What Is the Future Of Space Exploration?

The international economic collapse, and Bush Administration technological apartheid, has shrunk nations' space programs and great potentials of only a decade ago. Marsha Freeman reports.

Ten years ago, at the first World Space Congress in Washington, D.C., scientists, aerospace industry representatives, and space program officials from around the world were optimistic about the future of space technology development and exploration. The disintegration of the Soviet Union held out the promise of collaboration between the United States and the world's other great space power. With the Cold War over, the aerospace industry looked foward to a "peace dividend," that would free research and development resources from military programs for visionary space initiatives.

The prospects for growth in commercial space services were bright, with plans to orbit dozens of satellites to provide mobile telecommunications and Internet services, requiring the expansion of both satellite-manufacturing facilities, and the launch vehicles to carry them into space.

A few weeks after the World Space Congress, elections would bring Bill Clinton to the White House, his stated policy to "engage," rather than confront the People's Republic of China—the next emerging space power. American satellite makers would be able to launch their spacecraft on Chinese rockets, expanding their business, especially in Asia. The Clinton Administration would invite Russia to join the International Space Station, virtually combining the programs of the world's only two manned-space-exploration powers, to the benefit of both.

Failed Economic Policies Cut a Swath

The atmosphere, and the reality, of the second World Space Congress, held Oct. 10-18 in Houston, Texas, was entirely different from that prospect of a decade ago.

Over those ten years, failed International Monetary Fund-dictated economic policies have come perilously close to destroying the magnificent capabilities that were the Soviet space program. Similar policies, within the context of the global financial crisis, have led to declines in funding for space exploration by all of the major space powers, and now threaten major programs.

Over the course of the ten-day meeting, a speaker from the U.S. Jet Propulsion Laboratory reported that the Marconi data relay satellite planned for Mars could be delayed because of the funding problems of NASA's partner, the Italian Space Agency. The European Space Agency's Venus Express mission faces outright cancellation, if the Italian government, as it has indicated, cannot meet its commitments. Kohichiro Ozama reported at the Congress that Japan's Planet C mission to Venus is also on hold, because they do not have enough money to complete even the prototype model. Japan had previously announced that the completion of its contribution to the International Space Station—the Japanese Experiment Module—would be delayed for two years, due to funding problems.

Describing the French Mars exploration program, Jean-Louis Counil stated that the French Space Agency, CNES, had wanted to launch a mission in 2007 to include a science orbiter and four Net Landers for communications relay and scientific exploration on Mars. But estimates are that the mission would cost 400-500 million euros, and the "budget estimates were far too optimistic," he said. Now, the French are

More than 4,000 scientists and engineers attended the World Space Congress in Houston, but nearly all of the Chinese delegation, and many other delegates, were denied visas on bogus "technology transfer" concerns. Ironically, Chinese President Jiang Zenim visited Houston's Johnson Space Center on Oct. 23, a week after the Congress ended. Here, astronaut Andy Thomas briefs President Jiang in the Space Shuttle Mockup Facility.

looking for "cost reductions," will simplify the mission, and will "move it to 2009."

The budgetary problems of the two manned-space powers were already well known before the Houston meeting, with Russia stating it does not have enough money to build the Soyuz rockets to carry supplies and crew to the space station, and the United States threatening not to finish building the station.

In the United States over the past decade, the decline in defense spending, with no parallel increase in the civilian space program, has led to hundreds of thousands of layoffs in aerospace, and dozens of company mergers that reduced capacity in every sector of the industry. What remains are a few mega-giants, increasingly dependent upon money from the Department of Defense for survival.

The collapse of the telecommunications sector, bloated by speculative ventures and hyped high-priced services, has led to the cancellation of dozens of satellite launches and created an "overcapacity" of launch vehicles, leaving in the red companies that invested millions of dollars to develop new rockets. Michael Yarymovych, the president of the International Academy of Astronautics, stated on Oct. 13 that the community is in a "malaise," and that it will take the launch vehicle industry "a decade to catch up again."

Technological Apartheid Shrinks Conference

And the George W. Bush Administration is pursuing a Clash of Civilizations foreign policy, which precludes engaging dozens of nations in collaboration in space exploration—a program of technological apartheid under the guise of fighting terrorism.

As the delegates gathered for the marathon ten days of meetings in Houston, one of their first discoveries was that many of the papers that had been prepared, and were listed in the program, would not be presented. *EIR* was told that 80 Chinese scientists (nearly the entire delegation) were denied visas by the State Department. *Aviation Week* subsequently reported that Luan Enjie, the head of the Chinese space agency, was left stranded in Canada, unable to enter the United States. In addition, Russian, Indonesian, Romanian, Iranian, and Algerian scientists were denied visas.

The visas were denied, or "delayed" long enough to cancel participation, under the guise of fears of "technology transfer" to these nations. This is an obvious sham, considering that all of the presentations were unclassified and civilian in character, often accessible through the Internet, and will be available as conference proceedings. One real result was the loss of the opportunity to hear from Chinese scientists what their otherwise quite secret space program was planning. Ironically, the President of China, Jiang Zemin, visited the NASA Johnson Space Center in Houston less than a week after the conference that his nation's space experts were not allowed to attend.

In response to this slap in the face to the international scientific community, Marcio N. Barbosa, the Brazilian national who heads one of the main sponsoring organizations—the International Astronautical Federation—has sent a letter of complaint to the American Academy of Sciences, and the American Institute of Aeronautics and Astronautics, the U.S. hosts for the Houston Congress. The international scientific organizations indicated at the close of the conference that they will recommend that no future such meetings be held in the United States. The Bush Administration policy is "insane," one French Congress official told *EIR*.

In 1993, Chinese President Jiang Zemin (left) visited engineering facilities in Brazil where the China-Brazil Earth Remote Sensing (CBERS) satellite was under construction. The joint program was initiated to allow technology transfer, denied Brazil by the United States.

Despite this attempted sabotage of a crucial opportunity for the space community to meet, discuss, review programs, and plan for the future, and despite the economic crisis, which is "downsizing" the programs of the space-faring nations, there were new, innovative ideas presented, and many developing nations made clear they intend to be part of space exploration in the 21st Century.

Ibero-American National Commitments

No countries represented at the World Space Congress are facing a more severe existential financial crisis than Ibero-America's two space powers, Argentina and Brazil. Yet both nations made clear they will continue their programs, with or without the United States, and in spite of their current economic catastrophes. Marcio Barbosa stated, at a plenary session titled "Space Activities: An Engine for Serving Humanity," that with "courage and determination," mankind "could go back to the Moon in six years." He called for a "dialogue to build a bridge to solve the problems of humanity."

Throughout the 1970s and 1980s, the "empire" faction in the U.S. government, following former Secretary of State Henry Kissinger's dictum that there should be no economic powers allowed to develop in the South, tried desperately to stop the space programs of Argentina and Brazil. Particularly targetted were their launch vehicle development programs; these rockets, the United States insisted and continues to insist, were not being developed to launch satellites into orbit, but as missiles, to carry "weapons of mass destruction." The United States lied that international non-proliferation treaties would not prevent Ibero-American nations from developing space technology, but the Missile Technology Control Regime (MTCR), in fact, classifies any launch vehicle, and all its components, as a weapon or weapons.

Bowing to U.S. pressure, with the hope of gaining access to the technology it needed to upgrade its other space efforts, Argentina cancelled its Condor rocket program in 1990, and in 1991, signed the MTCR. But Brazil refused to capitulate, and continues to develop its independent launch capability, the Satellite Launch Vehicle (VLS). The next test launch, it was announced at the Congress, is scheduled for March 2003.

At a session on space law at the Houston conference, representatives from Brazil registered their objection to U.S. export control policy, and their determination to look elsewhere for cooperation in space. José Monserrat Filho, head of the Brazilian Society of Space Law in Rio de Janeiro, described the current U.S. dominance over technology-transfer policy as a "hegemony" that has developed from a "unipolar" world.

In 1996, the United States and Brazil signed a Framework Agreement on Cooperation in the Peaceful Uses of Outer Space. In 1999, President Bill Clinton met in Washington with Brazilian President Fernando Henrique Cardoso, and the following year, an agreement was signed outlining the use of Brazil's Alcântara launch site by American launch vehicles, and to launch American-built satellites. To this day, the Brazilian Houses of Congress have refused to ratify the agreement.

The reason is that, while the Technology Safeguards Agreement with the United States proposes to prevent unauthorized vehicle and satellite technology transfer to Brazilian institutions and companies at the Alcântara spaceport in return for cooperation, in fact, that cooperation will not exist unless Brazil cancels its VLS rocket program. The Brazilian Congress rightly sees the agreement as a threat to its national sovereignty.

As Monserrat stated, the agreement is not "an instrument of cooperation, but of technological safeguards. It would be a true instrument of cooperation if it would provide some technological transfer, train human resources, or contribute to the development of the Brazilian national space program. That is not the case."

The U.S. safeguards are aimed "at the VLS," Monserrat stated, "since the United States never accepted the VLS program," even though Brazil joined the Missile Technology Control Regime in 1995. "Apparently, Brazil's decision to join the MTCR does not guarantee Brazil a more trustworthy and flexible treatment by the U.S."

Brazil's International Partners

The MTCR requires that *every* member country sign the same restrictive technology transfer agreements that the United States imposes in implementing any cooperative programs with Brazil. This has stymied Brazil's efforts to negotiate launch contracts with most nations, so it has looked outside the mainly Western technology control framework for cooperation.

In 1988, a year after the MTCR went into effect, China and Brazil signed an agreement to develop, build, and launch two remote sensing satellites. At the time the program started,

Brazil's technology development center, INPE, stated that the cooperation with China was intended to "break down the developed countries' prejudice against advanced technology transfer." The first China-Brazil Remote Sensing (CBERS) satellite was built in Brazil and launched on a Chinese Long March rocket in October 1999.

Since the establishment of an independent Ukraine, following the dissolution of the Soviet Union, that nation has signed three cooperative space agreements with Brazil, starting in 1995. In November 1999, the two space agencies signed an agreement in Kiev including the launch of Ukraine's Tsyklon rocket from the Brazilian Alcântara launch site.

In November 2000, Professor Turner T. Isoun, the Minister for Science and Technology of Nigeria (seated, right), signed an agreement with Surrey Satellite Technology Ltd. for Nigeria's first space satellite. Signing for Surrey is Dr. Martin Sweeting.

Monserrat stated at the World Space Congress that "the basic difference between the U.S. and the Ukrainian agreements is that the Brazil-U.S.A. agreement seeks to close any opportunity for transfer of technology and cooperation. It further reinforces obstacles." By contrast, "the Technology Safeguard Agreement between Ukraine and Brazil does not have any similar provision. Ukraine and Brazil welcome each other's development, including an option for further development of joint programs." In fact, "both countries aim to solve their financial problems by joining efforts in finding innovative solutions to satisfy global market demand," Monserrat stated.

But Monserrat explained that the "success of the Brazil-Ukraine Agreement still depends upon the approval, by the Brazilian Congress, of the U.S.-Brazil Agreement," because of the "predominant position of U.S. clients in the world commercial launch market." But even such a step by Brazil will not ensure success, he said. The U.S. government must still grant its approval for U.S. companies to launch satellites from Alcântara, even on a Ukrainian rocket.

It remains to be seen what U.S. policy will be, as Ukraine and Brazil come closer to what they hope will be up to six Tsyklon rockets launched per year, starting in 2006.

There is no doubt that the financial crisis in Brazil has taken a toll on its space program. Earlier this year, Brazil informed NASA that it will not be able to meet its commitments to provide hardware for the International Space Station. At the World Space Congress, Fernando Raúl Colomb, from the Argentine space agency, CONAE, reported that a joint satellite program was on hold, due to the financial problems in Brazil.

Considering the fact, however, that Argentina itself is effectively bankrupt, *EIR* asked Colomb how his nation is continuing to fund its space program at all. His reply was that years ago, the nation of Argentina made a commitment to develop space technology. And while "Presidents change," this national commitment does not.

Africa Into Space

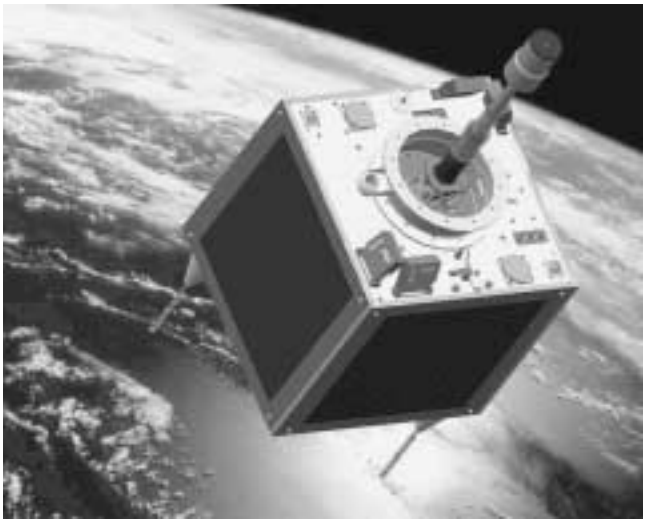
The same determination evidenced at the World Space Congress by Brazil and Argentina was demonstrated by numerous developing nations, which do not plan to be left in the backwaters of science and technology or economic progress in the 21st Century. A number of developing countries are entering the space age through a cooperative program initiated at the University of Surrey, England.

In 1978, a group of students at the university began experiments to develop micro-satellites, weighing 10-100 kilograms (approximately 20-200 pounds), and costing $3-6 million each. By comparison, conventional commercial satellites cost in the tens to hundreds of millions of dollars, and a like amount is needed to launch them into Earth orbit.

In 1985, the University formed Surrey Satellite Technology Ltd., and began an international outreach program to bring satellite technology and applications to nations that could not otherwise afford to make use of space technology. Over the past 20 years, Surrey has built and launched micro-satellites for Pakistan, South Africa, South Korea, Chile, Portugal, Thailand, Singapore, Malaysia, and China.

What is unique about the Surrey program is that it trains groups of scientists and engineers at its facilities in England, provides them with the opportunity to complete advanced degrees in science and engineering, and transfers the technology to the developing country. The purpose is to create a cadre of people who can then be the core of an indigenous space program in each nation. So far, Surrey has helped educate more than 70 foreign engineers, and an additional 320 have graduated from the university with Master of Science degrees.

One of the most innovative, on-going programs at Surrey



Seven nations are participating in Surrey's Disaster Monitoring Constellation. One of the seven satellites is depicted in this artist's illustration.

is the deployment of a Disaster Monitoring Constellation of satellites. The purpose of the Constellation is to monitor natural and man-made disasters, such as monsoons and other violent weather, out-of-control fires, and floods. When such disasters cannot be prevented, timely and accurate information can save thousands of lives, and avoid millions of dollars in damage.

The Constellation will consist of seven satellites, through the participation of Algeria, Great Britain, China, Nigeria, Thailand, Turkey, and Vietnam. One approximately 100 kg micro-satellite will be owned independently by each nation, providing remote sensing information to aid its agriculture, the development of infrastructure such as road and rail networks, water resource management, and the monitoring of special concerns such as desertification. But the Constellation, working together and coordinated through Surrey's ground-control station, can also provide same-day disaster information, which will be immediately made available to relief agencies.

At the Congress of the International Astronautical Federation in Toulouse last year, researchers from Algeria's Centre National des Techniques Spatiales described the importance, for their nation and North Africa, of their Disaster Monitoring Satellite, stating that with this project, "space is no longer the preserve of a few wealthy nations."

This year, at the World Space Congress, Prof. Robert Boroffice, who heads the National Space Research and Development Agency of Nigeria, discussed his country's participation in space technology development. "Space technology and access to space have been elusive to most developing countries over the last half of the 20th Century," he stated, as "technology was seen as very expensive and prestigious, meant only for the major industrialized countries."

But over the last decade, Boroffice said, "the trend has changed, with many developing countries embracing space technology as one of the major ways to achieve sustainable development. The present trend toward the use of small satellites in meeting national needs has aided this transition."

"Nigeria is a country at the threshold of technology development and industrialization," Boroffice stated. "It has a population of 88.5 million (1991 census) . . . with a wide variety of natural resources." He explained that "the prime objective" of the government of Nigeria is "the provision of adequate food, clean drinking water, shelter, health care delivery, good roads, and infrastructure for development, especially for rural dwellers, who constitute about 80% of the population."

While the value of satellite remote sensing data for development planning has long been recognized, Boroffice said, the absence of ground receiving stations in most developing nations means they have had to purchase the data at a high cost. Now Nigeria will be able to have its own, independent capability.

The Nigerian National Space Research and Development Agency was established in 1999, he reported. The objectives are to "develop indigenous capabilities for research and development in the major areas of space science and technolgoy," to manage natural resources, to develop an "effective and efficient communications system," and to train Nigerians "in the acquisition and application of modern technology."

In order to achieve the broad-ranging objectives of its national space plan, Nigeria has created three new centers, for Basic Space Science, for Satellite Technology Development, and for Geodesy and Geodynamics. To develop the human resources required, and to meet the objective of developing Nigerian technological products that can "feed our manufacturing industries," the study of space science is being made mandatory at all levels of education. There is a plan to develop facilities, such as planetaria, for public education.

In the first step of its national program plan, Nigeria is contributing a satellite to the Disaster Monitoring Constellation. For 15 months, 15 Nigerian engineers were trained at Surrey. Based on the success of that program, the government has decided to initiate a "second national project," NigeriaSAT-2, which is a small geostationary communications satellite "that has been selected specifically to address the lack of communications infrastructure in Nigeria."

"Experiences in other developing countries, such as India and Indonesia, have shown how satellite-based communication systems have opened up the rural areas of development," Boroffice stated. NigeriaSAT-2 will provide "independent communications coverage throughout Nigeria and regional coverage to some West African countries."

In sum, Boroffice said, "a well-funded space program will be a demonstration of the political will to acquire this strategic technology which is crucial to socio-economic development, and national security."

The Moon or Mars?

While many developing nations reported to the Congress on their progress in entering the space age, representatives from the already-established space powers were trying to find their way back to a vision of the future.

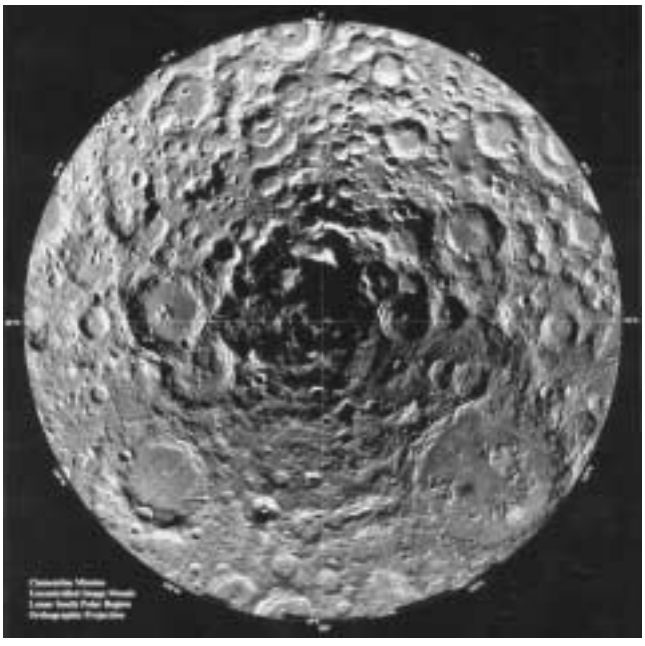
Throughout a series of presentations at the World Space Congress, Dr. Wesley Huntress, former NASA Associate Administrator for Space Science, and currently Director of the Carnegie Institution's Geophysical Laboratory, stated that what distinguishes the past from the present is that 50 years ago, even though we did not have a space program, "we had a vision." That vision, he said, "was spelled out by Wernher von Braun," in a 1950s series for *Colliers* magazine. "We had a vision for going to the Moon," Huntress recalled. Walt Disney produced television shows in 1954, with the help of von Braun, showing what the future of space exploration would be, including enormous space stations, then lunar landings, and finally, manned missions to Mars.

"We lost that vision after we went to the Moon," Huntress said, and since then we have just "huddled together," stuck in Earth orbit. Actually, as was pointed out by lunar scientist Paul Spudis, from the Johns Hopkins Applied Physics Laboratory, the Apollo program was a diversion from Wernher von Braun's incremental architecture. But it did create a vast infrastructure, which put almost any destination within reach. The von Braun plan had been, first, to enable people to live and work in nearby low-Earth orbit, providing them with reliable transportation to and from space, and living quarters. Then, a large, multi-use space station in orbit would be used to train astronauts to live in micro-gravity, and assemble, check-out, and fuel the large spacecraft heading to the Moon and later to Mars.

Huntress pointed out that what the space program needs now is "a destination, and not a piece of hardware." The International Space Station is not an end in itself, but a jumping-off point to somewhere else. For the past 50 years, it has been assumed that this "somewhere else" would first be the Moon, where scientific research, technology development and testing, and industrial manufacturing capability would lay the basis for going the tens of millions of miles to Mars.

Over the past few years, however, there has been a drumbeat to forget about going back to the Moon, and instead head straight for Mars. The announcement in 1996 by a team of scientists, proposing that artifacts found in a meteorite from Mars indicated the fossil remains of life, heightened public and scientific interest in the possibility that life exists, or existed, on the red planet.

On July 4, 1997, the diminutive Sojourner rover landed on Mars, and captivated the world with its plodding excursions over the Martian surface. Perhaps, some at the space agency thought, this renewed public excitement about Mars could be leveraged into Congressional support for increased NASA funding. Increased emphasis was put on the series of robotic Mars missions which NASA is in the midst of carrying out, and the question of finding life on Mars became their organizing principle.

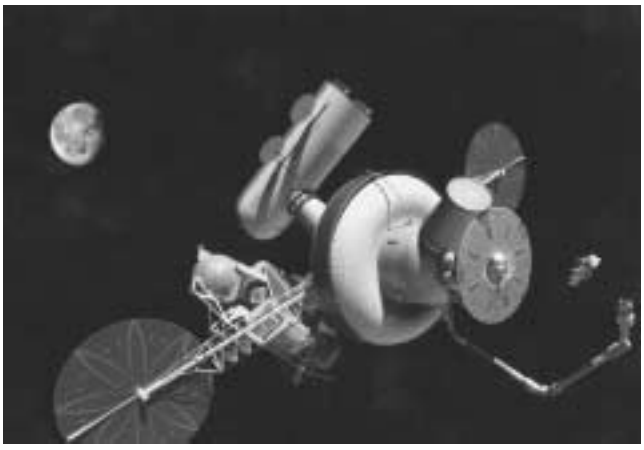


The 1994 Clementine spacecraft produced this spectacular image of the South Pole of the Moon. Measurements indicated the presence of water ice in the permanently shadowed regions, with subsequent observations by Lunar Prospector confirming this important discovery.

There is no question that the unmanned exploration of Mars must be carried out with a steady commitment over decades, and long-term planning and funding, to culminate in the human exploration and settlement of the red planet. But the 1998 founding of the Mars Society, and the high-profile organizing campaign by its founder, Robert Zubrin, threw rational long-term planning out the window, in exchange for the ephemeral promise of a "quick fix" for the space program. The public will not be excited by, or support, a manned return to the Moon, Zubrin insisted, because we've "been there, done that." The Moon is "not interesting," he often repeated, and will only divert scarce resources from the manned Mars mission. Since there is little (if any) money available now for future manned missions, Zubrin based his ill-conceived "Mars Direct" proposal on conventional technology, with the objective of launching crews to Mars within a decade, (before elected representatives lose interest in the project), spending as little money as possible.

At the World Space Congress, the issue of whether the next target for human exploration beyond Earth orbit should be the Moon or Mars, was crystalized in a debate between Zubrin and Paul Spudis, attended by hundreds of conference delegates. The debate, and companion technical sessions, allowed Spudis and the lunar proponents to make an eloquent case for the need to return to the Moon.

Spudis answered the question, "Why the Moon?" by stat-



NASA's Exploration Team has proposed that a "Gateway" facility be built at the Earth-Moon L1 point, 322,127 kilometers (about 190,000 miles) from Earth. The Gateway would include temporary living quarters for visiting crew, facilities to service astronomical observatories, and vehicle fueling and servicing centers for journeys to the Moon and Mars.

ing: "It's close; it's easy to get to; it's an interesting place to study; it's got what we need to survive; it's on the way to everywhere else." Also important, for the first long-term human venture off this planet, the Earth is always visible in the sky. The Moon can be reached easily in a few days. Spudis described it as a "miniature museum of geological processes and history, the study of which is relevant to all of the terrestrial planets." With its airless surface, the Moon contains a record of events in the Solar System, including the history of the Sun, over the last 4 billion years.

According to NASA, scientists attending a recent meeting in Crete proposed that the Moon may also contain a record of the early history of the Earth, which has been erased through millennia of tectonic, volcanic, and climatological processes. Lunar meteorites are found on the Earth. Why shouldn't pieces of the Earth that were blasted off by large impacts, be spewed over the surface of the Moon? A recent study indicates that as much as 20,000 kg of Earth material might be found in every 100 square kilometers of the Moon.

The most important thing we will learn on the Moon, Spudis stated, is how to process and use extraterrestrial resources. The ice recently discovered at the lunar South Pole "is enough to fill a small lake," estimated at 10 billion tons. The Moon is a "permanent space station," Spudis said, and we should use it to "learn to live off-planet." We can use it to "learn how to explore, and bootstrap cislunar infrastructure to go elsewhere."

Over the course of the Congress, Spudis proposed that there should be a human return to the Moon within five years. Existing technology could be used for the initial missions, and each would build up the infrastructure, leading to a permanent human presence. Over the course of the World Space Congress, innovative proposals were presented, by younger participants, for using the Moon as a platform for astronomy; and the unmanned lunar missions that are already under development in Europe and Japan, and under consideration in India, were described.

Veteran astronaut John Young expressed his support for manned lunar exploration at the Congress, by quoting space visionary Krafft Ehricke: "If God had wanted man to explore space, He would have given him a Moon."

Possible Next Steps from Earth Orbit

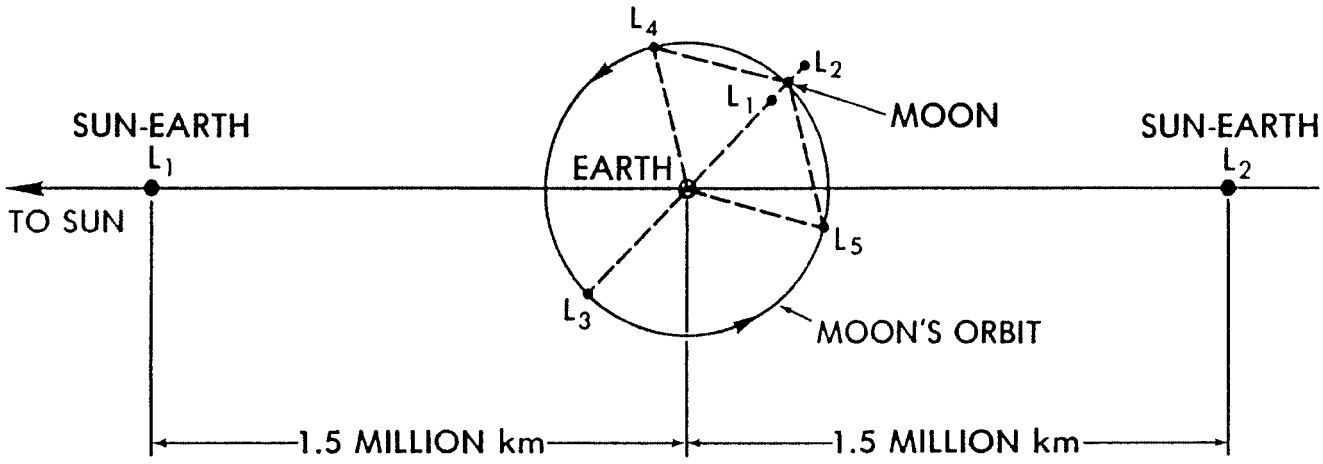
Former NASA official Huntress told a press conference on the last day of the Congress, that for many years, the space agency was "forbidden by the Administration and the Congress from having a plan" for future human space exploration. "This shackle has been lifted in the last few months," he stated, referring to a number of ongoing studies—by the Aurora project of the European Space Agency, the International Academy of Astronautics, and the long-range planning group, NASA Exploration Team (abbreviated NExT)—which are developing possible scenarios for programs beyond the space station. "It reminds me of just a few months into the Apollo program," Huntress said, when different scenarios were debated "when we had to decide how to go to the Moon."

In a paper titled, "Innovations in Mission Architecture for Exploration Beyond Earth Orbit," a team from the NASA Johnson Space Center and the Jet Propulsion Laboratory presented preliminary results from the NExT study. The motivation, as they explain it, is to "enable a stepping stone approach to science-driven, technology-enabled, human and robotic exploration." The strategy aims to "extend remote sensing of the planets and stars," to "expand the knowledge return from [unmanned] spacecraft," and to identify technologies that "enable exploration by humans beyond low-Earth orbit." They caution that the design concepts presented are used as "existence proofs and are not presumed to be final designs." There is no doubt that what they presented will be hotly debated in the space community.

Basically, the NASA team decided to dodge the bullet, by not endorsing either a Moon or Mars human exploration mission, but instead laying out an interim architecture that positions the space agency to carry out either, when a political decision is made. Space historian Howard McCurdy commented on the NExT proposal to *space.com* on Sept. 26, aptly stating: "This incremental step-at-a-time approach was adopted by space advocates after President Nixon, in 1970, denied the request for a comprehensive long-range plan." NASA's current leaders "have chosen to pursue this goal incrementally because they were told not to divert their attention beyond the space station until that project neared completion. Not only are they ready to undertake missions beyond, they have been waiting to do so since the agency was born."

The NExT proposal would take advantage of a feature of orbital mechanics that creates libration points between two large bodies in space, where the gravitational force between them reaches a kind of equilibrium. A small body placed at these libration points will remain somewhat at rest in relation

FIGURE 1
The Sun-Earth, Earth-Moon Libration Points



Source: Robert W. Farquhar, Johns Hopkins University Applied Physics Laboratory.

One mission design for human exploration of space beyond Earth orbit, makes use of the libration points in the Sun-Earth, Earth-Moon system—points where the gravitational forces of two bodies balance. From a staging facility at the Earth-Moon L1 libration point, missions could be sent to the Moon or beyond. The L1 libration point in the Sun-Earth system is already populated with unmanned satellites, uninterruptedly observing the Sun.

to the large bodies, in a relatively stable position. In the Earth-Moon, and Sun-Earth relationship, there are a variety of libration points, as seen in **Figure 1.** From these null-gravity, stable points in space, it is possible to travel anywhere else in the Solar System expending very little energy.

There are some locations that are preferable for the deployment of astronomical observatories. Already, telescopes, including the Solar Heliospheric Observatory (SOHO) and Advanced Composition Explorer, have been placed at the Sun-Earth L1 libration point, about 1.5 million kilometers (900,000 miles) from Earth, to obtain an uninterrupted view of the Sun. The planned follow-up for the Hubble Space Telescope will be placed there, as well.

One of the objections to the placement of expensive and delicate telescopes, such as the upcoming James Webb Space Telescope, at the Sun-Earth libration points, is that they cannot be serviced by astronauts from the Space Shuttle. The successful repair, maintenance, and upgrading of the Hubble Space Telescope by astronauts has made it into the magnificent facility that it is.

In his Congress presentation, on "Utilization of Libration Points for Human Exploration in the Sun-Earth-Moon System and Beyond," long-time space planner Robert Farquhar detailed the new astronomy missions slated to be deployed at Sun-Earth libration points over the next ten years. He proposed that the telescopes could be robotically transferred, over a matter of days, from their observational position, to a libration point in the closer Earth-Moon system, only 323,110 kilometers (about 190,000 miles) from Earth, for periodic servicing by astronauts. The NExT team proposes the emplacement of infrastructure at the Earth-Moon L1 point, to create a "Gateway," that will allow servicing of in-space facilities, and "support the range of potential destinations."

In Farquhar's design, a Deep-Space Shuttle would operate between the space station and Earth-Moon L2 libration point, and an Interplanetary Transfer Vehicle, stationed in the vicinity of the Earth-Moon L2 Gateway, could transport astronauts to their next stop. Reusable lunar landing vehicles could be stationed in the vicinity of the Earth-Moon libration point. Landing on the Moon from the libration point reduces the constraints, as compared to going directly from the Earth or from lunar orbit. Landings could take place at any time, and at any site on the Moon, such as the icy poles—not just in the equatorial regions, as were done in the Apollo program.

The NExT team also outlined their scenario for travelling from the Earth-Moon L1 Gateway to Mars, estimating that with advanced technologies—such as nuclear propulsion—significantly shorter travel times and increased payload capacity would result.

In her remarks to the Congress, astronaut and Chief Scientist at NASA headquarters, Shannon Lucid, made her case for visionary human exploration missions, noting that the session was taking place the day after Columbus Day. "Ancient sailors hugged the coastlines," she said. "Today we hug the rim of our planet." The International Space Station, which will help us answer the questions we need to know in order to explore further, she said, should be seen as the "pit-stop to the planets."