a long struggle to satisfy concerns in both houses of Congress, the bill attempts to achieve a balance between protecting passengers-to-be and addressing the needs of human space flight entrepreneurs to experiment with new technology. The legislation maintains the government's commitment to protecting third parties from private suborbital human space flight activities.

Every effort needs to be made by the U.S. government to protect its citizens from the devastation that could accompany a major launch or reentry accident. However, this industry must be given every opportunity to flourish. The debate over the imperative of human exploration of space has persisted since before a human was even launched on a rocket. Humans, by nature, are curious creatures, and we will go into space unless a cataclysmic event denies our opportunity to advance into the solar system and beyond. While pundits will continue to debate the role of government in human exploration of space, humans will continue to explore space, and governments should not stand in the way of private endeavors.

Commercial efforts in space exploration have proven lucrative in the telecommunications field, and there is every reason to believe that other space industries can prove to be equally successful. The United States has the opportunity to codify a climate of encouragement for the grand venture of private human space flight. If the government takes the appropriate actions, the nation can stay in step with current technological developments. ■

***Howard Trace* is a librarian working in Indianapolis and a student in the University of North Dakota Space Studies program.**

The Far Future of Astronomy from Space

Hubble, Chandra, and Spitzer have dramatically advanced scientific understanding of the cosmos when compared with their telescopic predecessors, but they are just the start of a long line of space-based telescopes that are certain to revolutionize astronomy in the decades ahead.

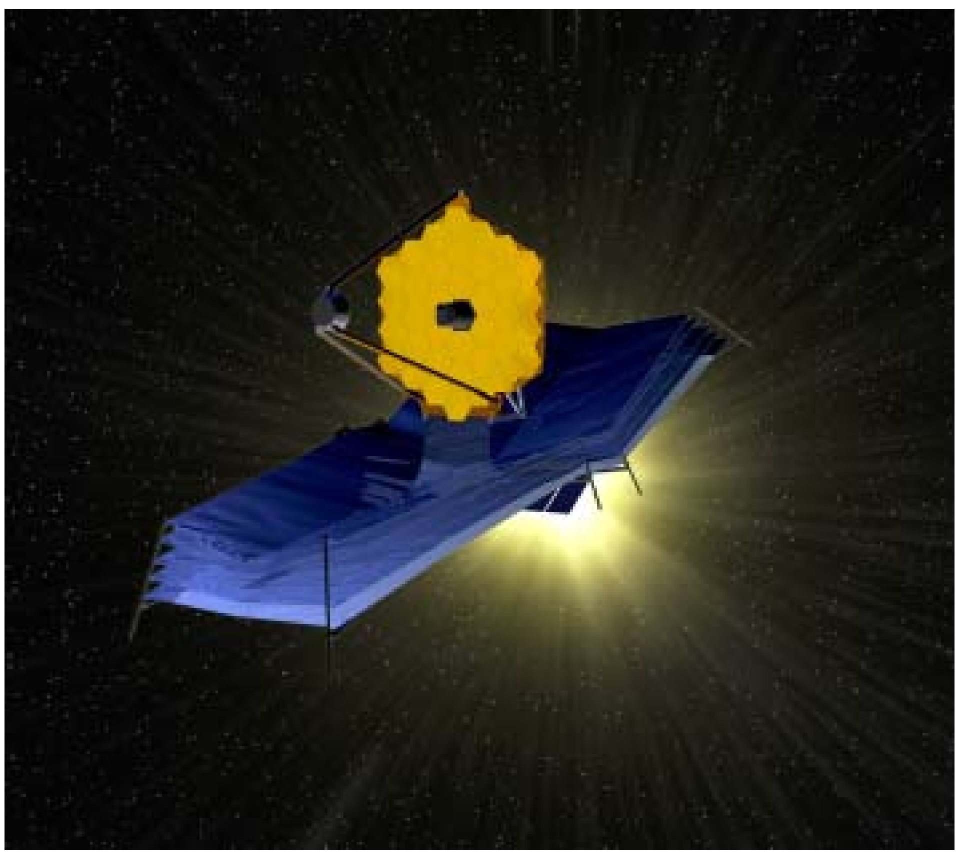
by Bruce Dorminey

Imagine a cosmic utopia where a gung ho attitude would be enough to implement long-term space policy; where the Hubble Space Telescope would always find funding, and those working on its ambitious successor would never have to justify the size of its mirror or the selection of a launch vehicle. In the blink of a visionary's eye, languorous feasibility studies, politics, and budget cuts would cease to exist. Then imagine the possibilities: a space-based science reserve chock full of observatories at the Earth-Sun L2 libration point, thousands of interferometrically-linked optical telescopes beyond the orbit of Jupiter, and kilometer-square solar sails doubling as low-frequency radio arrays at the very edge of our solar system.

Reality is altogether different. Yet despite political apathy, funding battles, and technological hurdles, the majority of space-based astronomical initiatives pay off handsomely, even if their significance is sometimes lost on John Q. Public. In its defense, the public is subjected to an almost constant media barrage about what's new, better, and different with each new observatory. It's enough to leave all but the most avid followers of astronomical technology scratching their heads. Judging from any given claim, telescopes appear to become obsolete almost as fast as cell phones. So, even if we are fortunate enough to lurch from one technological marvel to the next, what would ultimately satisfy the scientifically curious? We know that both ground- and lunar-based astronomy have viable futures, but what is ultimately to be gained from future grand space-based observatories—be they robotic or manned? And where would they best be positioned?

In space-based astronomy's forty-year history, there have been as many incremental steps as giant leaps. We have gone from NASA's Orbiting Astronomical Observatory, which failed a day after its launch in 1966, to an era of NASA's four great observatories, three of which—Chandra, Hubble, and Spitzer—are still in operation. Even so, the quest to mitigate the effects of Earth's atmosphere and search out optimal seeing conditions in the infrared, ultraviolet, x-ray, gamma-ray and low-frequency radio spectra by taking observations to space has always been fraught with high costs and technological risk.

"Our advantage in space depends almost entirely on the technologies available," said Harley Thronson, assistant associate administrator for technology in the science mission directorate at NASA headquarters. "That, in turn,



Beginning in 2011, the James Webb Space Telescope, shown in this artist's conception, will be capable of looking back to the near-beginning of time. (Source: Northrop Grumman Space Technology) depends on how much money the public is wiling to put into that technology. The broader science community is relatively ineffective in lobbying for its science programs. We are only seven-tenths of a percent of the federal budget."

Bigger, Better Telescopes

NASA's next big foray into astronomy comes with the launch in 2011 of the six-meter, segmented, autonomously-deployed infrared and optical James Webb Space Telescope (JWST), through which astronomers hope to push back the look-back time to only two hundred million years after the Big Bang. About halfway through JWST's optimal ten-year mission life in 2015, NASA may launch the Single Aperture Far-Infrared (SAFIR) telescope, a ten-meter class observatory that would fill a wavelength gap between the JWST and the planned ground-based Atacama Large Millimeter Array in Chile. With its ability to view the high-red-shift universe in the far-infrared, where most of the energy from the early universe is actually emitted, SAFIR would potentially answer questions about how the first stars formed, how such clusters of stars were organized, and how early galaxies formed. SAFIR would also watch ongoing planetary formation within our own galaxy.

A technician mounts hardware on a mirror segment developed through a demonstration program for the James Webb Space Telescope. The telescope's primary mirror will consist of eighteen hexagonal beryllium segments that will span 6.5 meters when the telescope begins operations. (Source: Northrop Grumman Space Technology)

If NASA decides to send SAFIR to the Earth-Sun L2 libration point, where the Earth offers constant shielding from the Sun, that might conveniently combine NASA's stated exploration goals involving human space flight beyond low Earth orbit (LEO) with space science, if only because SAFIR would be too large to deploy autonomously. But there is already clamor for more aperture, particularly in the far-infrared, which would benefit from telescopes on scales of twenty- to thirty-meters that could be built in piecemeal fashion in LEO or at the Earth-Moon L1 libration point, a sweet spot two days out from Earth that NASA has been considering. L1 is risky for astronauts due to its unprotected exposure to solar flares and other cosmic radiation but ideal for both the construction of large optical telescopes and crew vehicles for exploration of the solar system.

"Space telescopes are not good investments unless the new system you're building is dramatically better than the one you're replacing," said Ed Friedman, technical fellow at The Boeing Company. "That means getting a tenfold increase in the collecting area of that next telescope. Everything is in place to build telescopes bigger than Webb and to show a scalable technical path to the future."

Humans in the Loop

But instead of using the tried and true method of autonomous deployment, Friedman and other innovative space astronomy advocates propose using NASA's extensive extravehicular activity (EVA) experience with the Hubble servicing missions as a jumping-off point for the construction of thirty- to fifty- meter segmented optical telescopes in LEO. In 1992, in a simulated underwater EVA at NASA's Langley Research Center in Virginia, astronauts took only six hours to put together a thirty-six-panel, fourteen-meter reflector telescope on a truss-type platform.

Among other things, assembly in LEO or at L1 would enable just-in-time delivery of instruments and would offer testing in the actual environment before the observatory would be packed up and transferred for deployment at L2. The logical construction site today would seem to be the International Space Station (ISS), as it was initially designed to handle telescope construction. But the ISS's design structure changed before construction, and today it is plagued by a cloud of orbiting debris. In the words of Mark Lake, chief engineer at Composite Technology Development in Colorado, building a telescope at the ISS would be like "working in a septic tank" and would definitely cause major problems for an observatory's optical systems.

Astronaut servicing of the Hubble Space Telescope has been integral to the spacecraft's continued good health and state-of-the-art scientific capabilities. Will humans have a role in deploying and upgrading future space telescopes? (Source: NASA)

One way around this problem would simply be to install a self-managed, self-contained observatory construction facility with a large sunshade, either within close proximity to the ISS or in a different orbit altogether. It would house five or six astronauts at a time that would arrive to assemble the observatory once the parts were in place and stay for up to two weeks.

"The assembly option lets you lift the telescope in pieces," said Friedman, "so that you can use several large launchers or an array of small ones that get the parts to the right place at the right time."

Friedman cautions that the assembly platform would have to be more than just a one-off facility and would need to have a shelf-life long enough to assemble what he hopes will eventually be a plethora of observatories for deployment at L2. He envisions a large number of observatories at L2 in fifty years, with intelligent robots entrusted to replenish the observatories' cryogenic fluids for cooling and replace fuel needed for station-keeping. And if NASA and other space agencies can solve astronaut safety issues at such locales, then Friedman foresees a permanent human presence at L2, where astronauts could also interface with robonauts and oversee servicing and maintenance of various observatories.

Looking for Other Earths

NASA already has big plans for L2, with the launch of the first of its Terrestrial Planet Finder (TPF) missions planned for sometime around 2015. TPF, designed to search for and find Earth-like planets around some of the closest thirty to fifty stars, will begin by using a four- by six-meter elliptical mirror fitted with a visible-light coronagraph designed to build a high resolution image of the area around a star by blocking out the star's light. The telescope can then look for terrestrial-type planets which circle it. A follow-on mission by 2020 will use four, three-meter telescopes to conduct infrared and visible light interferometry, whereby photons' wavelength phases are combined to increase resolution. In Terrestrial Planet Finder, the interferometer will block out, or null, the starlight so that terrestrial-mass planets are more readily detectable.

NASA's Life Finder, with a projected launch by 2025, would indeed follow Friedman's axiom and ramp up the collecting area to four to six ten-meter interferometrically-linked telescopes to spectroscopically analyze data from such Earthlike planets for signa-

Sailing to the Stars

Like all sailing, the idea of solar sailing has long captured the human imagination. But eventually it may also offer astronomers an additional new window into the early universe. An array of kilometer-wide solar sails sent beyond the orbit of Pluto—a distance of roughly forty times the distance from the Earth to the Sun—could double as science probes for planetary studies of our own solar system and do the ultimate in inteferometrically-linked, low-frequency radio astronomy, says Tom Kuiper, a radio astronomer at the Jet Propulsion Laboratory.

The array's electronic dipoles would be embedded in the sails themselves, with the ultimate array featuring some twenty-one sails interferometrically-linked over nearly 30,000 kilometers. They could be manipulated via uplinked signals from NASA's Deep Space Network. Kuiper says with foreseen upgrades in ground-tracking, even at that great distance, a five-watt signal would be sufficient to relay data back to Earth. If the sails were launched beyond the Moon, each element could be manipulated to spiral in toward the Sun, catching an outflux of solar pressure and, in the process, giving each sail, or radio telescope, the momentum to begin its journey toward the outer solar system.

Kuiper believes that if NASA made a concerted effort, for a cost of a billion or so dollars the technology could be ready within five years. The first such element could be launched shortly after, making its way to the outer edge of the solar system within a few short years.

At that distance from the Sun, solar pressure would be minimal, so some sort of cold gas attitude control system, such as a nitrogen or hydrogen mixture, would be necessary to manipulate the elements and focus the antennas for pointing. But the scientific payoff would be as colossal as the array itself because it would enable radio astronomers to study the clumping of primordial hydrogen before and after the very first stars were formed and, in turn, follow the processes by which the earliest galaxies were organized.

—Bruce Dorminey

tures of life. By 2050, NASA hopes to get the first pixels of planets using ten, perhaps even twenty, ten-meter interferometrically-linked telescopes, offering astronomers their first broad views of clouds and oceans on such extra-solar earths. By century's end, Charles Beichman, TPF's project scientist, believes that we will have the first detailed images of nearby extra-solar earths, perhaps from the super-cool, dust-free vantage point beyond the orbit of our own Jupiter.

"A hundred-by-hundred-pixel image of an extra-solar earth would require between one thousand and ten thousand ten-meter telescopes," said Beichman. "For extra-solar earths within ten light years of our own planet, that would give you an image of the quality of a Hubble picture of Mars, offering a look at their churning oceans, continents, clouds, and polar caps. But because these planets would be rotating and that's what you want to see, you would need to build up such images within an hour; otherwise, it will have rotated or changed underneath you."

The same array would also offer the ability to study individual stars at high red-shift because of its incredible angular resolution—down to a billionth of an arcsecond. Today, we are only planning technology that will take us down to a millionth of an arcsecond. (By comparison, Venus's diameter on the sky is two to three arcseconds.) Currently, astronomers can only see objects at red-shifts of six, some nine hundred million years after the Big Bang. Yet an interferometer of the sort that Beichman believes we will see by the year 2100 would give astronomers the ability to observe individual objects and clumps of early stars back to a red-shift of twenty-five, or only 125 million years after the Big Bang.

The Need for New Technology

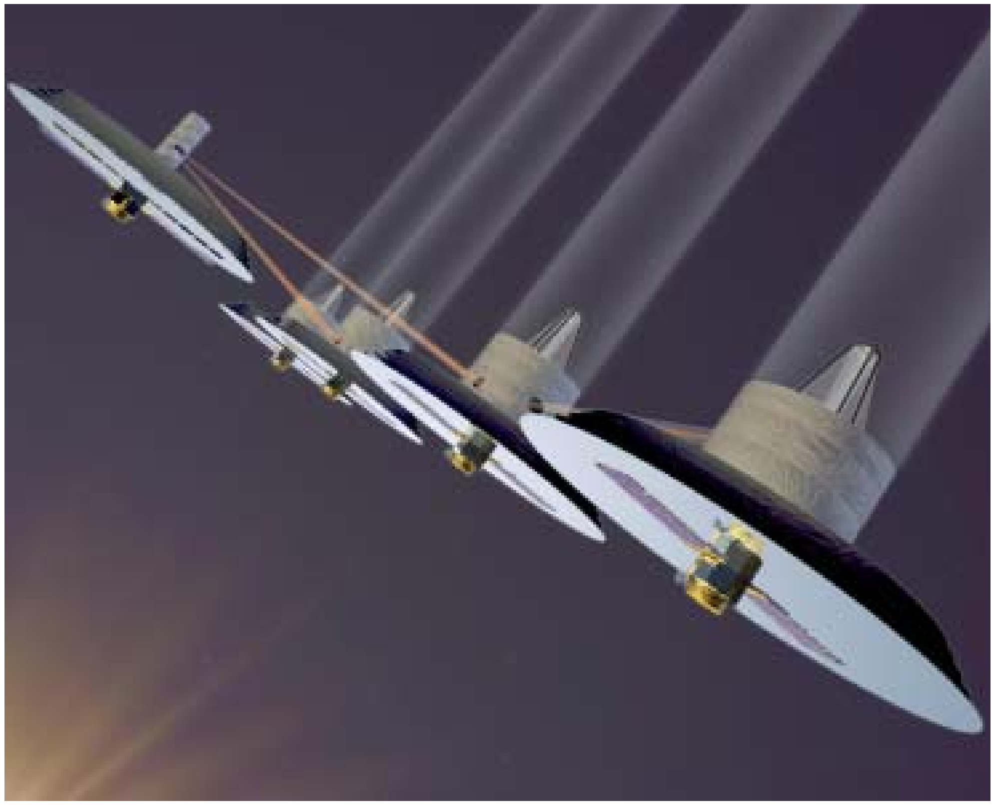
"It's one thing to be able to detect the rare ultra-luminous object at high red-shift and study it," said Mark Dickinson, formerly of the Space Telescope Science Institute in Baltimore and now an astronomer at the National Optical Astronomy Observatory in Tucson. "But if you really want to understand galaxy formation then you are going to need to resolve those objects and see what the internal structure is like and how those stars formed within star clusters. That's the kind of thing that you could do with the large interferometer."

Researchers at the Air Force Research Laboratory's directed energy directorate in Albuquerque are already working on membrane technologies for the Department of Defense that may one day have applications for large optical interferometers. Early tests of the membranes using aluminized Kapton, an amber-colored plastic film made by DuPont that has been used on spacecraft for decades, have been encouraging. In contrast to Hubble, whose primary 2.4-meter mirror has the flexibility of a bridge girder, such membranes of only a few thousandths of a centimeter thick may eventually be used to reflect, collect, and manipulate incoming photons in massive interferometer arrays. And they, in turn, could lighten the payloads of future astronomical missions that would need to be sent out to orbits beyond Jupiter.

But such grand schemes and technologies cannot be expected to flourish unless the astronomical and aerospace communities find more synergistic ways of long-range planning so that they may more effectively integrate future space-based science and technology. For unlike human space travel, which may eventually become open to anyone with the extra cash to pay for a ticket into LEO or even to the Moon, space-based astronomy is a pursuit that will certainly help humanity better understand its origins and our ultimate place in the universe but is unlikely to ever see privatization or profit.

"Technology that pushes the envelope also pushes the cost envelope," said Dickinson. "Even if we reach a point where launch costs are not a big deal, then it's going to be something else that drives up the costs. Some government agency is always going to have to be involved." ■

***Bruce Dorminey*, author of *Distant Wanderers: The Search for Planets Beyond the Solar System* (Springer Verlag, 2001), is a science journalist who specializes in coverage of astronomy.**



NASA's Terrestrial Planet Finder mission will search for Earth-like planets that might harbor life. The space agency has selected two mission architecture concepts for further study and technology development: an infrared interferometer, shown here, and a visible light coronagraph. (Source: NASA/JPL-Caltech)

2005 AAS/AIAA Astrodynamics Specialist Conference

August 7-11, 2005
Embassy Suites Hotel – Lake Tahoe Resort (877-497-8483)

The 2005 AAS/AIAA Astrodynamics Specialist Conference will be held at the Embassy Suites Lake Tahoe Resort in Lake Tahoe, California, on August 7-11, 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. Papers are sought from all areas of astrodynamics, including but not limited to:

- Orbital dynamics, perturbations, and stability
- Earth orbital and planetary mission studies
- Trajectory design and optimization
- Trajectories about libration points
- Low thrust mission and trajectory design
- Dynamical systems theory as applied to space flight problems
- Spacecraft guidance, navigation, and control
- Orbit determination and tracking
- Attitude dynamics, determination, and control
- Satellite constellations and formation flying
- Dynamics and control of large space structures and tethers
- Artificial and natural space debris

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, and a list of proposed activities and/or invited speakers and paper titles.

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. Authors are required to use an automated web-based system for submitting author information, the extended abstract, and a condensed abstract. The website for submitting this information is: http://www.pxinet.com/aas. If authors are unable to use the automated web-based system, they should contact the Technical Chairs for instructions on submitting papers by email.

The information required is as follows:

1. Paper title as well as the name, affiliation, postal address, telephone number, and email address of each author.
2. The text of the extended abstract, with a length of 500-1000 words and containing supporting tables and figures. The extended abstract should provide a clear and concise statement of the problem addressed and the results obtained. Submissions without extended abstracts will not be considered. The extended abstract must be uploaded in the form of a PDF file.
3. A condensed version of the abstract (100 words maximum) to be included in the printed conference program. Avoid using symbols and Greek characters in the short abstract. The short abstract must be pasted into the box provided on the web page.

The deadline for submitting abstracts is **March 4, 2005**. Notification of acceptance will be sent to the authors via email by **May 15, 2005**. Author instructions will be placed on the AAS Space Flight Mechanics Committee website: http://www.space-flight.org. Final manuscripts (50 copies) are required at the time of the meeting. Also, authors are required to provide their session chair 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 papers.

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.

For questions regarding submission of abstracts, please contact the Technical Chairs:

AAS Technical Chair
Dr. Bobby G. Williams, Kinetx, Inc.
Ph: 805-527-4890; Fax: 805-581-9211
Email: bobby.williams@kinetx.com

AIAA Technical Chair
Dr. Louis A. D'Amario
Jet Propulsion Laboratory
Ph: 818-354-3209; Fax: 818-393-6388
Email: louis.damario@jpl.nasa.gov

For other questions regarding the conference, please contact the General Chairs:

AAS General Chair
Dr. Kathleen Howell, Purdue University
Ph: 765-494-5786; Fax: 765-494-0307
Email: howell@ecn.purdue.edu

AIAA General Chair
Dr. Felix R. Hoots, AT&T
Ph: 703-506-5931; Fax: 703-506-4847
Email: hoots@att.com

Leaving Earth: Space Stations, Rival Superpowers, and the Quest for Interplanetary Travel

Reviewed by Donald C. Elder III

Leaving Earth: Space Stations, Rival Superpowers, and the Quest for Interplanetary Travel by Robert Zimmerman. Washington, D.C.: Joseph Henry Press, 2003. 528 pages. ISBN 0-30908548-9. $27.95.

The exploration of outer space, which began as a competition between two superpowers, gradually began to display small but promising examples of international cooperation. After the signing of the Bilateral Space Agreement on June 8, 1962, the United States and the Soviet Union agreed to conduct joint projects involving the *Echo II* telecommunication satellite; in the years to come, other ventures, such as Apollo-Soyuz, would follow in this path.

With the collapse of the Soviet Union, the field of astronautics has become a truly collaborative effort. In *Leaving Earth: Space Stations, Rival Superpowers, and the Quest for Interplanetary Travel*, Robert Zimmerman has done a masterful job of narrating this historic evolution. The American Astronautical Society has recognized Zimmerman's contribution to the field by awarding this scholarly effort the 2003 Eugene M. Emme Prize.

Zimmerman is particularly well suited for this task. His previous writings have focused on the subject of exploration broadly defined, culminating in his 1998 publication, *Genesis: The Story of Apollo 8*.

The author begins with a discussion of the impact that the American triumph in reaching the Moon had on both the United States and the Soviet Union, noting that both sides consequently reprioritized their space programs. Recognizing the futility of continuing preparations for a lunar mission, Soviet Premier Leonid Brezhnev in October 1969 announced that his nation would concentrate on building orbital space stations. NASA Administrator Thomas Paine had announced just days after Neil Armstrong's historic moon walk that the United States would place a space station in orbit. The competition between the two nations in outer space would remain an aspect of the Cold War, Zimmerman points out, with merely a different goal.

After establishing this premise, he then traces the steps that have gradually led to the International Space Station. In discussing these projects, he does a masterful job of giving both the American and Soviet programs a thorough treatment and presents a balanced account of this historical process, meting out praise to the pioneering efforts of the two sides relating to the creation of space stations while also noting the missteps that characterized these programs.

Tackling a complex subject, Zimmerman has organized his manuscript into logical mission segments and is careful to make his highly technical subject comprehensible to his audience. Indeed, schematic diagrams that he has included are particularly helpful in allowing readers to gain a clearer understanding of the complexity of the systems he describes.

A notable strength of *Leaving Earth* is the methodology that Zimmerman has employed. In creating his manuscript Zimmerman has drawn on a vast number of primary and secondary sources, including interviews that he conducted with personnel involved in the American and Soviet space programs. These eyewitness accounts allow Zimmerman to demonstrate the importance of human involvement in the development of space stations.

Although it would have been easy for Zimmerman to have become narrowly focused on the space flight projects themselves, he has avoided the adoption of such a myopic view. Rather, throughout the narrative, the author places the actual missions and the overarching goals into historical context.

The comprehensive nature of Zimmerman's work will allow readers to enhance their understanding of the subject regardless of their background. Clearly written and compellingly argued, *Leaving Earth* thus offers important insights into the international cooperation that most experts regard as a key element in the future of space exploration. ■

***Donald C. Elder III* is professor of history at Eastern New Mexico University.**

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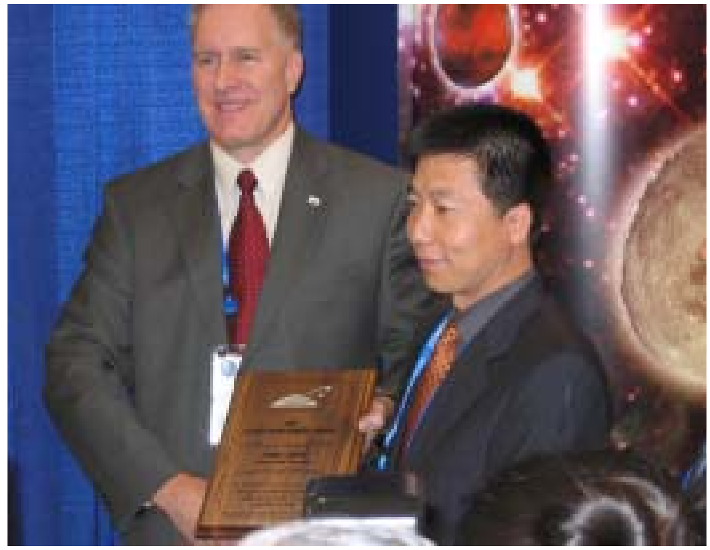
AAS Honors Chinese Taikonaut

The AAS presented its 2004 Flight Achievement Award to Chinese Taikonaut Yang Liwei on October 5, 2004, at a brief ceremony held during the International Astronautical Congress in Vancouver. The presentation was made at the AAS booth in the exhibition hall, taking advantage of both AAS's and Col. Yang's presence at the Congress, since Col. Yang was not able to attend the Society's Awards Banquet in Pasadena on November 16.

Presenting the award was AAS Executive Director Jim Kirkpatrick, who praised Col. Yang's accomplishment as the first Chinese to successfully orbit the Earth and return safely. He also noted that this was the first time since 1954 that this award had been presently solely to a non-American. After accepting his award, Col. Yang thanked the AAS for honoring him and presented the Society with a beautiful sculpture representing the Chinese manned space program. The sculpture is now on display at the AAS business office and is most likely the only one of its kind currently in the United States. ■



AAS Executive Director Jim Kirkpatrick (left) presents Col. Yang Liwei with the AAS 2004 Flight Achievement Award. (Source: AAS)

Conference Information

American Astronautical Society

- The AAS/AIAA Space Flight Mechanics Winter Meeting will be held January 23-27, 2005, at the Copper Mountain Resort in Copper Mountain, Colorado. For information, visit www.space-flight.org.
- The AAS Goddard Memorial Symposium returns to the Greenbelt Marriott March 29-30, 2005. The theme is *"Earth and Space Science: Exploring the Possibilities."* Program details will be posted on the AAS website.
- A complete report on the AAS National Conference and 51st Annual Meeting will be published in the next issue of *Space Times*. Presentations from the conference have been posted on the AAS website.

Upcoming events of interest to AAS members:

- First Space Exploration Conference, January 30-February 1, 2005, Orlando, Florida. Sponsored by NASA, AIAA, AAS, and others. www.aiaa.org
- Fourth International Workshop on Satellite Constellations and Formation Flying, February 14-16, 2005, Sao Jose dos Compos, Brazil. Sponsored by the Astrodynamics Committee of the International Astronautical Federation, in conjunction with the Brazilian National Institute for Space Research (INPE). www.dem.inpe.br/workconst4
- Space Exploration 2005, April 3-7, 2005, Albuquerque, New Mexico. Sponsored by the Space Engineering and Science Institute. www.sesinstitute.org
- The National Space Society's 2005 Annual International Space Development Conference (ISDC), May 19-22, 2005, Washington, D.C. www.nss.org

UPCOMING EVENTS

AAS Meeting Schedule

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

February 5–9, 2005
28th Rocky Mountain Guidance and Control Conference
Beaver Run Resort and Conference Center
Breckenridge, Colorado
www.aas-rocky-mountain-section.org
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March 29–30, 2005
43rd Goddard Memorial Symposium
"Earth and Space Science: Exploring the Possibilities"
Greenbelt Marriott Hotel
Greenbelt, Maryland
www.astronautical.org

June 2–4, 2005
***Student CanSat Competition**
Plaster City, California
www.cansatcompetition.com

August 7–11, 2005
***AAS/AIAA Astrodynamics Specialist Conference**
Embassy Suites Resort
Lake Tahoe, California
www.space-flight.org
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November 15–16, 2005
AAS National Conference and 52nd Annual Meeting
South Shore Harbour Resort
Houston, Texas
www.astronautical.org

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