Linda Billings (Colorado State University), Director of Science Communications
Life and Biomedical Sciences and Applications Division
NASA Headquarters, Washington, DC*

The Space Frontier:
What Is It? Where Is It? What Do We Do When We Get There?

National Space Society of Australia
Space Frontier Conference
Sydney, July 15, 1995

The best-known historian of the American frontier -- that is, the 19th-century "Wild West" -- is Frederick Jackson Turner, author of the famous essay, "The Significance of the Frontier in American History," written for a meeting of the American Historical Association in 1893. It was controversial then, and it still is today.... I'm going to talk about why....

The dictionary describes a "frontier" as a shifting or advancing zone that marks the successive limits of settlement and civilization, encompassing both geographical and conceptual elements. We tend to think of Turner's conception of the frontier as a physical place, but he also described the frontier as a psychological place: an organizing and motivating principle, "a form of society, rather than an area." (The psychological frontier is the place in space that I'm most interested in -- but more about that later....)

Some critics charged that Turner's frontier thesis glossed over the fact that materialistic interests were a major driver behind Western expansion. While Turner acknowledged that this was true, he also said the frontier embodies "the spirit of discovery, the courageous determination to break new paths, indifference to the dogma that because an institution or a condition exists, it must remain." This is the frontier spirit that still thrives today in our space community....

We continue to lean heavily on the frontier analogy as we pursue our journey into space: President Clinton reflected on it in his Apollo 11 anniversary proclamation last year, saying that "space exploration has become an integral part of our national character, capturing the spirit of optimism and adventure that has defined this country from its beginnings."

But here at the close of the 20th century, historians are still debating the merits of this frontier thesis, and a new school of thinkers is reevaluating the traditional idea of the frontier.

American historian Stephen Pyne -- an eloquent postmodern interpreter of the meaning and value of exploration in general and space exploration in particular -- has written that we have "a tendency to generalize 'exploration' into a universal expression of the human gene, to equate 'discovery' with 'curiosity' or with 'human spirit.' That it is, but not uniquely.... Exploration...appears to be a cultural invention.... Its vitality as an institution depends on the vitality of the whole civilization with which it interacts. To survey the motives for exploration is to survey all the motives that animate a

thriving civilization.... [E]xploration is a shared act of faith. It reinforces and reinterprets in updated garb myths, beliefs, and archetypes basic to its originating civilization." (*"The Third Great Age of Discovery,"* *The Scientific and Historical Rationales for Solar System Exploration, Space Policy Institute, George Washington University, Washington, D.C., 1988).*

The best contemporary interpreter of America's frontier past, in my opinion, is the brilliant historian Patricia Nelson Limerick. Dr. Limerick addressed a NASA conference last year on the historical value of space exploration, advising space advocates to think more deeply about what they're saying as they bandy about the space frontier analogy. NASA planners "should have more in the way of practical ballast giving weight to their thoughts," Limerick said, suggesting that "one of the best ways to give the space program grounding and ballast is to pay attention to Western American history.

"Nearly every supporter of space exploration and colonization has at some time used the frontier metaphor or analogy.... To the many advocates of space development, American history is a straight line, a vector of inevitability and manifest destiny linking the westward expansion of Anglo-Americans directly to the exploration and colonization of space. In using this analogy, space advocates have built their plans for the future on the foundation of a deeply flawed understanding of the past, [and] the blinders worn to screen the past have proven to be just as effective at distorting the view of the future," she said.

It might be best for the space community to abandon the frontier analogy, she recommended. "But the image and idea of the frontier is an enormously persistent and determining pattern of thought...." Given this reality, what the space community should do is "keep the frontier comparison, but try taking it seriously," she said.

"What would happen if those who have been eager to refer to space as the next frontier, the final frontier, the last frontier actually thought about the lessons of Western history?," she asked. "Leaving home and going West proved to be a very ineffective way of leaving...problems behind and an even less effective way of solving those problems.... The American West proved to be no escape at all from ethnic and racial tensions, from urban and industrial conflicts, from the...depletion of natural resources...or from frustration and failure."

Advocates promote space exploration as an escape from Earthly problems, colonization as a safety valve for social stresses, "technical solutions for all dilemmas..... Space boosters promise a wide and open distribution of benefits [but] in situations of colonization and settlement, occasions in which everyone gains and no one loses have been extremely rare," Limerick pointed out.

"Whether it occurs in terrestrial space or celestial space, expansion has been tough on the ideals and practices of democracy," she continued. "Principle takes a beating and expediency triumphs....."

"But the frontier analogy does carry the encouraging lesson that slowing down can carry real advantages.... Used in the conventional...way...the frontier comparison condemns caution and demands frenzied and precipitate action. Used seriously and thoughtfully, the frontier comparison calls for

thoughtful, measured and deliberate approaches to enterprises full of risk." *(Proceedings, "What is the Value of Space Exploration?", July 18-19, 1994, Washington, D.C.)*

These are wise words, and we should all heed them....

But why do we need to worry about this frontier stuff? It's because, as Limerick has said so well, the civil space program has changed radically since the 1960s. Apollo, a product of geopolitical competition unique to its time, was a hard act to follow. Yes, the space program has produced many practical benefits, but in the post-Cold War world of intense geoeconomic competition, spinoffs are not a sufficient justification for space spending. NASA's work now needs to be economically relevant, among other things. We have to justify our existence -- something we did not have to do before....

In the current political environment, the line between foreign and economic policy goals has blurred considerably -- America's partnership with Russia being the best illustration of this point. Expanding U.S.-Russian cooperation in space is not an altruistic exercise -- the Clinton Administration has made it clear that NASA's work with Russia, and also with Ukraine, is part of an important effort to stabilize the former Soviet economies and ensure that "market democracy" flourishes (and that Russia and Ukraine do not feel compelled to sell weapons to developing countries in order to get by...).

You all know about the historic Shuttle-Mir docking mission of just a few weeks ago, and Russia's participation in the International Space Station partnership. A joint U.S.-Ukraine Space Shuttle mission, STS 87, is scheduled for launch in October 1997 with a Ukrainian payload specialist aboard (an expert in plant biology). In the field of life sciences, NASA and Russia's Institute for Biomedical Problems are setting up a joint space biomedical center for training and research in Moscow. Many, many other cooperative efforts, from large to small, are also under way. But even so, as recently as last month Dan Goldin told his senior staff that NASA is not getting the message out loud and clear that cooperative efforts in space are not isolated events but part of a plan that extends beyond NASA to fulfill top-priority national policy goals.

Expanding cooperation goes beyond the former Soviet states to encompass other countries targeted by the Clinton administration for economic and foreign policy reasons: for example, Brazil -- NASA and the Brazilian government should be signing a framework space cooperation agreement soon; and South Africa -- a South African crew member on Space Shuttle mission STS 72 (Winston Scott) should be talking to South African school children during flight..... A single weekly report from NASA's international office cites cooperative activities with dozens of countries and multinational organizations: Canada, Chile, China, France, Germany, India Japan, Mexico, the Netherlands, Sweden, Switzerland, the U.K., the European Space Agency, and the United Nations.....

That's the good news -- the bad news, as you all know, is that NASA is in the process of reinvention, downsizing, and budget-cutting. I won't go into any details about these exercises -- all I'll say is that their time has come.... In Washington, we all live and die by the annual budget cycle: it's a horrible reality, and we engage in much wailing and hair-pulling over each

threatened loss of dollars. But as somebody famous once said, "It ain't over 'til it's over."

One potentially harmful effect of this year's round of political pugilism -- the latest, just before I left, was a threat from Rep. Jerry Lewis (R-CA) to shut down three of NASA's field centers, including Goddard Space Flight Center -- is that some members of the space community seem to be giving up hope of meeting long-term goals for space exploration in the face of such grim budget prospects and a poorly articulated rationale for moving onward. But I would argue that the Clinton administration has been, and continues to be, consistent in supporting NASA's long-term goal of human exploration of the solar system. In a 1992 campaign policy statement, Clinton promised to "seek to meet the needs of the United States and other nations while moving toward our long-term space objectives, including human exploration of the solar system." White House Science and Technology Adviser John Gibbons has asserted, repeatedly, that human space flight is and will continue to be a significant element of our domestic and international space program. I've already talked about expanding international cooperation in space. Meanwhile, the White House Office of Science and Technology Policy and the National Security Council have initiated a review of national space policy directives issued from 1988-1992, with the intent of resolve conflicts and redundancies....

Some complain that President Clinton has not made any public statement or approved any policy decision endorsing a return to the Moon or a human mission to Mars. President Bush did. But we've learned that a speech does not necessarily make a program materialize -- George Bush was no Jack Kennedy, Dan Quayle was no Lyndon Johnson, and the '80s were nothing like the '60s.

Some argue that the Administration's intensive cutting of NASA's budget is a sign of lack of support. But the White House has not proposed to eliminate the civilian space program, only to engage in some very uncomfortable and necessary belt-tightening. And let's face it, NASA's gotten rather bloated over years of dependable and substantial budget increases through three Republican presidential terms.

NASA's budget authority (real-year U.S. dollars) climbed from $7.2 billion in FY 1984 to $7.6 billion in '85, $7.8 billion in '86, $10.8 billion in '87, $9.0 billion in '88, $10.9 billion in '89, $12.3 billion in '90, $13.9 billion in '91, $14.3 billion in '92 and '93. With NASA's budget authority topped out at $14.5 billion for the current fiscal year, the Clinton Administration this year sent Congress a $14.3 billion budget request for NASA in FY 96, with plans to cut billions from previous projections of NASA spending for the next five years. Losing weight is a common exercise of middle age -- sometimes it's even life-saving....

NASA's budget request incorporates White House directions to reduce projected spending by $5 billion (U.S.) by the turn of the century, on top of an earlier requirement to cut $35 billion from projected spending for the same period. The Republican-controlled Congress is now pressuring NASA to make further significant cuts in various programs, especially the Mission to Planet Earth and Earth Observing System -- but to his credit, Mr. Goldin is defending his pared-down budget as slim enough.... In reporting the results of NASA's infamous "zero-based budget review," the exercise that determined how to accommodate the administration's budget-cutting directive, Mr. Goldin said

emphatically: "The deeper cuts Congress is contemplating simply go too far, and I am committed to fighting them."

I'm not known for my optimism, but in spite of all this budgetary bad news, I am optimistic about our future in space. While some members of the space community are still worrying that they won't have enough money to fulfill their dreams, others are figuring out what they can do with available resources, and then going ahead and doing it.

Researchers at Martin Marietta, in partnership with NASA's Johnson Space Center, Houston, Texas, are working on an automated method of extracting fuel for a Mars sample return from martian surface resources. This project moved from concept to successful hardware demonstration on a budget of about $100,000. The Center for Mars Exploration at NASA's Ames Research Center, Moffett Field, Calif., is advancing the development of virtual reality for robotic planetary exploration.... The center recently "borrowed" a Russian Mars rover unit for field testing. Russia's Babakin Center agreed to loan a Marsokhod rover to McDonnell Douglas in exchange for the U.S. company's loan of some computers to the Russian Institute for Space Research (IKI). Then NASA Ames contracted with McDonnell Douglas to use the rover. The cost of this project was in the hundreds of thousands, not millions.

Scientists are thinking positively as well. Researchers working with NASA's program in exobiology – the study of the origin, evolution, and distribution of life in the universe – spent the last year defining exobiology science goals for future Mars missions. They now have a strategy in hand for merging their goals with those of planetary geology, climatology, and other fields that have dominated Mars mission planning in recent years. Meanwhile, exobiologists are pursuing ground-based research in their continuing quest to better define the boundaries within which life can thrive, in preparation for extraterrestrial investigations. They're exploring the boundaries of life in harsh martian analog environments such as Antarctica, Siberia, and the Atacama Desert of Chile. Life scientists are also using Antarctica as an analog environment for human-factors research.

Meanwhile, the International Mars Exploration Working Group (U.S., Russia, ESA, Japan...) has developed a plan calling for launching probes to Mars at every launch opportunity from 1996 to 2003. NASA intends to launch two small missions at each opportunity. Robotic Mars exploration missions now under way include:

- NASA Mars Global Surveyor: 1996 launch (Delta); orbiter; partial replacement of Mars Observer investigations.
- NASA Mars Pathfinder: December 1996 launch (Delta); July 4, 1997, landing; lander and microrover; automated parachute-solid rocket-airbag landing method; rover will explore the Ares Vallis flood plain.
- Russia Mars 96 (former Mars 94) mission: 1996 launch (Proton); orbiter, two small landers, two penetrators.
- Japan Planet-B: 1998 launch (M-5); orbiter; atmospheric science, technology demonstration.
- NASA Mars Surveyor: 1998 launch (Med-Lite ELV); orbiter; payload TBD.
- NASA Mars Neolander (proposed): 1998 launch (Med-Lite); reduced-weight Pathfinder-derived lander, focusing on volatiles and climatology.
- U.S.-Russia "Mars Together"? 1998?

• NASA network of small surface meteorological stations (proposed): 2001 launch (Med-Lite).
• ESA Intermarsnet (proposed): 2003 launch (Ariane 5); orbiter (communications satellite) plus four landers built by an international consortium.

NASA's Enterprise for the Human Exploration and Development of Space (HEDS) -- one of five strategic enterprises around which the agency is organizing its programs -- is the agency's organizing principle for human exploration planning. This enterprise is intended (according to a June draft strategic plan) to create opportunities to gain knowledge, return a profit, experience wonder and inspire humanity -- a pretty big task to take on.... The goals of this enterprise are to understand and use nature's processes in space, explore and settle the solar system, achieve routine space travel, and enrich life on Earth through people living and working in space. This plan -- which includes no time-line or budget -- calls for human missions to the Moon and Mars following operation of the International Space Station and thorough robotic exploration of Mars....

The program that I work with, NASA's Life and Biomedical Sciences and Applications Program, has a critical role to play in the future of human exploration. This program is dedicated to understanding the role of gravity in living systems and ensuring the health, safety, and productivity of people living and working in space -- today, for weeks at a time on the Space Shuttle; tomorrow, for months at a time on space stations; and ultimately, on long-duration missions to other planets. Tending to life in space involves protecting it from radiation as well as biological and chemical contamination, maintaining proper atmospheric composition and pressure, providing food and water, disposing of wastes, providing spacesuits and other tools for extravehicular activity, and enabling efficient human-machine interaction, among other things.

In the space life sciences, we've just recently completed Stage 1: that is, figuring out, at the macroscopic level, what happens to humans in space. We've confirmed that bones and muscles deteriorate, cardiovascular function and fluid distribution alter, the immune system becomes less effective, the neurovestibular system falls out of synch.... And we know that everything's interconnected....

Now we're starting to work on Stage 2 -- a much more complicated endeavor: determining exactly how and why these changes occur, whether they threaten any harm, and whether and how we can control or reverse them. In addition to physiological deconditioning, other life sciences problems that stand in the way of human interplanetary exploration include radiation exposure, the need for fully recycling life support systems, and psychological stress due to isolation and confinement. But we're working on all of these problems....

We'll get a lot of life sciences work done on continuing Shuttle-Mir missions, the 16-day Life and Microgravity Sciences Spacelab mission or LMS (STS 78), set for launching in mid-1996 with 21 principle investigations including 15 in the life sciences; Neurolab, a 1998 Spacelab mission dedicated to neuroscience research; and many other space- and ground-based research projects.

(NASA Life Sciences Data Archive, including information through SLS 1, now accessible via World Wide Web: http://nssdc.gsfc.nasa.gov/life/nssdc/life_home.html)

With regard to new spacecraft, new missions, and new instruments for space exploration, "smaller, cheaper, faster, better" is NASA's current mantra. And it's actually getting us somewhere.... Mostly thanks to our huge defense budget, the U.S. is still a leader in microminiaturization, and this lead is helping to make smaller better spacecraft. For instance, the Jet Propulsion Laboratory's Center for Space Microelectronic Technology is developing a "camera on a chip" for NASA that will be smaller and cheaper than current state-of-the-art charge-coupled device (CCD) imaging systems. This Active Pixel Sensor, incorporating complementary metal-oxide semiconductor (CMOS) technology, is available for commercial licensing (JPL has already signed a technology cooperation agreement with AT&T Bell Laboratories.)

NASA set a budget limit of $150 million and a development time limit of three years for Discovery robotic solar system exploration missions: it picked two Discovery concepts (including Lunar Prospector) for development earlier this year, and though much grumbling occurred over shifting budget ceilings and vaguely defined project requirements, the space community is learning to love this program -- NASA even held a Discovery "lessons learned" workshop in Washington last month to help smooth the waters....

Just last month, NASA picked 23 industry and university partners to participate in five New Millennium "integrated product development" teams (230 proposals were submitted...). The teams will focus on autonomy, microelectronics, modular architecture and multifunctional systems, and science instruments and micro, electro and mechanical systems. The New Millennium program, managed by JPL, will support space-based development and validation of advanced technologies for small spacecraft -- comet or asteroid fly-bys, microlanders, earth observers, and so on. NASA plans to announce three New Millennium demonstration missions by the end of this summer, for launching in late 1997 or early 1998. Once it gets started, the New Millennium program should be launching one mission a year....

You've already heard about where things stand with the search for extraterrestrial intelligence -- Project Phoenix is a testament to the devotion of the former NASA SETI team.... I want to mention NASA's intensifying interest in searching for evidence of extrasolar planets -- related to, but different from, searching for evidence of extraterrestrial technology.... NASA Administrator Dan Goldin is absolutely wild about the idea of directly imaging planets around other stars, and right now, a team of space scientists is working on a report, or "roadmap," for Mr. Goldin that will tell him how we might achieve that goal (the roadmap should be complete this fall). NASA's experimental program for extrasolar planet searching has always been low-budget and until recently focused on interferometry and other indirect methods of collecting evidence of extrasolar planets....

JPL is just now completing a three-year interferometry test-bed project at the Mt. Palomar Observatory -- JPL had proposed developing a full-scale project at the Keck Observatory on Mauna Kea in Hawaii, but that plan is on hold for now. Because of Mr. Goldin's interest, emphasis is shifting to the identification and development of technologies for directly imaging such planets. Some

astronomers who are working in this area -- Anneila Sargent of JPL, for instance -- are optimistic that such technologies will be ready for deployment sooner rather than later.

One key element of future human exploration -- space transportation -- continues to be problematic. Through the '80s and '90s, every expert who's looked at future space transportation needs has come to the same conclusion: we need to drastically reduce the cost of access to space. Certainly we have no means of affordable transportation for human interplanetary travel -- not even on the horizon. And the current budget-cutting fever in Washington is affecting advanced technology development programs all across the government, not only at NASA.

The congressional Office of Technology Assessment -- a good outfit that Congress is threatening to dissolve as a money-saving measure – recently examined the Clinton Administration's 1994 space transportation policy and concluded that while it brings some order to a somewhat chaotic field, it does not resolve conflicts or eliminate redundancies between NASA and Defense Department space transportation development programs, nor does it resolve problems relating to competition and cooperation with foreign launch providers or conversion of excess ballistic missiles.

DOD currently spends $1.6 billion of its $1.9 billion annual space transportation budget on the Titan IV heavy-lift vehicle, leaving little for advanced transportation development and ignoring U.S. launch providers' need for a commercially competitive medium-sized launch vehicle. DOD's Evolved Expendable Launch Vehicle program might cut launch costs but 10 percent, but that's not enough to help commercial launch companies.... OTA also noted that if NASA proceeds with the development of a next-generation reusable launch vehicle (RLV) -- a possible follow-on to the X-33, X-34, and DC-X programs -- it could compete with EELVs, reducing or even eliminating any cost reduction generated by the EELV program. (Development and production of such a next-generation RLV could cost $6 billion to $20 billion, according to OTA.)

The DC-X, a vertical takeoff-and-landing vehicle most recently demonstrated earlier this month, continues to look promising -- but neither McDonnell Douglas nor the Pentagon will divulge how much its development is costing, as it's a "black" (classified) program. NASA's X-33 program is intended to prove the concept of a fully reusable single-stage-to-orbit space transportation system by the year 2000; the X-34 program is intended to produce, in partnership with industry, a partially reusable demonstration RLV for small payloads. OTA also found in the course of its space transportation analysis that lower-tier businesses involved in the space transportation business -- those which provide subsystems, components, and materials to prime contractors and who receive about half of the money spent on space launch procurements -- fear that they may go out of business if research and development funds stop trickling down from prime contractors to them, as they fear.... *("The National Transportation Policy: Issues for Congress," available via World Wide Web at: http://www.ota.gov)*

It's not easy for the space community to cope with all the changes that the end of the Cold War and global social, political, and economic upheaval have brought upon it. But it's possible. And it's important to keep up hope, to

understand that hope is an active condition. It implies preparation. Hope is the force that motivates people to take risks, with the expectation that some benefit might follow. It's what makes people try, and keep on trying. Thus giving up hope is a dangerous thing to do. Without it, the space community is vulnerable, enervated, nonproductive, and thus not likely to achieve its long-term goal of human exploration of the solar system.

As we get caught up in the daily grind, we may sometimes lose sight of the reason why we're doing what we're doing. But our mission is clear -- our mission is to explore the universe. For thousands of years, we've dreamed of exploring the cosmos. It was only 50 years ago that we developed the ability to do it. Throughout most of the Space Age, the Cold War kept our space exploration efforts pointed unerringly in a certain direction. In keeping with post-Cold War politics, we're now resetting our space compass, and it's causing a lot of confusion. It's downright unsettling. But there's no doubt we're on the right track: off the planet and into the deep, dark, immensely promising heart of space.

There's a broad, deep public value attached to all of this work: the value of discovery, progress, learning, improving the quality of life on Earth. Getting back to our mission, we're out to explore the universe. It's that simple. It's in our blood. Curiosity is what brought us out of caves, took us across oceans and continents, made us invent airplanes and telephones, and now draws us toward the stars. This is the frontier that we face: the vast frontier of our intellectual and spiritual potential -- perhaps an endless frontier....

And here's where I want to say a few words about my favorite subject: communications.... Most people think that NASA has a great PR machine, and in some respects that's true. From Mercury to Shuttle-Mir, NASA is and always has been good at getting coverage of its space flights. But what is is that NASA is telling the people? What story is it telling? What image is it conveying?

I would venture to say that we are *not* telling the story of space exploration, today or for the future. We are *not* talking about the value of the risks and challenges inherent in space flight. We are *not* explaining the purpose or importance of the fundamental scientific research we are doing in space. I don't mean to be critical -- the space community does put some effort into communications. But it's not enough. We need to work harder. We need to do more....

Last week, Ron Howard's film "Apollo 13" was still the #1 draw at American movie theaters. Why? I think that NASA supported the production of this film because it effectively conveys NASA's traditional "right stuff" image, clean-cut American flyboys being stoic, pulling through. I also think that the reason why the public likes this film is that it's about danger, risk, challenges, hard work, human ingenuity, a brush with death, turning failure to success. NASA's not comfortable talking in public about risks and danger. But that's what space exploration is all about. That's why we'll keep doing it.

In his turn-of-the-century essay, "The Moral Equivalent of War," the American philosopher William James wrote about the value of risk: "Without risks or prizes for the darer, history would be insipid indeed.... Great indeed is Fear; but it is not, as our military enthusiasts believe and try to make us

believe, the only stimulus for awakening the higher ranges of [our] spiritual energy...."

The global political, economic, and social upheaval that we are witnessing today is only a sign of the chaos that is a natural attendant to great change. And the challenge of change is good, because without change, we'll die. It's a basic principle of systems theory that without a constant flow of energy and information in and out of a system, it fails. We're in the process of becoming a global civilization *and* a spacefaring civilization.

The world around us changes at a much faster pace than human minds can keep up with (Thomas Kuhn, The Structure of Scientific Revolutions). Thus, the models we develop for understanding the world always seem to be out of date. Space exploration is leading the way toward a new paradigm for life on Earth, a paradigm we might not quite be ready to accept, but a paradigm whose time has come -- a paradigm of life without boundaries.

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**The views expressed in this paper are the author's, not NASA's.*