Is Asia Taking the Lead In Space Exploration?

At the International Astronautical Congress, the rapid pace of space development in Asia was in stark contrast to the lack of participation by the two space superpowers. Marsha Freeman reports from Beijing.

Chinese Vice President Li Yuanchao opened the 64th annual International Astronautical Congress, held Sept. 23-27 in Beijing, by offering to share China's extensive technology and experience in space exploration with all nations. "Mankind faces many challenges for which space can help, and China is ready to join the international community to exploit space for the benefit of all," he said, reporting that China now has 71 international agreements with 26 nations and regions.

This is in marked contrast to the Obama Administration's efforts to "pivot" U.S. policy in Asia into a strategic bulwark against China. At the Congress, which was attended by over 3,000 delegates from more than 70 nations, the widening gulf between China's space missions and future plans, and, in particular, the state of space missions in the United States, was dramatic. China's space activities, combined with fast-paced space developments in South Korea and India, underline the ongoing shift in global space-science leadership toward Asia.

Among the highlights:

• South Korean participants announced that their new President, Park Geun-Hye, has approved the acceleration of that nation's lunar program by five years. The plan is to carry out an ambitious mission to orbit the Moon and place a lander on its surface, by 2020.

• On Oct. 28, India will launch the Mangalayaan spacecraft to Mars, thereby becoming the fourth nation to send a spacecraft to the Red Planet.

• On Dec. 2, China's Chang'e-3 spacecraft will be launched to the Moon. This will be the world's first soft landing on the Moon (i.e., slowly, so as to prevent damage or destruction) since NASA's Apollo 17 mission in 1972.

• To the shock of participants, NASA had no exhibit and little representation at the conference.

Where Was NASA?

Dozens of scientists and NASA mission managers were unable to attend and present their prepared papers, due to travel budget restrictions imposed by the U.S. budget sequestration. The budget stalemate in Washington has left the National Aeronautics & Space Administration with the likelihood of another year's continuing resolution (with funding at the FY12 level), for fiscal year 2014. This would be a $2 billion reduction from what had been projected.

Although FY14 was supposed to start on Oct. 1, it did not—the Federal government shut down instead, threatening NASA's ongoing missions, and further delaying the few missions that are currently under devel-

International Astronautical Federation

Federation President Kiyoshi Higuchi (left) presents an award to China National Space Admministration director Ma Xingrui for his foundational work in the Chinese space program over three decades.

opment. The exhibition hall at the Aeronautics Congress featured more than 70 space agencies, companies, and organizations from every corner of the world, with no exhibit from NASA.

But the most embarrassing aspect of U.S. space policy made quite public at the Congress is the American prohibition against working with the Chinese in space, which policy was most recently codified into law, thanks to Rep. Frank Wolf (R-Va.). This self-inflicted stupidity, which dogged NASA Administrator Charles Bolden throughout the Congress, was raised during the very first session.

For years, space cooperation with China has been a political football in Washington, part of an attempt by a handful of Congressmen to hold cooperation hostage to accusations of human rights violations, technology spying and stealing, and other politically motivated issues.

This U.S. clampdown did little, if anything, to slow down or otherwise hamper the Chinese civilian or military space programs.

Indeed, the head of the **China National Space Administration (CNSA), Ma Xingrui**, made very clear that China has invited other nations to join its space station program and "help other developing countries to put their astronauts in space." Ma stated tersely that the CNSA is "not a party to the multilateral efforts," because "an invitation has not been issued."

Where Was Russia?

The diminished participation of representatives from the Russian space program was also disappointing to participants. It was shocking, if not altogether surprising, that the director of **Roscosmos**, the Russian Federal Space Agency, did not attend, and that the Roscosmos representative, Deputy Director **Sergei Saveliev**, did not participate in the press conference with his international counterparts. Due to launch and other hardware failures in the Russian program over the past 18 months, it has been under strong criticism. Deputy Prime Minister Dmitri Rogozin had ordered a review of the agency and recommendations for reform.

Just ten days after the close of the Congress, the Russian media announced that Roscosmos Director Gen. Vladimir Popovkin (ret.) had been replaced.

On Oct. 9, Rogozin reported to President Vladimir Putin on the results of the study of Roscosmos: The agency will be split into two parts, with one overseeing planning and mission execution, and the other, a consolidation of the broad Russian aerospace industry, combining military and civilian programs.

China's Asia-Pacific Initiatives

China's outreach to other Asian nations was represented in part by the **Asia-Pacific Space Organization (APSCO)**, whose exhibit was a significant part of the Chinese exhibition at the Congress.

The initiative that resulted in the creation of APSCO began soon after China established a civilian space agency in 1992, when it hosted the First Asia-Pacific Workshop on Multilateral Cooperation in Space Technology and Applications, with representatives from Pakistan and Thailand. Between 1994 and 2003, seven

conferences were held in Thailand, Pakistan, the Republic of Korea, Bahrain, Iran, and China. In 2008, APSCO held its inaugural ceremony, with the signatory countries of China, Bangladesh, Indonesia, Iran, Mongolia, Pakistan, Peru, and Thailand. Representatives from Argentina, Malaysia, the Philippines, Russia, and Sri Lanka also attended. Discussions have taken place with Chile and Brazil. In 2011, Turkey became the ninth member-state.

APSCO has so far concentrated its efforts on making available to member-states technology and data sharing in remote sensing, navigation, and communications. **Dr. Maqbool Chaudry**, Director General of Strategic Planning and Program Management, said at the Congress in Beijing that the organization is now moving into additional fields of cooperation, based on the needs of the members. In this earthquake-prone region, Dr. Chaudry reports, there is great interest in determining earthquake precursors. Ground-based ionospheric sounding sensors developed by China are being made available to other nations. In addition, APSCO is studying the possibility of developing a satellite payload for a space-based study of pre-earthquake changes in the magnetosphere and ionosphere.

Dr. Chaudry explained that in much of this region, which suffers extreme rainfall, the resulting attenuation of signals from satellites leads to interruption and unreliability of communications. APSCO has a study underway, led by Thailand, to improve the modeling of the atmospheric effects of weather.

APSCO has a growing training and education program, offering short training courses, as well as a Master's program on space technology application. As important as these space applications are for economic infrastructure, Dr. Chaudry reported that every one of APSCO's member-states has also expressed a desire to have its astronauts fly on China's manned spacecraft.

During the Congress, the head of China's space agency, Ma Xingrui, met with **Kazakstan National Space Agency** head and former Soviet cosmonaut **Talgat Musabaev**. During Chinese President Xi Jingping's last official visit to Kazakstan earlier in September, Musabaev said, the two nations signed an intergovernmental agreement creating a legal and practical framework for space cooperation.

"China is developing space activity by leaps and bounds and becoming one of the leading space powers," Musabaev said. The two space agencies reportedly discussed cooperation in manned space flight, and the possibility of a cosmonaut from Kazakstan joining a Chinese Shenzhou crew.

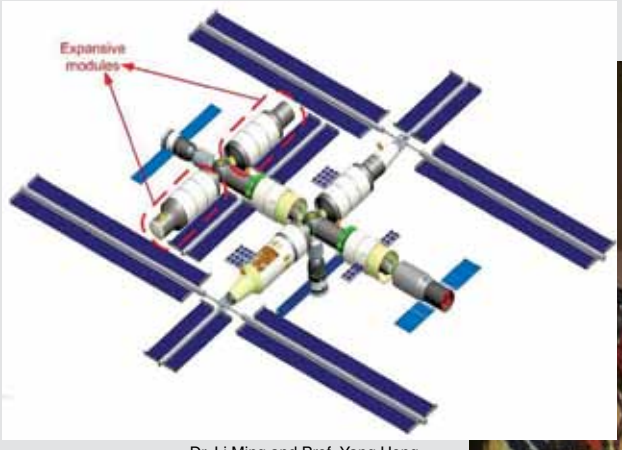
A little further from home, China has solidified and extended its cooperation with the **National Space Agency of Ukraine**. During the Beijing Congress, **Director General Yuriy Alexseyev** participated in the second meeting of the Ukraine-China Commission on cooperation. According to a report in nrcu.gov, Alexaseyev explained that Ukraine (which was an integral part of the Soviet space program), has more than a dozen contracts with China, mainly to supply space equipment. There is also the possibility of using Ukrainian deep-space communications capabilities at the National Space Facilities Control and Test Center in

Strategic Defense of Earth

A panel discussion at the Congress, titled "NEOs and Planetary Defense—Where Do We Stand?", considered various approaches to protecting the Earth from Near-Earth Objects such as asteroids and comets. Proposals for a variety of mitigation techniques were put forward by Romanian cosmonaut Dorin Prunariu, on behalf of the world's organization of astronauts and cosmonauts, the Assocation of Space Explorers.

In response to the report that Russia and the U.S. recently signed an agreement that includes the potential use of nuclear explosions to avoid impacts with Earth, panel member Dr. Sergio Camacho, head of the Action Team on Near Earth Objects for the United Nations, responded that if we have only a brief warning of danger, nuclear explosions could be the best option.

Unfortunately, no Russian government representative or scientist spoke during the panel discussion. Russian Deputy Prime Minister Dmitri Rogozin has repeatedly called for a global Strategic Defense of Earth, which he reitered as recently as Oct. 16.



Dr. Li Ming and Prof. Yang Hong

This diagram of China's 2020 space station shows two "expansive modules" which are being offered to other nations, to add their own laboratories.

21st Century Science & Technology/Marsha Freeman

The Chinese exhibit at the Congress included this proud display of the nation's astronauts and vision of the future.

21st Century Science & Technology/Marsha Freeman

This scale model of China's next lunar mission, Chang'e-3, was displayed at the Congress. It will be the first soft landing on the Moon since 1972, and is scheduled for launch on Dec. 2.

China's space station program builds upon its highly successful Shenzhou flights. The capsule that brought the three Shenzhou-10 crew members back from orbit last June was on exhibit at the Congress.

21st Century Science & Technology/Marsha Freeman

Yevpatoriya, and a group of Chinese scientists recently visited that site.

China Extends Its Reach to the West

Since the "opening up" of China's space program, with the establishment of a civilian space agency in 1992, each mission in its manned space program has been progressively more "transparent," and by the time of the Shenzhou-10 mission in June, the live coverage, commentary, and interviews mirrored NASA's coverage of its Space Shuttle launches. China's willingness to share its technological expertise began in its own, Asian, neighborhood; but with the waning of the U.S. space program and the technological challenges in Russia, "nontraditional" Chinese partners, particularly in Europe, are taking an active interest.

At the Beijing Congress, former German astronaut **Thomas Reiter**, who is now the **European Space Agency (ESA)** Director of Human Spaceflight and Operations, reported that various exchanges between the ESA and the Chinese Manned Space Agency have taken place, "for identifying opportunities for collaboration in particular areas of astronaut training and utilization."

It has escaped no one's attention that currently, and in at least the near future, only Russia and China are able to launch people into space. ESA has already expressed an interest in flying astronauts on future Chinese Shenzhou missions, and on April 19, the Chinese established the **International Cooperation and Exchange Center**, under the Chinese Manned Space Agency, to promote international cooperation in human space flight. It is run by **China Great Wall Industry**, which is the commercial arm of the Chinese launch and satellite industries. In the same vein, if the International Space Station ends its useful life in 2020, it is China that will have room available on a space station. Reiter referred to this option, stating that "the focus of the Chinese space program on future exploitation of Low Earth Orbit may offer opportunities for cooperation in this field."

On Oct. 14, ESA announced that its Directorate of Science and Robotic Exploration will hold two workshops next year with the Chinese Academy of Sciences. The first, to be held in China, will bring together scientists from Europe and China who will present their proposals for future space science missions. For the second workshop, which will be held in Europe, joint teams will present joint proposals. One would assume that the ultimate goal is to choose one joint mission that will fly.

Space Science

China has lagged behind other space-faring nations in making contributions to space science, particularly in astronomy and cosmology. This is ironic, not least because the first recorded observations of eclipses in history and the two earliest observations of Halley's comet were made in ancient China. Recently a Strategic Pioneer Program on Space Science was formulated, and five space science missions were chosen and are being implemented. These include the Hard X-ray Modulation Telescope, which will be China's first astronomical satellite. It will carry out an all-sky survey to detect high-energy objects. Also under development are an instrument to detect high-energy cosmic and gamma rays, a recoverable satellite for microgravity and life science experiments, and the Kuafu mission, to image the Sun-Earth space weather system, and do *in situ* particle measurements of the solar wind.

The Strategic Pioneer Program also includes a group of study projects to select future science missions. The first group, selected in 2011, includes a solar orbiting telescope, a spacecraft to study the electromagnetically active layers of the Earth's atmosphere, and astronomy missions. A second group, selected earlier this year, includes a search for extrasolar planets, an advanced solar observatory, and a water cycle observation mission. Through these initiatives, China plans to make contributions to major areas of global interest in space science. The **National Space Science Center**, under the Chinese Academy of Sciences, is targeting the year 2020, to have the full range of capabilities to manage space science missions, and have state-of-the-art innovative technical capabilities.

A Chinese 'Woman on the Moon?'

For centuries before American astronauts reached the Moon, Chinese mythology had transported the goddess Chang'e there. China began its actual lunar exploration program, and its first foray into deep space (beyond Earth orbit) with the launch of the **Chang'e-1** lunar orbiter on Oct. 24, 2007. Three years later, the **Chang'e-2** orbiter returned stunning high-resolution photographs of the Moon, and **Chang'e-3** is scheduled for launch on Dec. 2.

China's two women astronauts, Wang Yaping (above) and Liu Yang, appeared together in public for the first time at the Beijing conference.

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Chang'e-3 is an ambitious effort, combining two first-time technical challenges in the same mission: a lander and a rover. The lander carries its own scientific instruments, one of which is included on a lunar payload for the first time. During a pre-conference **Galaxy Forum China** on "Human Moon Mission: Giant Steps into the Galaxy," organized by the International Lunar Observatory Association, **Dr. Jin Zhu,** from the **Beijing Planetarium**, explained that the Moon is not only an important object of study in itself, but also "an observational site," where we can "make simultaneous, multi-wavelength observations," in the optical, gamma ray, radio, infrared, and ultraviolet portions of the electromagnetic spectrum.

Prof. Jianyan Wei, from the **National Astronautical Observatories of China**, reported that aboard the Chang'e-3 lander is a near-ultraviolet telescope, which will monitor bright stars, and do an all-sky survey. Its observations will be coordinated with ground-based telescopes. Selected targets will be tracked for 10 days, Professor Wei said, in addition to the broader sky scans. The scientific objectives include monitoring the long-term variability of stars, studying violent flares from other stars, and observing objects in low latitudes in the galactic plane, not visible from Earth. Chinese scientists have set up a bank of ultraviolet telescopes on the ground, he reported, "to identify targets that Chang'e-3 can be targeted to also observe."

Undoubtedly, what will garner the most excitement from the public will be the activities of the mission's 220-pound rover, which is designed to survive for at least three months. To increase public visibility, understanding, and support for the program, China's lunar exploration program is collecting candidate names from the public for the rover aboard Chang'e-3.

Chang'e-4 will essentially repeat the upcoming mission, using hardware identical to Chang'e-3. (For decades, NASA also built doubles of all of its interplanetary spacecraft, to have a ready back-up in case of failure, a practice which has been largely eliminated due to long-term budget restrictions.) **Chang-e-5** will have the first robotic return of samples from the Moon to the Earth since the Soviet Luna 24 spacecraft carried out a sample return in 1976. As reported at the conference, studies are underway to develop automatic lunar soil-sample-drilling equipment, and improved lunar rover vision systems for teleoperation from Earth.

At every opportunity, almost regardless of the topic of discussion at hand, Chinese space representatives were asked if (or when) their country is planning a human expedition to the Moon. Each representative demurred, stating that the government has not yet approved such a mission. But papers presented by Chinese researchers at the Congress indicate that work is already underway to support such an undertaking.

Scientists from the **Beijing Special Engineering Design and Research Institute** reported on their study of a variety of technical approaches for manned lunar landings. They considered various trajectories for the flight, options for the assembly of lunar-bound vehicles, and launch-vehicle capabilities for the mission scenarios. They conclude that while current launch technology should be used, larger-capacity vehicles are required "to carry out large-scale lunar exploration, establish lunar bases, and manned exploration to Mars."

No manned mission to the Moon will be able to be executed by any space agency without the development

of heavy-lift rocket launchers, at least in the 100-ton-payload range. Although no formal approval has been given for a Chinese manned lunar mission, the family of Long March vehicles under development will culminate in a rocket with a launch capacity that could exceed that of NASA's Saturn V rocket, which took astronauts to the Moon. The proposed **Long March 9** would be the largest launcher in space history. One possible design allows 133 metric tons of payload to be delivered to low Earth orbit, more than the Saturn V. Rocket designers are awaiting government approval to proceed with development.

To a Space Station, and Beyond

That Chinese space planners can even consider such a long-range and ambitious plan is based upon the unqualified success of their Shenzhou series of manned space missions. The most recent—**Shenzhou-10**—carried out a two-week mission in June, with the three astronauts performing an array of science experiments aboard the **Tiangong-1** small laboratory module. The highlight of the mission, watched by 60 million children in China, was a series of experiments by China's second female astronaut, **Wang Yaping**. For the first time, she and the first female astronaut, **Liu Yang**, appeared together in public at the Beijing conference.

Now that China has demonstrated that it can safely launch a crew, rendezvous and dock with an orbiting module, perform space walks, and work productively in orbit, it is ready to extend the stay and activity of human crews.

At the Congress, **Dr. Li Ming,** head of the **Institute of Manned Space System Engineering of the China Academy of Space Technology**, added detail to China's plans for manned space flight. Next, a small space lab, **Tiangong-2**, will be launched, with advancements allowing longer stay-time for crew, regenerative life support systems to reduce supplies that must be brought from Earth, and propellant refueling on orbit to extend the operating life of the spacecraft. Tiangong-2 will be manned for relatively short stays, and will be resupplied by an unmanned cargo ship, similar to Russia's Progress cargo carrier.

These steps are preparatory to China's planned space station, slated for complete assembly by 2023. It will consist of a core module, which manages and controls all of the systems on the station; two experiment modules, which include the living quarters for the crew; and docking ports for visiting cargo carriers, Shenzhou spacecraft, and potentially carriers from other nations. The station will support a crew of three.

In his Congress presentation, Dr. Li stressed China's desire for international cooperation, and said that China's station "has the capability to further expand [with] two additional experiment modules." He added, "We are now making endeavors in human space flight cooperation between the European Space Agency and the Chinese Manned Space Agency."

Recently, China's first astronaut, **Yang Liwei**, extended an invitation to foreign space agencies to train crew members for flights on Shenzhou craft. Astronaut Liu Yang reiterated this offer at the Congress. The German space agency is already working with China, having flown experiments on the last Shenzhou mission, and France has also been in discussions with China on cooperation. The European Space Agency, according to Dr. Li, is considering cooperation in microgravity research, human physiology and space medicine, and astronaut selection.

Looking beyond Earth orbit, and assuming manned exploration of the Moon, teams of Chinese scientists are looking further ahead, to Mars. An extremely challenging mission concept was advanced by teams at the **Qian Xuesen Laboratory of Space Technology** and the **Lunar Exploration Engineering Center**, both in Beijing. Described as a **"Mars Plural Mode"** mission, it entails one mission which would deploy a Mars orbiter, an atmospheric balloon, a rover, and surface penetrators. Although the presenters readily admitted under questioning how difficult this multi-layered deployment would be, it is an innovative approach that should provoke further research.

Korea to the Moon

China is not the only nation in Asia extending its reach. One of the most exciting developments reported at the conference came from South Korea. **Dr. Gwang-hyeok Ju,** from the **Korea Aerospace Research Institute (KARI)**, reported that President Park Geun-Hye initiated a strategic planning study to design and implement a robotic lunar exploration mission, soon after she was elected last February. Park follows in the footsteps of her father, Park Chung Hee, who, as president (1961-79), transformed South Korea into a modern industrial state from one of the poorest nations in the world, following the devastation of the Korean War.

As Dr. Ju explained to this writer, Korea has focused its resources to accomplish national goals, such as previous decades' leadership in the automobile, and then electronics, industries. In the future, Dr. Ju said, Korea must become a leader in the "knowledge economy." This places space development and exploration alongside other national strategic programs, such as thermonuclear fusion energy, as a priority.

The new **Korean Lunar Exploration Program (KLPE)** accelerates the timetable by five years, with a plan to place an orbiter around the Moon and a lander on the surface, by 2020. The 2011 National Space Development plan had envisioned an orbiter in 2023, and a lander in 2025. The combined orbiter/lander spacecraft will be Korean designed and built, and launched on a next-generation **Korean Space Launch Vehicle-2**. To meet this shortened time frame, Dr. Ju reported that in 2017, an "orbiter pathfinder" would be developed through cooperation with NASA. The orbiter pathfinder will be based on a small space science modular design (in the 200-kilogram range) from Ames Research Center in California. This pathfinder will give Korean scientists and engineers experience in carrying out deep space exploration.

Korea Aerospace Research Institute

In 2008, Dr. Yi So-yeon became the first Korean astronaut, spending nine days on the International Space Station. South Korea plans to continue cooperation with the U.S. in its new lunar program, while it develops its own launch and spacecraft capabilities for lunar exploration in the next decade.

The 2020 lunar mission is an ambitious one, with its orbiter and a lander which will carry a small rover. After studying the results of all of the previous lunar missions, KARI has determined that the main objectives are twofold: The first is to validate technology, such as a "space Internet" experiment, and communications with space-based antennas, to prepare for future missions. The second will focus on two fields of observation little studied previously: the seismology of the Moon, and data collected by a magnetometer to measure the regions of unusually high magnetic-field strength.

As might be expected, the first question to Dr. Ju following his presentation, was how he could be sure the government would provide the funding. "Unlike other countries," he replied, "once we have approval from the government, we can go through to the end" of the program. He said that federal government approval is expected by the end of this year.

Looking further into the future, the **Ministry of Science, ICT [Information Communications Technology] and Future Planning** created the **International Space Exploration Research Institute** at Hanyang University, focused on the use of extraterrestrial resources. Research and technology demonstration areas include extreme terrain rovers, to enable access to challenging but geologically interesting regions, drilling systems, and the use of *in situ* resources for waterless lunar concrete, and lunar concrete construction techniques. One of the participating organizations with the Institute is the New York-based **Honeybee Robotics**, which built tools being used by NASA's Mars rovers, including Curiosity. Long-range Korean space exploration, as outlined by Dr. Ju, includes a mission to return samples from the Moon by 2030, and an unmanned Mars exploration mission by that time.

There is no doubt that South Korea's intention is to be a leader in space, not just in Asia, but globally.

India to Mars

Like China, India has been thwarted in its ability to cooperate with other nations in space exploration due to policies, largely promulgated by the United States, under the rubric of "non-proliferation." Like China, India did not, however, abandon its ambition to become a space-faring nation, but invested in its domestic re-

search and development and industry, making substantial progress as one of the world's few space-faring nations.

India's confidence has been buoyed by the successful execution of its first deep-space mission, **Chandrayaan-1**, launched to the Moon in October 2008. At the Beijing Congress's plenary session with the heads of the world's space agencies, **Dr. S. Ramakishnan** explained that he was taking the place of the director of the **Indian Space Research Organization (ISRO), Dr. K. Radhakrishnan**, who had to remain in India to oversee launch preparation for India's first spacecraft to Mars. The launch window for India's **Mars Orbiter Mission (MOM)** is from Oct. 28-Nov. 19, and the spacecraft, **Mangalyaan**, which is Hindi for "Mars craft," arrived at the Sriharikota spaceport the first week in October.

The Mars Orbiter Mission is designed largely as a technology demonstrator, to test equipment for deep-space travel. Its scientific instruments will look for methane in the atmosphere, which could be a signature of life. Indian scientists report they are not at all discouraged by recent data from NASA's Mars rover Curiosity, which did not detect methane in the atmosphere of Gale Crater. There is a whole planet to explore!

India Space Research Organization

Indian engineers and technicians place the scientific instruments in the Mars Orbiter Mission spacecraft, readying it for launch as early as Oct. 28. The craft builds upon India's Chandrayaan lunar mission.

'Leadership?'

NASA Administrator Charlie Bolden claimed, in his remarks during the first session of the Congress, that he "leads the world's leading space-faring nation." Since other space agency heads on the panel had confirmed their interest and plans for cooperation with China, Bolden's remarks led the moderator of the panel to ask the hapless Administrator: "Does this mean Charlie Bolden is 'home alone?'" referring to the American movie of that name, in which a young boy is accidentally left home when his family leaves town for Christmas.

The policy of excluding Chinese participation in U.S. space projects, a slap in the face not only to China but to the world scientific community, has encountered vocal resistance. America's most accomplished scientists studying extrasolar planets announced during the first week in October their refusal to participate in their own upcoming technical conference, the 2nd Kepler Science Conference (Nov. 4-8), because scientists who are Chinese nationals, and have been doing research at U.S. universities, were not allowed to register for the meeting.

Leadership is not expressed by successfully carrying out projects that were designed years or even decades ago. Leadership is the ability to look into the future and move society in the direction required to get there. President Kennedy's leadership in space was that he could look, with passion and imagination, a decade and more ahead, see where he thought the United States should be, and approve the plan to get there.

China and the newer space-faring nations of Asia are not in a race with the U.S., Russia, or primarily even with each other, as is often asserted. They are not satisfied with the present, and they certainly have no thought of going backward. They are planning for the future.

That, Mr. Bolden, is leadership.