# Exploring the Moon Through International Cooperation

*An international conference in Beijing at the end of July mapped out how to coordinate the global campaign that is under way for exploring the Moon. Marsha Freeman reports.*

At the conclusion of the eighth conference of the International Lunar Exploration Working Group (ILEWG), held in Beijing July 23-27, representatives of 18 nations signed the "Lunar Beijing Declaration." This document commits spacefaring nations to coordinate the operation and scientific results of an extraordinary array of missions that will be launched over the next two years to the Moon. China, India, Japan, and the United States have spacecraft in preparation, and the European Space Agency's SMART-1 spacecraft is now completing its one-year lunar mission.

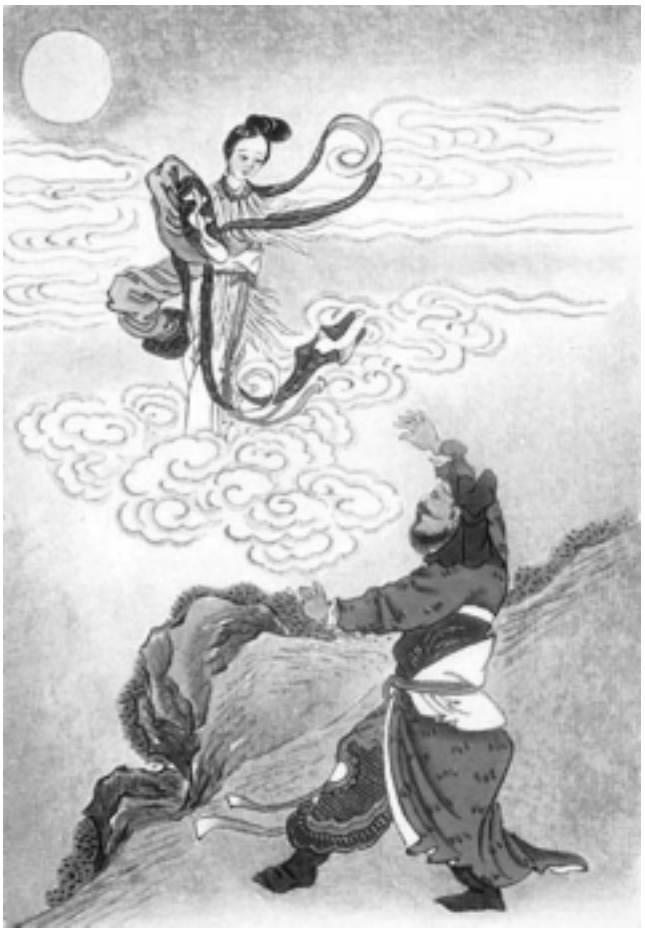
The Beijing Declaration recognizes that when these four new spacecraft begin their missions, "our understanding of the Moon and its resources will be revolutionized as the rich array of data from this flotilla is analyzed around the world." It proposes a series of international actions to optimize the return from the coming missions. Should the proposals be implemented, cooperation among the world's leading nations will proceed on the highest level, the exploration of the Solar System.

To institutionalize long-term international cooperation, the delegates adopted the proposal made by Louis Friedman of the Planetary Society, and Wesley Huntress, director of the Geophysical Laboratory of the Carnegie Institution, that there be an "International Lunar Decade." This would be modelled on the International Polar Years of 1882-83 and 1932-33, and the International Geophysical Year of 1957-58, which promoted the study of the Earth, and during which the first Earth-orbiting satellite was launched into space. The proposed International Lunar Decade would span the 2007 launching of the new robotic lunar orbiters, to the approximate 2019 planned manned return to the Moon.

The upcoming international exploratory assault on the Moon will take place in three stages. First, a series of four unmanned orbiters will be launched in 2007 and 2008 by China, Japan, India, and the United States. Later, unmanned landers and rovers will explore the Moon *in situ,* and samples of lunar rock and soil will be returned to Earth laboratories for more intensive analysis. Finally, toward the end of the next decade, men will return to the Moon. The concern of the international lunar scientists and mission planners is that opportunities may be lost and resources wasted, if there is duplication of effort, or if critically needed capabilities are overlooked, because of a lack of coordination.

The International Lunar Exploration Working Group was initiated in 1992, primarily by scientists who, although there were no planned lunar expeditions at that time, believed it was important to continue to plan for the missions that would be realized in the future. That this meeting of ILEWG took place in China was a recognition that China is playing an increasingly important role in space exploration activity, which until recently has been carried out only by "industrialized" countries. The current chairman of ILEWG, is from the Indian Space Research Organization, also underlining the importance of Asia in space exploration.

In fact, largely in response to China's becoming the third nation to launch a man into space, both the European Space Agency and Japan, for the first time since the 1990s, are considering developing their own manned space projects.



*China's lunar mission is named after the mythical goddess Chang'e, who flew to the Moon. It is China's first mission beyond Earth orbit, scheduled for launch next April.*


*The logo chosen for China's Chang'e mission.*

The hosting of the conference by China, and the strong participation by India and Japan, underscored the leadership that will be provided by Asian nations in this second, post-Apollo, phase of intensive lunar exploration.

## Global Outreach

At present, the missions that will be soon heading for the Moon have been planned by national space agencies, not in a coordinated way, although some have involved international participation through the contribution of scientific instruments. But with four spacecraft soon to be in orbit around the Moon simultaneously, there is the opportunity to increase the efficiency and productivity of each. Toward that end, the Lunar Beijing Declaration proposes that the data from each mission be cross-correlated with the others, especially where more than one spacecraft will be carrying similar instruments. It recommends that common standards be used for spacecraft communications, so they can "talk" to the same Earth tracking stations, and to each other.

For the next phase, early in the next decade, which will include unmanned landers, rovers, impactors, and penetrators, the space experts suggest that there be coordination in choosing targets for landers, and that the necessary groundwork begin to be laid for the long-term development of the Moon. They recommend that infrastructure be developed jointly for relaying data back to Earth, to aid in navigation around and on the Moon, and to establish a lunar internet. The Declaration recommends that there be a geophysical seismic network deployed on the Moon, and an international scientific working group established to define the common standard for future lunar networks of other instruments. The approach is to provide the global communications, navigation, and information infrastructure on the Moon similar to that which allows people on Earth to communicate, navigate, and share data.

Although each national space agency will pursue its own missions, the movement of human civilization to the Moon will be the work of all nations. This is recognized in the goal of the Declaration, to "inspire a new generation of lunar explorers." To that end, China's National Space Administration sponsored a "public day" during the conference, which brought 300 students into contact with top lunar scientists and program managers.

Answering questions from students at his presentation on China's space program, Academician Ouyang Ziyuan, the chief scientist of China's lunar program, who has lobbied the government to begin the effort since the late 1990s, explained that China cannot be left out of the enterprise that advances great nations. This view was articulated by representatives of many nations, who must often answer the question, why are we going to the Moon?

## A Goddess to the Moon

China's lunar program actually began in 1978, when the United States presented the Chinese government with 1 gram of a lunar sample from the Apollo program. Now it is aiming itself for the Moon, hoping for international collaboration.

In 2004, the government of China approved a three-phase lunar exploration program, which is that nation's first foray in to deep space, beyond Earth orbit. Next April, the Chang'e spacecraft, named after a goddess who flew to the Moon in a Chinese fairy tale, will be launched from China. It will orbit the Moon for one year, in a 200-kilometer polar orbit, with

EIRNS/Marsha Freeman

*The second stage of China's lunar program will include a lander and rover. College students are competing to design the lunar robot. One model was demonstrated at the Beijing conference.*

EIRNS/William Jones

*Sun Laiyan, head of China's National Space Administration, will meet with NASA Administrator Mike Griffin in China in September, for discussions on cooperation in space.*

the scientific objectives of creating a three-dimensional "portrait" of the Moon; analyzing 14 minerals on the surface, to determine the Moon's chemical composition; and studying the cislunar environment, between the Earth and the Moon.

According to lunar program chief scientist Ouyang Ziyuan, China will also focus on improving the understanding of the Moon's reserves of helium-3, which will be needed as fuel for fusion power plants. "The current estimate is between 1 million and 5 million tons, and we will try to improve [that] a little," he told *China Daily* during the conference. Were fusion energy to meet global energy demands, he explained, "each year three Space Shuttle missions could bring enough fuel for all human beings across the world."

Responding to criticism of China's expenditure of $175 million for its lunar program, Ouyang reported that, compared with the huge potential benefits of the lunar program, the same amount of money builds 3 kilometers of subway in Beijing. Last year, Ouyang told a Chinese audience that "the lunar exploration program will have an incalculably valuable effect on the spirit and motivation [of the Chinese people], and I ask you, how much is that worth?"

During the opening session of the ILEWG conference in Beijing, Sun Laiyan, the head of China's National Space Administration, said that the Moon has been prominent in Chinese myths and has been "under a secret veil." He described the 2004 decision for lunar exploration as a "key national policy" with the goal of "improving innovation" in China.

Sun reported that China will be establishing an "expert committee" on the scientific applications of the Chang'e program. Up to 100 universities and institutes will participate, to carry out research using the lunar data sent back from the spacecraft. The committee is to meet in September for the first time, to decide on the distribution of research and ensure a wide participation among educational institutions. He added that "scientists from other countries will join the data analysis."

Sun also presented an update on the status of Chang'e, reporting that progress was being made in all five systems needed for the mission: the satellite itself, the rocket that will launch it, ground- and sea-tracking and control, ground operations, and the launch center. The second phase of China's lunar program, Sun explained, will center on a soft landing on the Moon and a rover in 2012, to do an *in situ* survey near the landing site. This will help prepare the stage-three sample return mission. During the conference sessions, university students from some of the research institutions that are competing to have their rover concept chosen to go to the Moon, demonstrated their wares, informing and entertaining conference participants.

To explain his view of international cooperation, Sun ended his presentation with an old Chinese saying, which, in paraphrase, counsels: If there are two of us and we each exchange an apple, we each still have only one apple. But if we exchange ideas, we each have two ideas.

## India's International Lunar Mission

ILEWG Chairman Navenda Bhandari, from the Indian Space Research Organization (ISRO), stated in his welcoming remarks to the Beijing conference that "despite one half a century" of space exploration, "we know very little about

the Moon. It is the most mysterious and important body in the Solar System." The Moon's historical "link to the solar nebula is the key to understanding the early evolution of the Earth," he said. Over the coming decade, there will be a "continuous presence" of spacecraft at the Moon, and the international scientific community should "debate the priorities and problems."

J.N. Goswami, a planetary geologist from ISRO, reported that Chandrayaan-1, which means "Moon-craft" in Sanskrit, will be launched by 2008. It is India's first deep space mission, and was proposed by the Indian scientific community in 1993. He stressed the importance of coordinating the numerous lunar missions, so that each subsequent mission receives input from the previous ones.

Some of the questions Indian scientists would like to address, Goswami reported, include whether there was a magma ocean on the Moon, the Moon's bulk chemistry, the cause and nature of the asymmetry of the near and far sides of the Moon, and how water and other volatiles have been transported throughout the Moon's history.

From the beginning, India decided that its first lunar mission would be international in scope. Chandrayaan-1 will carry three instruments contributed by the European Space Agency, and one from the Space Laboratory of Bulgaria, in addition to those from India. Cooperation with the United States has been of interest to both sides, but politically complex.

During the recent visit of NASA Administrator Mike Griffin to India, he and ISRO chairman Madhaven Nair signed Memoranda of Understanding on May 9, to allow two American-built instruments to fly on India's Moon craft. It was the first visit to India by a U.S. space official in 30 years, and Dr. Griffin was reminded by Indian officials that the United States still has sanctions on Indian space enterprises, which were imposed after India's 1998 nuclear test. Since President Bush's visit to India one year ago, the United States has held out the carrot of space and civilian nuclear cooperation, to garner India's support for U.S. foreign policies in Iran and elsewhere. The recent agreement is one of the carrots.

The American instruments that will fly to the Moon on Chandryaan-1 are a Mini Synthetic Aperture Radar, being developed by Johns Hopkins University's Applied Physics Laboratory; and a Moon Mineralolgy Mapper, being built by Brown University and NASA's Jet Propulsion Laboratory. These were selected from 16 proposals that had been submitted to ISRO from all over the world.

India's Chandrayaan-1 spacecraft will be in a polar orbit of the Moon at a low, 100-kilometer altitude. The mission is projected to last two years, and carry out high-resolution mineralogical and chemical imaging of the polar regions and of lunar rocks, and map the topography and other features of the lunar landscape.

The spacecraft will also be carrying a small impactor, which will be dropped to the lunar surface. During its 18-minute fall to the surface, three instruments onboard the small probe will take measurements, and the orbiter will observe the dust that is kicked up from the impact. The impactor is also designed to qualify some of the technologies that will be needed in the future for soft landings on the Moon.

If Chandrayaan-1 is a success, Indian space officials have stated that follow-on unmanned lunar missions will be considered.

## Russia To Return to the Moon

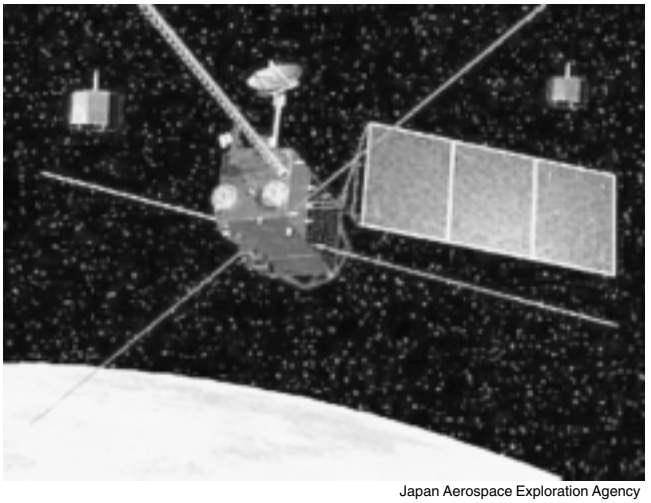
In the late 1950s, the Soviet Union took an early lead in lunar exploration. Most of the craters on the far side of the Moon, which is not seen from the Earth, are named for Russian scientists, because the craters were photographed for the first time by the Russian Luna-3 spacecraft in 1959. Soviet spacecraft produced stunning results from a series of 20 successful robotic lunar missions through the mid-1970s, and brought back soil and dust samples from the Moon. Over the next three decades, the Soviet Union then concentrated on missions to Venus and Mars.

Recently, however, Russian scientists have described a mission they are putting forward called Lunar Globe, to robotically explore the Moon with an orbiter, and to deploy penetrators around the lunar surface. At the conference in Beijing, Academician Erik Galimov, Director of the Vernadsky Institute of Geochemistry and Analytical Chemistry, described the Lunar Globe project: Its purpose is to study the seismology and internal structure of the Moon, which will shed light on its origin. The orbiting spacecraft would deploy 13 high-speed penetrators into the top layer of the lunar surface.

According to the current design, two of the penetrators will be aimed at the Apollo 11 and Apollo 12 landing sites, to retrieve subsurface data complementary to that obtained during the U.S. manned missions, 37 years ago. Another 10 high-speed penetrators are to form a seismic network. The orbiting mother ship would also drop a small lander into a crater at the Moon's south pole, to search for signs of water ice.

Previously, Lunar Globe had been scheduled for launch in 2012, but Galimov said he was delivering a "new message" at the conference—that it is possible it will be ready in 2009. The Russian Phobos-Grunt mission is designed to return samples from the Phobos of Mars, and is to be launched in three years. Because the two spacecraft would be similar, the design and manufacture of the lunar spacecraft should be able to be accelerated.

Academician Galimov assured the somewhat skeptical audience—which has sadly watched the underfunded Russian space program cancel one mission after another—that "Russia intends to intensify its lunar activity, and do a series of experiments." In fact, the Russian space program, which has been starved for funds over the past decade, saw an increase of 30% in its budget in 2005, and an additional 50% increase is slated for this year, according to Russian space officials. Galimov also mentioned that a manned Russian lunar mission was under consideration.



Japan Aerospace Exploration Agency

*Japan's Selene mission includes an orbiting spacecraft, and two small satellites, seen in this artist's drawing, which will relay communications, and create a gravity map of the Moon.*

The isotope helium-3, as fuel for advanced thermonuclear fusion reactions, Dr. Galimov stated, will be a foundation of the next stage, which is the "economic utilization of the Moon." He explained that the concentration of helium-3 in the lunar soil, or regolith, is very low, but "the amount is enormous." To obtain this resource, "billions of tons of lunar soil must be mined." Although he proposed that the "deployment of such a mining industry will take 50-70 years," he emphasized that since we have no choice, "we should get started as early as possible!"

Russian space officials have indicated that international cooperation will be key to their proposed lunar projects. During the 36th Congress of the United Nations Committee on Space Research (COSPAR), which was held in Beijing the week before the ILEWG conference, Nikolai Sanko from Roskosmos reported that Russia and China are holding talks on joint programs for lunar exploration. Sanko suggested that the two countries' scientists will pool their efforts. "It is not ruled out that our devices or means for sampling the lunar surface will be installed on Chinese [spacecraft], and that Chinese devices will be installed on Russian craft," he told *Itar-Tass.*

## Ambitious Designs on the Moon

In 1990, Japan initiated its lunar exploration program, launching its Hiten (Muses-A) spacecraft to the Moon. During its technology demonstration mission, Hiten injected a tiny probe, Hagoromo, into orbit around the Moon, and Hiten remained in orbit there until it was crashed into the surface in 1993.

Japan's space scientists and mission planners have developed a very creative, and highly complex series of missions to the Moon, and because of difficult technology challenges, its two lunar missions have been delayed. Lunar-A, initiated in 1991, and scheduled originally for launch in 1997, is designed to carry out seismic studies, and directly investigate the interior of the Moon for the first time, slamming a pair of penetrators up to a depth of ten feet into the lunar surface.

The penetrators are missile-shaped and are attached to the sides of an orbiter. After release from the orbiter, they are to use small side jets to orient themselves. The penetrators are designed to withstand a grueling impact environment, 10,000 times the force of Earth's gravity. Design problems found during tests of the penetrators delayed the mission, as have other technical and funding problems. Scientists now hope to launch Lunar-A by 2010.

Before Lunar-A starts its highly complex mission, Japan is planning to launch Selene—Selenological and Engineering Explorer—to the Moon in 2007. At the Beijing ILEWG conference, Dr. Hajime Inoue, from Japan's space agency, JAXA, explained that Selene consists of three spacecraft—a main craft that will be in a 100-kilometer altitude polar orbit, and two small daughter satellites. One small satellite, called Rstar, will function as a communications relay, to transmit data from the orbiter to Earth when the orbiter is on the far side of the Moon and out of Earth contact. Dr. T. Iwata from JAXA explained to the conference the importance of the second small satellite, Vstar. Estimates of the gravity field on the far side of the Moon have been made by observing the perturbations in a satellite's orbit as it circles the Moon, he said. But the measurements are not precise. Vstar will do global mapping of the Moon, with a focus on the gravity variations.

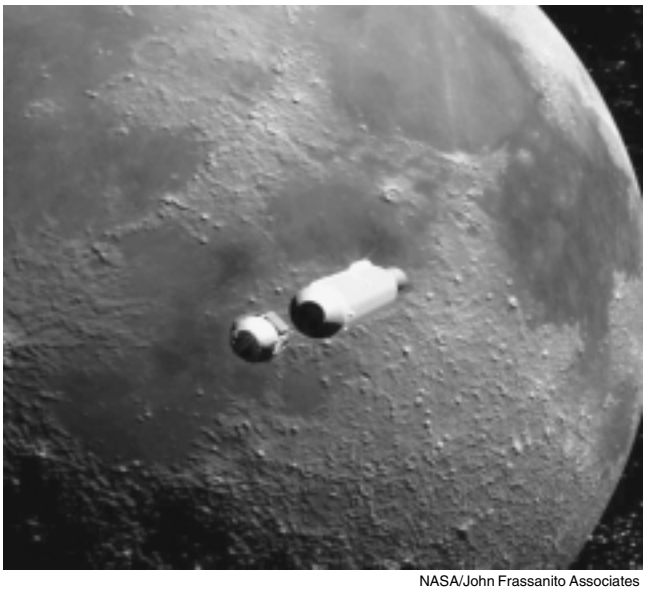
Dr. Iwata also reported that using both small satellites in tandem will allow scientists to determine their position within 20 centimeters of accuracy, by establishing a very long baseline interferometry network. These assets, for relay communications and precision navigation, are a forerunner of the kind of permanent infrastructure that will be needed for future exploration of the Moon.

The Selene orbiter will carry an extraordinary complement of 14 scientific instruments, to study the topology, chemistry, magnetic fields, and other characteristics of the Moon and its environment. JAXA also plans to broadcast real-time images from the Moon to the public, to create interest and excitement about the program.

## A Crash Landing on the Moon

NASA's contribution to the lunar armada that will be leaving Earth's shores over the next two years is the Lunar Reconnaissance Orbiter (LRO), slated for launch in October 2008. LRO will orbit the Moon at an average altitude of about 30 miles (50 kilometers), for at least one year, and image our neighbor with unprecedented resolution. To establish a firmer footing for future human lunar exploration and settlement, LRO will be using a suite of instruments to try to characterize what are assumed to be deposits of water ice at the lunar poles.

The 50-km orbit is very challenging, and this will be a



NASA/John Frassanito Associates

*NASA's Lunar Reconnaissance Orbiter will dispatch a small "shepherding spacecraft" (left) to make observations as the rocket's upper stage (right) impacts the lunar South Pole.*

EIRNS/Marsha Freeman

*The future of space exploration: Chinese students on Summer holiday in a park in Beijing.*

first attempt at such a low-altitude mission. So close to the lunar surface, the spacecraft's orbit becomes unstable because of the gravity variations of the Moon, so active propulsion onboard the craft will be used to keep it in a stable orbit. In addition to all of its scientific lunar objectives, LRO will also image the historic U.S. and Soviet landings sites on the Moon, including NASA's unmanned Ranger and Surveyor probes, and sites where the Apollo astronauts walked. Soviet Lunakhod rovers should also be visible. Observing changes that may have taken place over the past 30 years is of great interest.

At such high resolution, even relatively small craters should be able to be imaged, and scientists expect to see hundreds of small craters in the 10-meter range, for the first time.

As NASA was developing the LRO spacecraft, an opportunity presented itself to give a piggyback ride to a small companion spacecraft; and in April 2006, the space agency chose the Lunar Crater Observation and Sensing Satellite, or LCROSS. It will take measurments when the upper stage of LRO's rocket slams into the hydrogen- and potentially water-rich Shackelton Crater at the south pole of the Moon. About 15 minutes later, after the booster's upper stage makes its impact, the LCROSS probe itself will crash into the crater floor. Scientists hope to be able to verify that the enhanced hydrogen signature that has been previously measured, indicates the presence of water ice.

So far, NASA's implementation of the Vision for Space Exploration has been as a national program. Workshops have been held to involve space agencies of other nations; and at the Beijing conference, Michael Wargo, NASA's chief lunar scientist for Exploration Systems, proposed that there be a Global Strategy for Exploration. The purpose would be to conduct an international dialogue to determine "what we will do when we get to the Moon, and why we will explore," Wargo stated. One of the goals of the Strategy, Wargo stated, is to "strengthen and create new global partnerships." NASA has many partnerships with spacefaring nations. The one glaring exception is China.

At the public day of the Beijing conference, former Chinese space agency head Luan Enjie, who now heads the lunar program, told the audience of college students that during his six-year tenure as China's space program head, it was a pity that he had never "shaken hands" with his counterpart at NASA.

Appreciating that China is seriously advancing in space technology, and that U.S. China policy has been geopolitical and uninformed, Congressmen Mark Kirk (R-Ill.) and Rick Larsen (D-Wash.) formed the U.S.-China Working Group in the House of Representatives in 2005. After a visit to China's space facilities last Spring, they proposed projects, such as common docking between the two nations' manned spacecraft, as potential areas of cooperation. They are formulating an agenda of issues that they hope Mike Griffin will discuss with the Chinese during his upcoming trip.

There is no better arena for international cooperation than the exploration of the Solar System. The window of opportunity is at hand.