POTENTIAL INTERNATIONAL COOPERATION IN NASA'S NEW EXPLORATION INITIATIVE

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BY

MARCIA S. SMITH
SPECIALIST IN AEROSPACE AND TELECOMMUNICATIONS POLICY
CONGRESSIONAL RESEARCH SERVICE

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Mr. Chairman, members of the Committee, thank you for inviting me here today to testify about potential international cooperation in President Bush's exploration initiative. You asked that I provide an overview of the international space setting, to provide information about the roles that Europe, Russia, and India might play, and to raise related issues that might be of interest to the committee.

The New Exploration Initiative

On January 14, 2004, President George W. Bush made a major space policy address in which he directed NASA to focus its activities on returning humans to the Moon by 2020 and someday sending them to Mars and "worlds beyond." The President invited other countries to participate, saying —

> We'll invite other nations to share the challenges and opportunities of this new era of discovery. The vision I outline here is a journey, not a race. And I call on other nations to join us on this journey, in the spirit of cooperation and friendship.

The International Space Setting

The President's exploration initiative involves both human and robotic space flights to the Moon, Mars, and "worlds beyond," as well as space-based observatories and other spacecraft to answer the question of whether there is life elsewhere in the universe. This broadly scoped exploration program opens a wide range of opportunities for international participation.

The number of countries involved in space activities is probably larger than most people realize. The list of "launching countries" — those that have their own launch vehicles and launch sites — includes the United States, Russia, Europe, China, Japan, India, and Israel. Like the United States, Russia, Europe, and Japan have sent spacecraft to the Moon and beyond (see Appendix 1).

Although the United States, Russia, and China are the only countries capable of launching people into space, astronauts and cosmonauts from 29 other countries have journeyed into space on American or Russian spacecraft.[1] Many countries have their own communications or remote

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[1] Afghanistan, Austria, Belgium, Bulgaria, Canada, Cuba, Czechoslovakia, France, Germany, Hungary, India, Israel, Italy, Japan, Kazakhstan, Mexico, Mongolia, the Netherlands, Poland, Romania, Saudi Arabia, Slovakia, South Africa, Spain, Switzerland, Syria, Ukraine, United Kingdom, and Vietnam.

sensing satellites.[2] Virtually every country in the world *uses* satellites, primarily for communications, weather, navigation, and remote sensing.

NASA's authority to conduct international space activities is codified in Section 205 of the 1958 National Aeronautics and Space Act, which created NASA. Since that time, the agency has engaged in thousands of cooperative arrangements ranging from the exchange of data, to training scientists how to interpret remote sensing imagery, to foreign experiments on U.S. satellites and U.S. experiments on foreign satellites, to joint development of spacecraft, to construction of the International Space Station (ISS). Cooperation has been undertaken not only with U.S. allies, but with our rivals as well. Even at the height of U.S.-Soviet space competition in the early days of the Space Age, the two countries also worked together—at the United Nations through the Committee on Peaceful Uses of Outer Space, and through bilateral cooperative agreements as early as 1962.

While the number of potential partners for the new exploration initiative is large, it is likely that attention will focus first on countries with whom the United States has traditionally cooperated in large space endeavors such as ISS (which involves Canada, Europe, Russia, and Japan), and those with the ability to launch spacecraft. You asked that I focus my remarks on the potential roles that Europe, Russia, and India could play.

Europe

Brief Overview. European countries conduct space activities in a number of ways. Some countries, such as France, Germany, and Italy have substantial national space programs, and may invite international cooperation in those activities on a bi- or multi-lateral basis. Other European space activities are conducted under the aegis of the European Space Agency (ESA). ESA currently has 15 members: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Some of ESA's programs are mandatory (all members must contribute to them) and others are optional (countries can choose whether or not to participate). Europe's participation in the ISS program is primarily through ESA, where it is an optional program. Eleven ESA members participate.[3] (The United States and Italy also have a separate bilateral agreement covering certain hardware provided by Italy.) ESA and the European Union (EU)[4] are working closely together today, and in January 2004, the European Parliament adopted a "Resolution on the Action Plan for Implementing the European Space Policy." ESA and the EU are jointly sponsoring the development of the Galileo navigation satellite system, and are encouraging other countries to join them in that program.

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[2] A comprehensive list is outside the scope of this testimony, but, in addition to the launching countries, includes Algeria, Argentina, Australia, Brazil, Canada, Egypt, Indonesia, Nigeria, Malaysia, Morocco, Pakistan, Philippines, Saudi Arabia, South Africa, South Korea, Taiwan, Turkey, and the United Arab Emirates.

[3] Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom are signatories to the ISS Intergovernmental Agreement. The United Kingdom does not provide funding for the ISS program, however, so in some case the number of participants is cited as 10.

[4] The EU members are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Ten more countries will join the EU in May 2004: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia. Additional countries have applications pending.

ESA developed the Ariane launch vehicle; its first launch was in 1979. Ariane launches are conducted by the French company, Arianespace, from Kourou, French Guiana, on the northern coast of South America. ESA also is developing a smaller launch vehicle, Vega, and has a cooperative agreement with Russia to launch Russia's Soyuz launch vehicle from Kourou. Arianespace is often cited as being the dominant provider of commercial space launch services in the world, but the downturn in the commercial space market has affected Arianespace along with other commercial launch services companies. Consequently, ESA adopted a European Guaranteed Access to Space (EGAS) program that will provide 960 million euros to Arianespace through 2009.

Astronauts from several European countries have flown into space as representatives of ESA or their own countries on Russian or American spacecraft. In the late 1980s, ESA announced a plan to develop its own human space flight vehicle, Hermes, but the program was terminated because of cost considerations.

ESA and individual European countries have built and launched a large number of spacecraft including space-based observatories and other scientific satellites (including some to destinations beyond the Moon, see Appendix 1), as well as satellites for communications, weather, and remote sensing. They are primarily for civilian purposes, but some of the non-ESA satellites are military.

ESA's 2003 budget was 2.7 billion euros ($3.1 billion using today's exchange rate).

Current Interest in Space Exploration. ESA initiated the Aurora program in 2001 to formulate and implement "a European long-term plan for the robotic and human exploration of solar system bodies holding promise for traces of life."[5] The Aurora program envisions an international human mission to Mars by 2025. ESA's Mars Express spacecraft is now in orbit around Mars, and SMART-1 is currently enroute to the Moon.

The European reaction to President Bush's speech was generally supportive, though cautionary about obtaining the required resources to conduct such a program. In a joint ESA-EU statement, ESA's Director General, Jean-Jacques Dordain, stated that "The important point in looking at the American vision is that space is an international field. A coherent European Space Policy does not make any sense if not grounded in the larger global context." He added that "Unlike in the days of the Cold War, getting to the moon and Mars is not about proving one's superiority over a political enemy. It is about all of us, around the world, working together for the common benefit."[6]

Potential Role in the Exploration Initiative. European countries individually and through ESA could participate in the exploration initiative at many levels, including providing launch capacity, building and operating robotic and human spacecraft, providing scientific instruments, and providing astronauts. The United States has a long history of cooperation with ESA and individual European countries on scientific and human space flight programs, including the space shuttle and the International Space Station.

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[5] See ESA's Aurora Web site: www.esa.int/SPECIALS/Aurora/ESA9LZPV16D_0.html.

[6] Europe's United Response to US Space Plans. European Commission press release, February 18, 2004.

Russia

Brief Overview. The Soviet Union launched the first satellite into space (Sputnik, 1957), the first person into space (Yuri Gagarin, 1961), the first space station (Salyut 1, in 1971) and achieved many other space "firsts." The Soviets conducted a broad space program similar to that of the United States, with spacecraft orbiting the Earth for scientific or applications purposes (military and civilian), probes sent to the Moon and Mars, and a robust human space flight program. Since 1967, Soyuz spacecraft have been used to take cosmonauts into space. The Soyuz has been upgraded several times, and is currently designated Soyuz TMA. The Soviets were not able to develop a Saturn V-class launch vehicle capable of sending cosmonauts to the Moon during the 1960s, and concentrated instead on activities in Earth orbit, operating seven space stations from 1971-2001. The best known of these is the Mir space station complex (1986-2001). It was permanently occupied by cosmonauts from 1989-1999, and intermittently occupied in other years. Mir was deorbited in 2001. Crews sometimes included individuals from other countries, including the United States.

Russia developed a space shuttle similar (but not identical) to the U.S. shuttle. Called Buran, it was launched only once, in 1988, without a crew. By this time, the Soviets had succeeded in developing a Saturn V-class launch vehicle, called Energia. Energia was launched only twice, however (including the Buran flight).

Following the collapse of the Soviet Union in 1991, Russia sharply reduced funding for space activities. The Energia and Buran programs were discontinued. Yuri Koptev, who headed the Russian space agency from its founding in 1992 until March 2004, often said that the Russian space budget was approximately one-tenth of its level under the Soviet government. According to Mr. Koptev, the 2004 budget for Russian civilian space activities is $526 million.[7]

Russia restructured its space program in March 2004. The Russian Aviation and Space Agency, which Mr. Koptev headed, was split into two, with aviation programs transferred to one agency, and space programs placed in a new Federal Space Agency subordinate to the Ministry of Industry and Energy. Mr. Koptev was replaced by Col. Gen. Anatoly Perminov, who previously headed Russia's military space program. What impact, if any, these changes will have on U.S.-Russian space cooperation is not known at this time.

The United States and the Soviet Union/Russia have cooperated in space activities since the early 1960s in space science and human space flight activities. The two countries conducted the Apollo-Soyuz Test Project in 1975 where a U.S Apollo spacecraft docked with a Russia Soyuz spacecraft for two days of joint experiments. From 1995-1998, seven U.S. astronauts remained on Russia's space station *Mir* for long duration (several month) missions, Russian cosmonauts flew on the U.S. space shuttle seven times, and nine space shuttle missions docked with *Mir* to exchange crews and deliver supplies. Russia joined the U.S.-led International Space Station program in 1993 and Russians and Americans now routinely fly on each other's space vehicles and share duties on space station crews. Russia is currently providing the only access to the space station for crews and cargo while the U.S. space shuttle is grounded.

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[7] Russian Aerospace Agency to Have $632 Million for 2004 Air, Space Craft Programs. Moscow Agentstvo Voyennykh Novostey WWW-Text in English, 1252 GMT, 29 Jan 04 (via Foreign Broadcast Information Service, hereafter FBIS).

Current Interest in Space Exploration. Although the Soviets were never able to send cosmonauts to the Moon, and funding for space activities declined dramatically after the collapse of the Soviet Union, Russian government and industry space officials continue to express strong interest in human exploration missions. At an international space conference in the fall of 2003, then-director of the Russian space agency, Yuri Koptev, outlined long-term Russian plans, including permanent human bases on the Moon and Mars. He added that "we believe that an organization similar to the one for the ISS should be the basis for implementation of such ambitious projects."[8]

Following President Bush's speech, however, Mr. Koptev expressed skepticism, saying that he thought it was "a tool in the current election campaign"[9] and said "It is necessary to drop emotions in order to see what real benefit people can derive from visiting these planets."[10] Mr. Koptev's successor, Gen. Perminov, expressed a more favorable view, saying that he supports President Bush's initiative, and wants more international cooperation in Russian space activities overall.[11] On April 12, 2004, in celebration of Cosmonautics Day, Russian President Putin stopped short of embracing such plans, but said that space "was and remains an object of our national pride" and only by developing its space industry can "Russia claim leadership in the world." He added that the economic situation in Russia constrains the amount of funding available for space activities, but "I want you to know that everyone in the leadership of the country understands that space activities fall into the category of the most important things."[12]

Potential Role in the Exploration Initiative. The Russians could cooperate in the exploration initiative at many levels. They have a range of launch vehicles that are launched from three sites (Plesetsk, near the Arctic Circle; Svobodny, in eastern Siberia; and the Baikonur Cosmodrome, near the Aral Sea in Kazakhstan, which Russia leases from Kazakhstan). As noted, the heavy-lift Energia launch vehicle was discontinued, but possibly could be resurrected if sufficient funding were provided. If development of a new launch vehicle is required, Russian rocket engines could be used. Russia already builds the engines (RD-180s) for one of the U.S. launch vehicle families (Atlas).

Russia has extensive experience in long-duration human space flight. Three Russian cosmonauts have stayed in space continuously for one year or more; the longest mission was 14 ½ months. (The longest any American has remained in orbit continuously is 6 ½ months.) The Russians also launched a series of Bion biosatellite missions that carried animals for life sciences experiments. NASA cooperated with Russia on some of these missions,[13] and may be interested in using such free-flying spacecraft to augment research on the International Space Station.

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[8] Morring, Frank. Big Plans. Aviation Week & Space Technology, Oct. 13, 2003, p. 29.

[9] Russian Space Chief Calls US Space Plans an [sic] Campaign 'Tool' for Bush. Moscow Agentstvo Voyennykh Novostey WWW-Test in English, 1052 GMT, 29 Jan 04 (via FBIS).

[10] Moscow ITAR-TASS in English, 1028 GMT, 17 Feb 04 (via FBIS).

[11] Pieson, Dmitry. Perminov Supports Moon/Mars Plans, International Cooperation. Aerospace Daily, 5 April 2004, p. 5.

[12] Russia: Putin Acknowledges Budget Problems in Space Exploration. Moscow, ITAR-TASS in English, 1730 GMT, 12 Apr 04 (via FBIS).

[13] NASA's participation in the last two Bion flights, Bion 11 and 12, in 1996-1997, was controversial, especially after a rhesus money used for the experiments on Bion 11 died during a post-flight examination. After an independent review, NASA suspended its participation in primate research on Bion 12.

Russia also has considerable experience with the use of nuclear reactors in space, an area in which NASA is interested. Russia is the only country to have used nuclear reactors operationally in space (the United States has launched only one test reactor into space, in 1965). They were developed to power Radar Ocean Reconnaissance satellites (RORSATs) beginning in 1967, but the Soviets terminated their use after three incidents (in 1978, 1983, and 1988) in which spacecraft malfunctions caused, or nearly caused, radioactive material to return to Earth. Russia has less experience than NASA with radioisotope thermal generators (RTGs), another type of nuclear power source for spacecraft, but today provides the plutonium used in U.S. RTGs.

Russia has launched many probes to the Moon, Venus, and Mars (see Appendix 1), and two to Halley's Comet. The most recent Russian Mars probes (Phobos 1 and 2, and Mars '96) involved extensive international cooperation

India

Brief Overview. India conducted its first launch in 1979, and typically launches once or twice a year. India has three launch vehicles: the ASLV for low Earth orbits, the PSLV for polar orbits, and the new GSLV for launches to geostationary orbit. Launches are conducted from Sriharikota, an island off the southeast coast of India. India hopes to enter the commercial launch services market using the GSLV.

Most of India's satellites are test satellites related to the development of new or improved launch vehicles, or are for remote sensing. India also has purchased or built communications/weather satellites that are launched for India by foreign commercial space launch service providers. India's annual space budget is approximately $450 million.[14]

One Indian, Rakesh Sharma, has flown in space, on a Russian spacecraft in 1984.[15]

Current Interest in Exploration. In 2003, India announced plans to launch a robotic spacecraft to the Moon in 2007 and is inviting other countries to participate. India is offering to fly 10 kilogram payloads from interested countries for free. Canada, Germany, Russia, Israel, Europe, and the United States reportedly have expressed interest. The United States and India renewed cooperation in scientific areas, including space exploration, after the United States lifted sanctions imposed in 1998 following India's nuclear weapons tests.

The head of the Indian Space Research Organization (ISRO), G. Madhavan Nair, has stated that the robotic lunar probe, Chandrayaan-1, is only the first step in India's space exploration plans. India's President Kalam and Prime Minister Vajpayee also have made supportive statements not only about robotic missions, but about eventual human space flights to Mars.

Potential Role in the Exploration Initiative. India could offer launch services, and if its lunar probe is successful, that could open possibilities for other robotic missions.

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[14] Rohde, David. India's Lofty Ambitions in Space Meet Earthly Realities. New York Times, January 24, 2004, p. A3.

[15] NASA astronaut Kalpana Chawla, who perished aboard the space shuttle Columbia in 2003, was born and raised in India, but had become a U.S. citizen.

Issues

The exploration initiative is still in its earliest definition stages and is likely to take decades to complete. It is difficult to predict at this early stage what issues will arise as it is carried out. Among those likely to require early attention are specific questions concerning how to prevent unwanted technology transfer while not impeding cooperation, and how to protect the U.S. industrial base while encouraging international participation. Today, however, I would like to focus on three broader issues: who will join us, the line between cooperation and dependence, and whether a review of the U.N. space treaties is needed.

Who Will Join Us? Many countries have aspirations to send human and robotic spacecraft to the Moon, Mars, and beyond. In virtually every discussion, the assumption is that these will be international undertakings because of their cost. While international projects are more difficult to manage, which may increase their total cost, the cost to each participant may be less than if the program were conducted by one nation alone. The President has invited international participation in a U.S.-led exploration initiative. The questions are what countries do we want to include, and will they want to join?

Several factors weigh in decisions about who to invite to join international projects. These include not only who can offer needed capabilities and funding, but political relationships. In a program such as this, likely to span several decades, the latter can be particularly complicated. Few would have expected in the 1980s that Russia would be a partner in ISS a decade later, and the only country capable of sending people and cargo to it today. Not surprisingly, in conjunction with the President's speech, NASA's first outreach was to its partners in the International Space Station program, but the question on many minds is whether China will be included in the new initiative. At a press conference after President Bush's speech, NASA Administrator O'Keefe was asked that question. He responded that there is an opportunity to open that debate, but did not want to speculate on its outcome Congress may wish to consider the advantages and disadvantages of having China as a partner, or as a competitor, in the exploration initiative.

After we identify whom we want to invite, the question will be whether they will agree to join us. The United States has a rich history of international cooperation, and many countries have benefitted from it. We also have, by far, the most financial resources. NASA's budget is five times that of ESA and 30 times that of the Russian space agency. But for all of the successes of U.S.-led international cooperation, there have been strains as well. In any international space endeavor, compromises and adjustments must be made. The United States has demonstrated flexibility when partners have not been able to fulfill their promises, and others have had to adjust to changes in U.S. plans. The International Space Station is a prime example of both. As the leader of that project, though, there is a greater impact when the United States changes its plans, and there have been many throughout the past two decades. Now, the President's exploration initiative involves another major change, with termination of the space shuttle program as soon as space station construction is completed, and ending NASA's use of ISS by FY2017. The President assured the ISS partners that the United States would fulfill its obligations, but it is not clear how that will be accomplished without the shuttle.

Only the partners themselves can answer the question of whether they view ISS as a positive or negative experience, but it necessarily will factor into their judgments about the current offer. Another factor is what role they would play in setting the goals and objectives of the exploration initiative. So far, the message is that they are being invited only to help "achieve this set of American, U.S. objectives," as NASA Administrator O'Keefe stated after the President's speech.

Whether they will want to participate under that condition, or look for other opportunities where they might be able to develop a shared vision, is not clear. With the end of the Cold War, and the emergence of more countries with launch capabilities, the United States can no longer assume that traditional partners like Europe, Japan, and Canada would necessarily choose to join with the United States, instead of Russia or China, for example.

How Dependent Should the U.S. Be on International Partners? Traditionally, NASA has established cooperative programs in a manner such that other countries were not in the "critical path"— that is the program could be accomplished even if the foreign partner did not fulfill its obligations. This policy began to change when Russia joined the space station program in 1993. Although Congress directed that Russian participation should "enhance and not enable" the space station,[16] the revised design was clearly dependent on Russia for life support, emergency crew return, attitude control, reboost, and other functions, especially in the early phases of space station construction. Today, because of the space shuttle *Columbia* accident, NASA is completely dependent on Russia for taking astronauts to and from the space station, and delivering cargo.

The situation today demonstrates the value of international cooperation, but also raises the question of whether the United States wants to put itself in the position of being dependent on other nations to execute its space activities. As noted, one of the two major U.S. launch vehicle families, Atlas, is dependent on engines designed and built in Russia. Under the President's initiative, U.S. access to the space station between 2010 (when the shuttle is retired) and 2014 (when the new Crew Exploration Vehicle is available) also would be dependent on Russia. While some view that as similar to the situation today, it would, in fact, be quite different. The reasons are too complex to discuss fully in this statement (see CRS Issue Brief IB93017), but briefly, today, there is an agreement in place where Russia is launching U.S. crews and cargo to ISS at no cost to NASA. It expires in 2006, however, and no agreement has been negotiated for 2010-2014. Russia could charge whatever price it wanted for those services, and if the Iran Nonproliferation Act is still in effect, it is not clear if NASA could pay. There also is a difference between the emergency situation today, necessitated by the *Columbia* tragedy, and an intentional decision to terminate NASA's ability to launch astronauts into space and hope that the political relationship with Russia remains stable and an agreement can be negotiated to enable U.S. astronauts to continue working aboard ISS. In this sense, the President's decision may be interpreted as forgoing "assured human access to space." To the extent the decision could create a condition where U.S. astronauts might not be able to work aboard ISS, a facility being built largely at U.S. taxpayer expense, Congress may choose to explore its implications. More broadly, where to draw the line between cooperation and dependence might be an issue of congressional interest.

Are New International Treaties or Principles Needed? The United States is a party to four U.N. treaties that regulate space activities: the Outer Space Treaty, the Astronaut Rescue and Return Agreement, the Registration Convention, and the Liability Convention. None of the major space faring countries, including the United States, is a party to a fifth U.N. space treaty, the Moon Agreement, which focuses on exploitation of the Moon.[17] A brief synopsis of the five space treaties is included in Appendix 2. The U.N. also developed several legal principles for space

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[16] H. Rept. 103-273, to accompany H.R. 2491, the FY1994 VA-HUD-IA appropriations bill (P.L. 103-124).

[17] The 10 countries that are parties to the Moon Agreement (meaning they have both signed and ratified it) are Australia, Austria, Chile, Kazakhstan, Mexico, Morocco, The Netherlands, Pakistan, Philippines, and Uruguay. Five others have signed it (France, Guatemala, India, Peru, and Romania), but have not ratified it, so are not bound by its provisions.

activities, including Principles Relevant to the Use of Nuclear Power Sources in Outer Space, that could impact exploration plans.

Even before President Bush's announcement, some observers were suggesting that it was time to review the space treaties to determine if any changes or new agreements are needed to reflect the growing role of the private sector in space. The treaties were negotiated in an era when space programs were conducted by governments, not private entities. There is growing debate about whether or not the treaties preclude private property rights in space, for example. These issues have not been the subject of intense interest in recent years because the likelihood of any nation or company setting up mining operations, for example, on the Moon or other celestial bodies has seemed remote. With President Bush's announcement, however, that day may be drawing nearer, and a review of the space treaties may be in order.

Conclusion

As is often said, to be a leader, one must have followers. With the wider variety of international cooperative opportunities available today, potential partners might want a stronger voice in deciding what is to be done and how — to have a shared vision, not just a U.S. vision — and choose other international arrangements.

The United States still has by far the largest budget for civilian space activities, however. That fact, coupled with the large number of successful U.S.-led cooperative space endeavors over the past 46 years, may convince other countries to join us rather than establish partnerships of their own without U.S. involvement.

At the same time, questions may arise about whether the United States may be going too far in becoming dependent on other countries for human access to space. Choosing to make the U.S. human space flight program dependent on Russia for at least 4 years is a significant departure from past policy. While it may signal a broader attitude towards cooperation, the advantages and disadvantages of losing "assured human access to space" may be a timely topic for discussion.

The exploration initiative offers the United States an opportunity to affirm its historic role in fostering international cooperation in space. The key will be whether we can adapt to the changed landscape of cooperative possibilities, and continue to lead the world in the peaceful exploration of space.

Appendix 1: European, Russian, and Japanese Spacecraft Launched to the Moon and Beyond

Spacecraft	Launch Year	Mission
Europe		
Helios 1 and 2	1974, 1976	German spacecraft, launched by NASA, to study the Sun.
Giotto	1985	ESA spacecraft, launched by ESA, that intercepted Halley's Comet in 1986.
Ulysses	1990	ESA spacecraft, launched by NASA, in polar orbit around the Sun.
Solar & Heliospheric Observatory (SOHO)	1995	ESA spacecraft, launched by NASA, at Sun-Earth L-1 Lagrange point for solar-terrestrial studies.
Huygens	1997	ESA probe that is attached to the U.S. Cassini spacecraft, which will reach Saturn in July 2004. The probe will detach from Cassini and descend through the atmosphere of Titan, one of Saturn's moons.
Mars Express/Beagle 2	2003	ESA spacecraft, launched by Russia, that is in orbit around Mars. Contact with Beagle 2, a lander, was lost after it separated from Mars Express.
SMART-1	2003	ESA spacecraft, launched by ESA, that is enroute to the Moon. Due to reach lunar orbit in early 2005.
Rosetta	2004	ESA spacecraft, launched by ESA, that is scheduled to reach Comet 67P/Churyumov-Gerasimenko in 2014, enter orbit around it, and land a small spacecraft on its icy nucleus.
Soviet Union/Russia		
Luna 1-24	1959-1976	Series of spacecraft to impact, orbit, or land on the Moon, including two rovers (Lunokhod 1 and 2), and three robotic sample return missions (Luna 16, 20, and 24). Luna 2, in 1959 was first "landing" (impact) on Moon. Luna 3, also in 1959, sent back first pictures of the far side of the Moon. Luna 10, in 1966, was first spacecraft to orbit the Moon. Luna 16, in1970, was the first robotic sample return mission. Lunokhod 1 (Luna 17), in 1970, was first robotic lunar rover. This series experienced a mixture of successes and failures.
Zond 1-3	1962	Zond 1 went to Venus, but was not operating when it reached that planet. Zond 2 and 3 made fly-bys of Mars, but were not operating when they reached the planet.
Zond 4-8	1968-1970	Automated precursors for human trips to the Moon.

Spacecraft	Launch Year	Mission
Mars 1-7	1960-1973	Contact with Mars 1 was lost before it reached the planet.. Mars 2 and 3 were orbiter/lander pairs. The orbiters were successful, the landers were not (both reached the surface, but only Mars 3 transmitted thereafter, and only for 20 seconds). Mars 4 and 5 were orbiters; Mars 6 and 7 were landers. Mars 5 was a success. Mars 4 and 7 missed the planet. Mars 6 transmitted during descent, but contact was lost before landing. Western analysts believe there were other Mars attempts that failed and were given generic Kosmos designations.
Phobos 1 and 2	1988	Intended to study Phobos, one of the moons of Mars, and Mars itself. Contact with Phobos 1 was lost before it reached Mars. Phobos 2 successfully orbited Mars and returned data, but contact was lost when it maneuvered to study Phobos.
Mars 96	1996	Failed attempt to send a spacecraft to Mars that had an orbiter, two small landers, and two surface penetrators. Spacecraft did not reach the correct orbit, and reentered Earth's atmosphere.
Zond 1, Venera 1-16	1961-1983	Series of probes to fly-by, orbit or land on Venus. Mixture of successes and failures. Venera 7, in 1970, made first successful landing on Venus. Venera 9, in 1975, was first spacecraft to transmit pictures from the surface of another planet. Venera 13 and 14, in 1982, used drills to obtain core sample for *in situ* chemical analysis. Venera 15 and 16, in 1983, carried side-looking radars to map Venus' surface from a polar orbit.
Vega 1 and 2	1984	Dropped off landers at Venus, then intercepted Halley's Comet in March 1986.
Japan		
Sakigake and Suisei	1985	Two spacecraft that studied Halley's Comet.
Muses A	1990	Engineering test for future lunar probes.
Nozmoni	1998	Failed attempt to orbit Mars.

Prepared by CRS

Appendix 2: Synopsis of the U.N. Space Treaties

The United States is a party to the first four of the following treaties, which were developed through the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). It is not a party to the fifth, the Moon Agreement, nor are any other of the major spacefaring countries. The numbers of ratifications and signatures to these treaties shown below are current as of January 2003 (the most recent data available). The texts of the treaties, and the lists of signatories, ("States Parties") are available at http://www.oosa.unvienna.org/SpaceLaw/spacelaw.htm.

Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space Including the Moon and Other Celestial Bodies (the "Outer Space Treaty")

Entered into force 10 October 1967. 98 ratifications and 27 signatures.

- Exploration and use of outer space* shall be for the benefit of, and in the interests of, all countries and shall be province of all mankind.
- Outer space is free for exploration and use by all States and there shall be free access to all areas of celestial bodies.
- There shall be freedom of scientific investigation in outer space and States shall facilitate international cooperation in such investigations.
- Outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;
- Nuclear weapons or other weapons of mass destruction shall not be placed in orbit or on celestial bodies or stationed in space in any other manner.
- The Moon and other celestial bodies shall be used exclusively for peaceful purposes.
- The establishment of military bases, installations or fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden; the use of military personnel for scientific research or other peaceful purposes is permitted.
- Astronauts shall be regarded as envoys of all mankind.
- States Parties are responsible for national space activities, whether undertaken by governmental or non-governmental (e.g. private sector) entities; the activities of non-governmental entities require authorization and continuing supervision of the appropriate State Party.
- States Parties are internationally liable to other States Parties for damage caused by their space objects.
- Studies and exploration of outer space are to be conducted so as to avoid harmful contamination and adverse changes to the environment of Earth resulting from the introduction of extraterrestrial matter.
- All stations, installations, equipment and space vehicles on the Moon and other celestial bodies shall be open to representatives of other States Parties on a basis of reciprocity.

** Where "outer space" appears in this synopsis, the full phrase is "outer space, including the Moon and other celestial bodies." It was shortened here for brevity's sake.*

Agreement on the Rescue of Astronauts, Return of Astronauts, and Return of Objects Launched into Space (the "Astronaut Rescue and Return Agreement")

Entered into force 3 December 1968. 88 ratifications, 25 signatures, and 1 acceptance of rights and obligations.

- States Parties are to render humanitarian assistance to astronauts in distress or who have made an emergency or unintended landing on their territory, and to return the astronauts to the launching authority.

- States Parties are to return objects launched into outer space or their component parts to the launching authority if they land on their territory.

Convention on International Liability for Damage Caused by Space Objects (the "Liability Convention")

Entered into force 1 September 1972. 82 ratification, 25 signatures, 2 acceptances of rights and obligations.

- Procedures are created for presenting and resolving claims for damages caused by space objects on the Earth, to aircraft, or to other space objects.
- The launching state is absolutely liable for damage caused on Earth's surface or to aircraft in flight; if the damage is caused elsewhere (e.g., in space), the launching state is liable only if the damage is due to its fault or the fault of persons for whom it is responsible.

Convention on Registration of Objects Launched into Outer Space (the "Registration Convention")

Entered into force 15 September 1976. 44 ratifications, 4 signatures, and 2 acceptances of rights and obligations.

- States Parties are to maintain a national register of objects launched into space.
- States Parties must report certain information about the launch and payload to the United Nations as soon as practicable, and notify the U.N. when an object no longer is in orbit.

Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the "Moon Agreement")

Entered into force 11 July 1984. 10 ratifications and 5 signatures.

- Exploration and use of the Moon shall be carried out for the benefit and in the interest of all countries, and due regard shall be paid to the interests of present and future generations and to the need to promote higher standards of living and conditions of economic and social progress and development in accordance with the U.N. charter.
- The Moon and its natural resources are the common heritage of mankind; neither the surface nor the subsurface nor any part thereof shall become property of any State, international intergovernmental or non-governmental organization, national organization or non-governmental entity or of any natural person.
- States Parties shall undertake to establish an international regime to govern the exploitation of the Moon's natural resources as such exploitation is about to become feasible. The regime's purposes include the orderly and safe development of the Moon's natural resources, the rational management of those resources, the expansion of opportunities to use those resources, and an equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries which have contributed either directly or indirectly to the exploration of the Moon, shall be given special consideration.
- States Parties bear international responsibility for national activities on the Moon, whether by governmental or non-governmental entities. Activities of non-governmental entities must take place only under the authority and continuing supervision of the appropriate State Party.
- All space vehicles, equipment, facilities, etc. shall be open to other States Parties so all States Parties may assure themselves that activities of others are in conformance with this agreement. Procedures are established for resolving differences.