China Is Leading Mankind in Space

by Marsha Freeman and William Jones

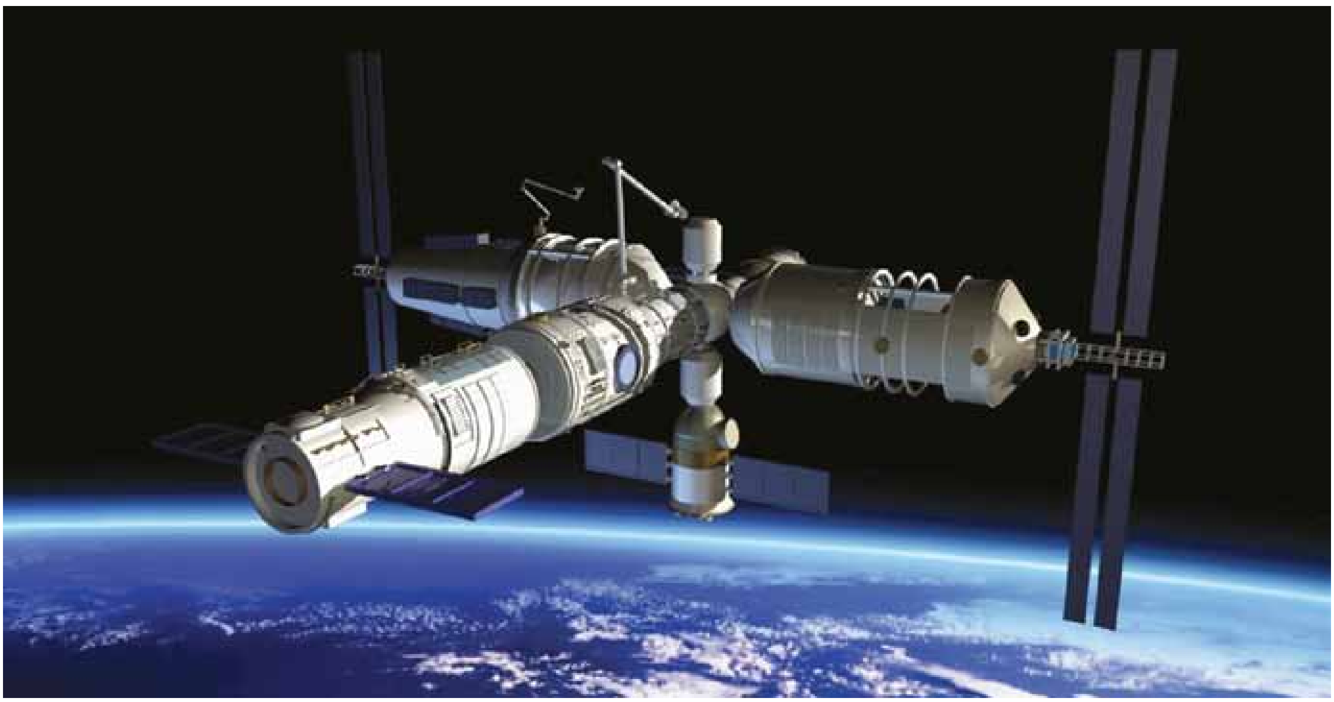
Man is a being of high aspirations.
—Shelley

Sept. 3—China is in the midst of a broad-based, multi-decade space exploration program, which will bring major scientific discoveries, and with them, many other benefits to mankind over the coming decade, as Man realizes his true nature as a cosmic species. China's space initiatives dovetail with its goal of creating a knowledge-based society, where economic progress is the outcome of breakthroughs in science, and their applications through innovation in new technology.

Although China did not first enter space until the 1970s, the nation now has underway short-term manned missions to carry out scientific experiments in low Earth orbit; deep-space robotic exploration missions to the Moon; space science observatories; and an array of applications satellites. On the agenda are a long-duration manned space station; challenging lunar missions that will break new ground in science; space science satellites for the exploration of the Universe; and the application of space technologies that will enable implementation of the Great Projects of the New Silk Road.

The "New Silk Road," or "One Belt, One Road" initiative, put forward by President Xi Jinping in 2013, is engaging 60 nations, from China's Asian neighbors, through Central and Eastern Europe, to nations in Western Europe, in great infrastructure projects, and new development corridors. Through this program; through the new multilateral financial institutions to fund great projects, like the AIIB and the New Development Bank; and through its own national innovation-driven economic development projects, China is at the center of the mobilization to finally replace the bankrupt postwar Anglo-American financial system, in order to create a global transformation to a growth-based new world order.

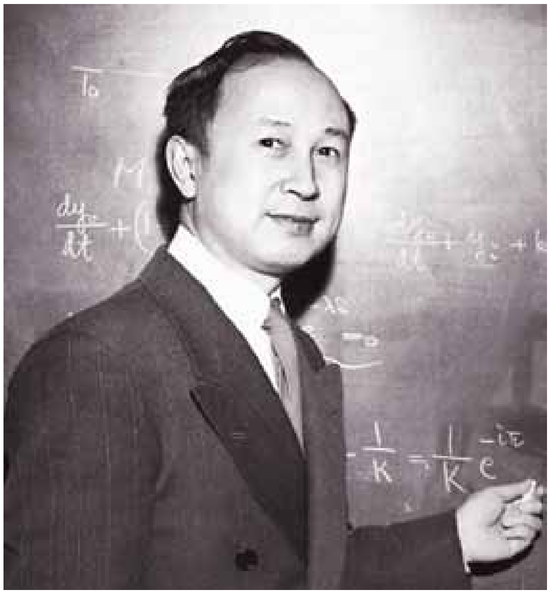
Hostile observers criticize China's space program for allegedly competing with other developing space



China National Space Administration

The goal of China's space program is to create a space-faring civilization, that meets the scientific and engineering challenges of exploring the Solar System and deep space. China's space station, seen here in a artist's rendering, will be the base from which mankind will venture forth to explore.

powers, such as India; for only repeating what the United States and Russia have already accomplished; and as a secretive effort, run by a "Communist" regime, closed off from the rest of the world. None of that is true. Either they make these claims out of ignorance, or, more often, in a conscious and determined effort to try to undermine China's emerging leadership role in space exploration, ahead of a former U.S. "super-power," controlled by a former British Empire, which have both seen their international stature in science and technology, along with their productive economies, severely eroded over the past two decades.



Qian Xuesen, became the "father" of China's rocket program, after having been deported from the United States. Here, he is teaching in California before returning to China.

The civilian Chinese space program had a later start than those of the other nations, such as the United States, the Soviet Union, Western Europe, and Japan. But China does not measure itself, or determine its schedule, based on the activities of others. There is no Chinese "space race." Missions are planned, and are executed when they are ready. Each program, such as in manned space and lunar exploration, proceeds through a progression of increasingly-difficult steps, towards a defined goal. Successes once won are not repeated. Each mission poses new challenges.

China is in the process of virtually remaking its civilian space capabilities. A new, more efficient launch complex has been inaugurated on Hainan Island. An entirely new family of launch vehicles is under development. The Long March 5 will have the capacity to orbit future 20-ton space station modules, and eventually the heavy-lift Long March 9 will take men to the Moon.

And, in the past few years, China has taken a dramatic step to open its space program to international collaboration, and boasts cooperation agreements with over 30 nations. But beyond agreements to share technology, now China has also invited other nations to be participants in its once-closed manned space program, offering to accommodate foreign astronauts on its future space station.

The fact that the U.S. space agency has been forbidden by law from manned space cooperation with China since 2011, has been attacked and ridiculed by former U.S. astronauts, policy shapers, and even by NASA Administrator Charlie Bolden. The European Space Agency is already having its astronauts learn Chinese.

In 2022, when the Chinese space station is fully operational, the International Space Station will be nearing the end of its life. Will the United States continue to have a manned space program at all? When the Chinese make major scientific advancements in their lunar program, and plan for manned landings, will the United States continue the Obama policy of selling off the nation's scientific patrimony and future to the "private sector?"

China has invited the rest of the world to join in its global development program, and the venture of Man and his creative intelligence into space.

Inspiring the Space Venture

The world first began to take notice of China's burgeoning space program in 2003, with the launch of Yang Liwei, China's first man in space. But China's interest and fascination with space goes further back.

Readers are probably aware of the shock effect that the 1957 Soviet launch of Sputnik had on U.S. political circles, leading to the initiation of a fast track on space and rocket development in the United States. Sputnik also had its effect on the Chinese leadership. Coincidentally, Chinese leader Mao Tse-tung arrived on his second—and last—visit to Russia, in November 1957, just one month after Sputnik was launched. On his arrival, he congratulated the Soviets for their "great accomplishment that exemplifies the beginning of a new era of humankind's progressive conquest of nature." In advance of Mao's visit, the Chinese and Soviets had signed agreements whereby Russia would assist China in the development of nuclear weapons, missiles, and aircraft.

China also had its own resources as well. Chinese-born Qian Xuesen was a protege of the Hungarian-American aeronautics and astronautics scientist Theodore von Karman at the California Institute of Technology. In November 1943, Qian was one of the founders of the Jet Propulsion Laboratory at the California Institute of Technology. The laboratory became one of the early pioneers of rocketry and ballistic missile technology in the United States.

The Dong Feng-1, developed under Qian's guidance, seen here, was based on the Soviet R2 missile, itself a derivative of the German V-2 rocket.

Qian's accomplishments were so impressive that at the end of World War II, he was inducted into the U.S. military, in order to go to Germany to interrogate the team of German rocket scientists led by Wernher von Braun, who had surrendered to the Americans and were prepared to work with the United States on developing rockets. Rudolph Hermann, one of the von Braun team at Peenemünde, who had designed their wind tunnel, relates his encounter with Qian during his interrogation. "I remember one of them," Hermann writes, "Dr. Qian, von Karman's closest associate, because he had written the paper about the "Pressure Distribution on a Cone in Supersonic Flow." He was the only scientist who had ever written a complete theory [on the subject]. We knew about his theory, because it was published about two years prior to the end of the war. We had used his theory and tested it in our tunnel exactly. I found out that nobody so far had tested Dr. Qian's theory in his country. We did it, because we had the equipment, we had the supersonic tunnel, the scientists and the engineers."

When he was at Cal Tech, Qian was involved with a group of young scientists and engineers that included future rocket-developer Frank Malina, future physicist Frank Oppenheimer, and others who were surreptitiously doing experiments on suborbital sounding (research) rockets. Qian's favorite pastime was listening to Bach or symphonies of Beethoven. And, like many young men in 1930s America, he and his friends were interested in social issues, reading works of left-wing thinkers including articles by Stalin and Lenin, and debating issues of social justice.

In 1950, as Qian was preparing to go back to China to visit his parents, he was arrested by the FBI, largely for his "complicity" in these early student gatherings. He was stripped of his security clearance and was held under house arrest for five years, and then deported to China. There he would serve as the leader of China's missile and nascent space program, and be the space program's strongest proponent. After Mao's visit to the Soviet Union in 1957, Qian went to Moscow to consolidate Soviet help on the missile program. After months of negotiations, the Soviets gave two R2 missiles to China.

But China might have started a missile program, even before Qian returned to his homeland.

In 1946, while waiting for an invitation to come to the United States to join his fellow Peenemünde rocket

In 1946, while waiting to come to the United States, German visionary Krafft Ehricke developed a proposal for Chinese officials to create a rocket program in China. He proposed that unemployed German rocket experts go to China to create the cadre and manufacturing capability for the future.

The Table of Contents of Krafft Ehricke's China proposal.

team members, space visionary Krafft Ehricke, proposed to Republic of China military representatives in occupied Germany, that unemployed German rocket experts go to China, and help create a rocket program.[1] China would have advanced quickly in developing space technology, had they accepted that proposal.

But as it turned out, the conditions Qian Xuesen found when he returned to China, were rather disheartening for starting a program so advanced as space and rocketry. "We had no research team personnel and metalworking shops." Qian wrote. "At that time my thoughts completely changed, from optimism to pessimism. I really felt that in scientific research it would be difficult to progress even an inch, and I was worried to death about it. I didn't know how to struggle in a difficult environment… how to start from scratch." Nevertheless, by 1958 Qian Xuesen had developed a program with the code name "581" for China to launch a satellite. When adopted, the mission was widely acclaimed and "Launch a satellite" became a national slogan. Children born throughout the country during that time were often named "Weixing," the Chinese word for satellite.

The initial program was to launch suborbital sounding rockets and eventually a satellite. However, the program was delayed by several factors. The break with the Soviet Union in 1960 led to the departure of the hundreds of the Soviet experts who were working in China. The "Great Leap Forward," which was Mao's disastrous forced-march attempt to jump-start the economy without providing the needed economic underpinnings, was followed soon by the cataclysmic "Cultural Revolution," where thousands of leading scientists were rounded up, sent off to the countryside, or even killed. Only a core of the defense-related programs, including rocketry, were somewhat immune from the devastation wreaked by the youthful Red Guards on the intellectual elites of China.

A Halting Beginning

Nevertheless, in February 1960, China succeeded in launching its first indigenously produced liquid-fueled rocket, reaching an altitude of 8 kilometers. In 1964, China launched its first medium-range ballistic missile. In 1962, after the flight of Yuri Gagarin, Qian Xuesen wrote a book, *Interplanetary Flight*, which stimulated the thinking of Chinese scientists regarding space flight.

Deng Xiaoping became the leader of China not long after the death of Mao in 1976. He was responsible for the policy of "reform and opening up" which began the transformation of China into a major economic power. Deng placed the development of science and technology at the center of China's reforms. This photo was taken in 1979.

In January 1965, Qian began again to put before the Party Central Committee his program for building a satellite. This led to the establishment of the 651 Design Institute, which would be responsible for the project. The first satellite, "The East Is Red 1," was launched on April 24, 1970.

With the end of the Cultural Revolution and the death of Mao in 1976, Deng Xiaoping began his "reform and opening up" policy, which did indeed open up China to the outside world. For several decades, China became the low-wage manufacturing center of the world. But it was not Deng's intention that this would always be the case.

One of the first measures he took was to bring back the exiled professors to the universities, and again open up the universities to all eligible students. He also revived the Chinese Academy of Sciences. But Deng's goal was to resolve many of the economic problems

1. See, "A 1946 Proposal for a Chinese Rocket Program," Marsha Freeman, in *History of Rocketry and Astronautics,* 2015, Univelt, for the American Astronautical Society.

facing China after a period of great devastation. While a primitive astronautics program had been initiated in the 1960s, it was canceled by Mao in 1971, for political reasons. While Deng was keen on enhancing China's capabilities in launching satellites, manned space flight was not yet on the agenda, in spite of urgings by Qian Xuesen.

In January 1977 and again in March 1978, Qian sent letters to Chen Xin, the director of the CSTND (Commission for Science, Technology and Industry for National Defense), who had been involved in medical science and in the original astronaut training program, asking for his support for a crash program to get a person into space by 1985, but apparently he was not heeded.

This all changed with the 1983 announcement by President Ronald Reagan, who, under the influence of economist and Presidential candidate Lyndon LaRouche, launched the Strategic Defense Initiative, with its promise of new technological breakthroughs. It was clear to some of the key scientists involved in the Chinese satellite program that the U.S. commitment had changed things entirely, and this provoked a major debate at the highest levels in China.

Some Chinese scientists, as related by Gong Xiaohua,[2] argued that missile defense "is not just a military program but a far-reaching political striving to preserve American superiority." In fact, this was an untruth which was being spread deliberately against LaRouche's SDI. In reality, LaRouche and Reagan had always agreed that SDI technologies should be shared with the Soviets, and used worldwide, especially for the industrialization of developing countries. Other Chinese scientists argued that the real objective was "to push forward new advanced technologies and national economic development," which was precisely LaRouche's idea for the program, if it is interpreted to mean development of *all* nations.

China National Space Administration

Each of China's manned Shenzhou missions has advanced China's steps toward a permanent manned presence in space. On the Shenzhou-9 mission in 2008, the first extravehicular activity ("space walk") was conducted. This capability will be needed to assemble the planned space station.

Some Chinese scientists argued that this required China to rapidly upgrade its own technological level, while others wanted to build up the economic base gradually and not launch any new major technological projects, including human space flight, until they had improved China's economic performance.

Those pushing for a major science-driver program won out, and in March 1986, Chinese planners finalized their plan for research and development, Plan 863. A second dispute arose when the planners presented their proposal to Deng Xiaoping. Would the research be targeted solely to defense needs, or would it be geared to the civilian economy? Deng called for a dual-technology approach. Plan 863 designated seven areas which would be the priorities for development: life sciences, information, energy, defense, automation, new materials, and aerospace.

In February 1987, a special committee was established to develop a detailed plan for the space sector, organized around the operation of a space station in low-Earth orbit, which could be used for the long-term conduct of human scientific experiments. Human space flight was again on the agenda. All told, the 863 Program of scientific research resulted in 2,000 domestic and international patents, and the emergence of an indigenous Chinese IT sector that is today a world leader. In 1997 China issued a new Research program, Plan 973, and in 2013, a further National Key Research and Development Plan was propagated, which incorporated the work of the earlier plans in a more comprehensive structure.

China Puts Men Into Space

The early 1990s brought dramatic changes. The new economic direction of the Chinese leadership, combined with the collapse of the Soviet Union, created

2. ``The Inside Story of China's Space Policy Making, 2005,'' page 263, (in Chinese); quoted in, *A Place for One Man's Mat: China's Space Program, 1956-2003*, by Gregory Kulacki and Jeffrey G. Lewis, 2009, American Academy of Arts & Sciences.

new possibilities for an accelerated and far-reaching Chinese space program

In 1992, Chinese space scientists formulated a development program with the aim of launching a Chinese astronaut into Earth orbit. This was not conceived as a single event, to make a statement or impress either the Chinese people or the world. Rather, just as it was in the eyes of President Kennedy, the German space pioneers, and the leaders of the U.S. space program, the early manned missions would be the first steps to take mankind beyond the Earth, to create a space-faring civilization.

At the same time, many restrictions that had been placed upon the leaders of the former Soviet Union's space program, were gone, and they were now in a position to be able to share their science and technology with the rest of the world. In 1992, Russia created a civilian space agency, and with it the opportunity for international collaboration. For the United States, this made possible the Shuttle/Mir program of mutually-beneficial joint manned orbital missions. For China, it opened the door to gain access, especially in the manned-space field, to Russia's preeminent technology. The first Chinese astronauts were trained in Russia, and the sharing of some of the technology from Russia's Soyuz manned capsule aided the development of China's Shenzhou manned spacecraft.

Theo Pirard

At the Naples, Italy International Astronautical Congress in 2012, the authors had the opportunity to meet Liu Yang, the first female Chinese astronaut, who flew on the Shenzhou-9 mission, earlier that year.

On the morning of Oct. 14, 2003, a 38-year-old military pilot, Yang Liwei, became the first Chinese astronaut to orbit the Earth. China became only the third nation in the world, after Russia and the United States, to launch a man into space. The decision had been made in 1992 to embark on a manned space program, and since 1998, fourteen Chinese astronauts had been training for the mission.

In fact, China had considered carrying out a manned space program as early as 1967, during the heat of the United States-Soviet space race, but it remained only as a draft program, *Aerospace China* reported in 2003.

Although Yang's mission came decades after Yuri Gagarin's, it was not a simple copy of that world-historic feat. Following China's philosophy of having each space mission break new ground, Yang's Shenzhou-5 spacecraft may have looked like a Russian Soyuz,— but unlike Gagarin's craft, Yang was able to maneuver the Shenzhou, changing its orbit. This would be needed in later missions, in order to rendezvous and dock with other spacecraft.

The mission also included an orbital module, which stayed in space after Yang returned to Earth, and carried out microgravity experiments. In fact, the Shenzhou was nearly twice the mass of the original Soyuz, and was even larger than the vehicles that carry crew to the International Space Station. That first flight was designed in preparation for the much more complex missions to come.

World space experts claimed to be caught by surprise at Yang's flight. But, in the year 2000, the Office of the State Council of China had released, for the first time in English, an eight-page white paper, titled, "China's Space Activities." It was written by Luan Enjie, the head of CNSA (China National Space Administration) from 1998-2006. The paper outlined the goals for the following 20 years. Included were manned space flights, as well as a pre-study of outer-space exploration of the Moon.

The year following Yang's mission, Chinese space officials laid out the step-by-step plan for China's manned space program: multiple-crew missions, extravehicular (space walk) activities, the rendezvous and docking of two space vehicles, the operation of scientific experiments in micro-gravity, and a man-tended science laboratory,— all to culminate in a space station that can be operated long-term. This is exactly the plan China has been executing.

China has developed the launch, life support, and full array of technologies needed for its manned space program. Shenzhou missions have carried up to three crew members, and have docked with the unmanned Tiangong-1 module both manually and automatically. Astronauts have performed space walks, carried out scientific experiments, all to prepare for the assembly and operation of lengthy stays on its future space station. And to engage everyone, and particularly the young, in this national science-driven exploration, during the 2013 Shenzhou-10 mission, China's second female crew member, Wang Yaping, taught physics lessons to 60 million Chinese students from Earth orbit.

The next step in China's manned space program will be the mid-September launch of the Tiangong-2 module, seen here being completed. A two-man crew will carry out scientific experiments in the small lab for 30 days.

Later this month, China will launch the Tiangong-2 orbital module. Although the same size as the first, the crew will remain in orbit for 30 days, doubling the stay of the previous Tiangong-1 mission. In order to carry the supplies needed for the extended stay, only two crew members, rather than three, will be on the Shenzhou-11 spacecraft that will deliver them to the module, before the end of this year. After the Shenzhou-11 crew has completed their mission, a new unmanned cargo ship, named Tianzhou, similar in function to the Russian Progress cargo ships, will carry out tests with Tiangong-2, including the refueling of the module in orbit.

In 2018, China plans to launch the first component for its space station, which should be fully operational by 2022. The long-range goal is to use the station to prepare for the manned missions into deep space that will follow in the future. The biomedical effects of microgravity and the radiation environment of deep space, the long-lived reliability of space hardware, the psychological impact of a confined habitat, and remote operations, will be tested on the space station in near-by Earth orbit, before Chinese space travelers head for the Moon.

In October 2013, Chinese officials used the occasion of the 64th International Astronautical Congress in Beijing, to invite all other space-faring nations to participate in China's future space station. Astronaut Yang Liwei extended an invitation to foreign space agencies to train crew members for flights on Shenzhou spacecraft to the station. The European Space Agency, its director reported, is already having its astronauts learn Chinese.

The station will include three Chinese laboratory modules, but docking ports will be installed that can accommodate laboratories contributed by other nations.

Deep-Space Exploration

A decade before China's manned space program had achieved its first success in 2003, scientists had been making public their intention to explore the Moon. The most vocal promoter of lunar exploration has been Ouyang Ziyuan.

In a video presentation about Ouyang's life, which aired in 2008, China Central Television (CCTV) relates that his interest in the Moon began in childhood, when

Chinese Academy of Sciences

The father, and chief scientist, of China's lunar program, who created the field of cosmochemistry in China, is Ouyang Ziyuan. Here, he is addressing students in 2010, in his passionate drive to create the next generation of scientists.

he heard the legend of the Chinese princess, Chang'e, and her flight to the Moon. Later, as a geologist, space intrigued him when he studied the impacts of meteorites which had visited Earth from outer space.

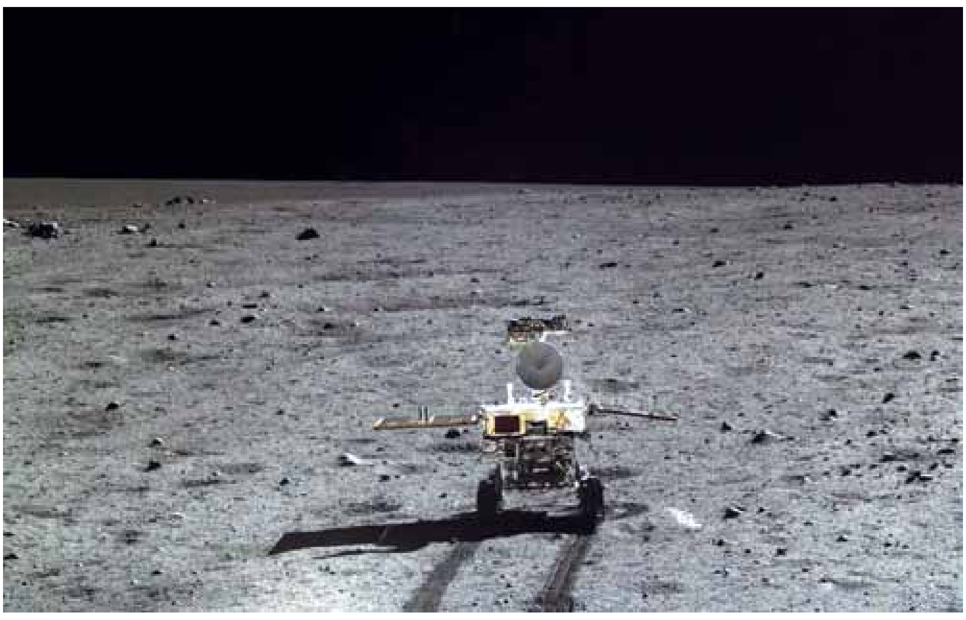
His scientific interest turned to the Moon, when, under President Nixon's post-Apollo "Goodwill Rocks" diplomatic initiative, in 1978, China was one of 135 nations to receive a rock from the U.S that Apollo astronauts had brought back from the Moon. This one-half gram lunar sample from our nearest heavenly body was examined by Chinese scientists, and excited Ouyang's imagination, posing more questions about the origin of the Moon than had even been considered before. He originated the study of cosmochemistry in China to enable more challenging studies of the Moon.

In a 2013 interview, Ouyang recalls that in 1992, China's government approved a manned space program, and the following year, the scientists submitted a proposal for the first lunar mission. Three years later, the Academy of Sciences agreed to study the program, and finally, in 1998, the three-phase lunar plan was approved by the Academy. In 2004, the Chang'e series of missions was appproved by the federal government, with Ouyang as the chief scientist.

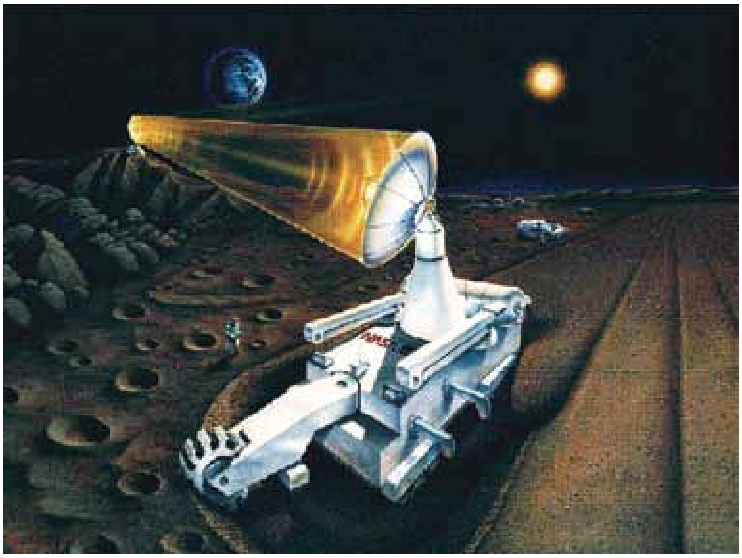
During the decade that the lunar exploration program was under consideration, Ouyang decided that public education and support would encourage a positive decision by the government. He embarked upon a series of popular science lectures about the Moon, which he has continued to the present day. He has focused on educational institutions, in order to recruit the next generation of scientists and engineers. He believes it is the responsibility of the scientist to create a knowledge and love of science in the population at large.

As far back as 2006, before the first lunar Chang'e-1 mission, Ouyang has been discussing the importance of utilizing lunar resources, singling out the isotope helium-3, rare on Earth, as a fuel for fusion. "Currently nuclear fusion technology is not mature," he explained, "but once it is commercialized, fuel supply will become a problem." "Each year, three Space Shuttle missions could bring back enough fuel for all human beings across the world," he said. In China's three-phase lunar program, the "third target" is to improve our understanding of helium-3 reserves.

In early 2003, Ouyang stated that China is expected to complete its first exploration of the Moon in 2010.



The fruit of Ouyang's decade-long planning of lunar missions is the succession of groundbreaking Chang'e missions to the Moon. Here, the diminutive Chang'e-3 rover, Yutu, which landed on the Moon at the end of 2013, sits amidst the stark lunar landscape. It carried out the first radar investigations of the subsurface of the Moon.



University of Wisconsin, Fusion Technology Center

China plans to not only carry out experiments in order to answer some of the most challenging questions about the Moon, but also to exploit its resources, such as helium-3 as a fuel for fusion energy, which could power the Earth.

Following that, it will establish a base on the Moon. A few months later, he explained that the first in a series of China's robot lunar missions, under its multi-phase China Lunar Exploration Project (CLEP), would be a satellite to orbit the Moon. It would be named Chang'e, after a mythical Chinese princess who flies to the Moon with her pet rabbit, Yutu.

In the second phase, China would place lunar landers on the surface, with remote-controlled rovers,—which it has accomplished. In the third phase, a spacecraft would land, collect samples, and return them to the Earth. This is now scheduled for 2017. Earth's nearest neighbor probably holds the key to humanity's future subsistence and development, says Ouyang. Lunar exploration he said, should be carried out through international cooperation.

China's National Space Administration head, Luan Enjie, speaking at an aerospace conference that year, explained: "The Moon contains various special resources for humanity to develop and use, notably, helium-3. It is a clean, efficient, safe, and cheap new type of nuclear fusion fuel for mankind's future long-term use, and it will help change the energy-resource structure of human society." A news release by *Xinhua News Agency* about Luan's announcement, reported that, "On the Moon, there are between 300,000 and 500,000 tons of Helium-3 reserves. In fusion reactors, it would be capable of sustaining the Earth's electricity [production] for 7,000 years." The mining of helium-3 is a centerpiece of China's goals in lunar exploration.

In 2006, China hosted the eighth conference of the prestigious International Lunar Exploration Working Group, which gathers together the top lunar scientists and mission planners from around the globe. The Beijing Declaration released at that conference committed all space-faring nations to coordinate the operation and scientific results from the array of lunar missions that were being planned, in addition to China, by the United States, Russia, Europe, India, and Japan.

China has carefully followed the progression of lunar missions that was enumerated in its original plan. Chang'e-1, launched in 2007, explored the Moon from lunar orbit. Its scientific instruments analyzed minerals on the surface of the Moon. The Chang'e-2 mission, in 2010, did more detailed mapping, and, after completing its lunar mission, was deployed to a further distance in deep space.

The Chang'e-3 mission captured the imagination of the entire world in 2013, when the lander deployed the 300-pound Yutu (Jade Rabbit) rover on the surface, the first to traverse the Moon since the 1970s. Although Yutu's ability to travel over the lunar surface did not extend past the first cycle of the 14-day lunar night, its ground-penetrating radar and astronomical telescope continued to transmit scientific data, via the lander and orbiter, back to Earth.

Remarking on Jan. 17, 2014 on the significance of China's lunar program, Lyndon LaRouche described the Chang'e-3 landing as "a brilliant enterprise." As do the Chinese scientists, LaRouche stressed that "there is a raw material which has dropped on the Moon as part of the radiation of thermonuclear fusion [from the Sun], essentially that is, of helium-3… which has accumulated on the surface of the Moon, [and] is now the most promising factor in planning the future of the life of the human species." LaRouche added that "if we transmit the benefit of the Moon's accumulation [from the Sun's] thermonuclear fusion, *we are no longer Earthlings*." This formulation echoes that of space visionary Krafft Ehricke, whose extensive plans for the industrial development of the Moon, as the "seventh continent" of the Earth, were based on mankind's "extraterrestrial imperative."

The Chang'e-5T mission, in November 2014, tested technology that will be critical to next year's Chang'e-5 sample return mission, by sending a small capsule from lunar orbit back to Earth. It took this stunning photo of the lunar far side and Earth.

The success of the Chang'e-3 mission, gave Chinese space planners the confidence to move on to the next step, and re-purpose the back-up spacecraft that had been designated Chang'e-4, were it needed to repeat the landing/roving mission. The new November 2014 mission was designated Chang'e-5T, denoting that it was a test mission for the future mission 5, which will return a lunar sample to Earth. Chang'e-5T successfully swung around the Moon, and carried out a dry run for the future sample return. The mock Return Module successfully plunged through the Earth's atmosphere and was recovered, in a practice run for delivering lunar samples to scientists. The actual Chang'e-5 sample return mission is now scheduled for 2017.

Responding to often-heard complaints from self-appointed U.S. space experts, lunar scientist Paul Spudis told *space.com's* Leonard David after the Chang'e-5T success: "China now has positive practical experience with all of the elements of a human mission to the Moon… And to the brainless twits who might comment that they are only doing something that we have already done, I will simply note that no one at the current incarnation of NASA has done it."

A lunar sample return is a challenging mission which will involve landing a craft, collecting samples, storing them in an hermetically-sealed capsule, launching the capsule from the surface of the Moon to link up with a craft in lunar orbit, which will head back to Earth, and release the capsule with the samples, to be dropped through the atmosphere.

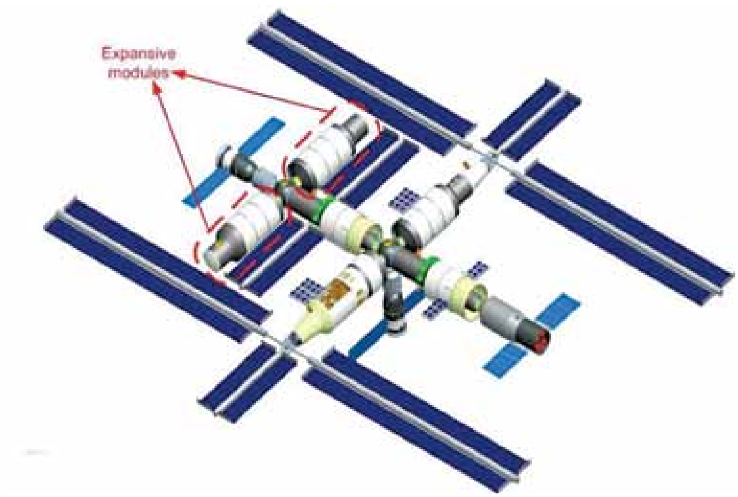
Other, still more challenging lunar missions are also being planned.

On the Space Frontier

In 2018, China plans to take another bold step in lunar exploration, which, based on its success to date, has been added to the original lunar exploration program. Chang'e-4 will land on the far (non-Earth-facing) side of the Moon, which has never been done by any space agency before. Through photographs taken by orbiters, it is known that the far side of the Moon is significantly different than the face we can see from Earth.

Without a direct line of sight to the Earth, the lander will communicate with Mission Control through an orbiter, which will serve as a relay. The relay satellite is planned to be deployed to the fairly gravitationally-stable L2 point, at a distance of one million miles from the Earth, where it will always have a line of sight to both the lander and the Earth. Even from the earliest fuzzy photographs of the far side of the Moon, sent back from a Russian orbiter in the late 1950s, it could be seen that the hemisphere of the Moon that never faces the Earth, has a different history, topography, and most likely geology and geochemistry, than the Earth-facing near side. Having been sheltered from many of the Earth's effects, it should reveal a more pristine history of the early Solar System.

High-resolution images, most recently delivered by NASA's Lunar Reconnaissance Orbiter, have revealed less evidence of volcanic activity than the near side. There is a higher density of impact craters, including the deepest one on the Moon, located at the south pole. But in addition to what we will learn about the Moon's origin, history, and evolution, the early Earth, and the Solar System,— the far side presents the opportunity to



As a demonstration of the ability of mankind to live and work in space, and as a stepping stone to the lunar and Mars missions that will follow, China plans to start deploying components for a long-duration space station in 2018, with full operation four years later. In this depiction, the two large cylindrical modules in the center, with the large solar arrays attached, are Chinese experiment modules. The two that are marked "Expansive modules" are docking spaces being offered to other nations who have been invited to send their own laboratories to the station.

look out at the universe in a way we cannot do as well from the Earth, or even from Earth orbit.

The far side of the Moon is shielded from the massive amount of radio signals (noise) coming from our electromagnetically-active Earth civilization. Radio waves, at the very low end of the electromagnetic spectrum, are emitted by galaxies, which will first become revealed by placing radio telescopes on the far side of the Moon. Radio astronomy studies of the Sun and regions of our Solar System will also improve when we can extend the range of frequencies that we can detect.

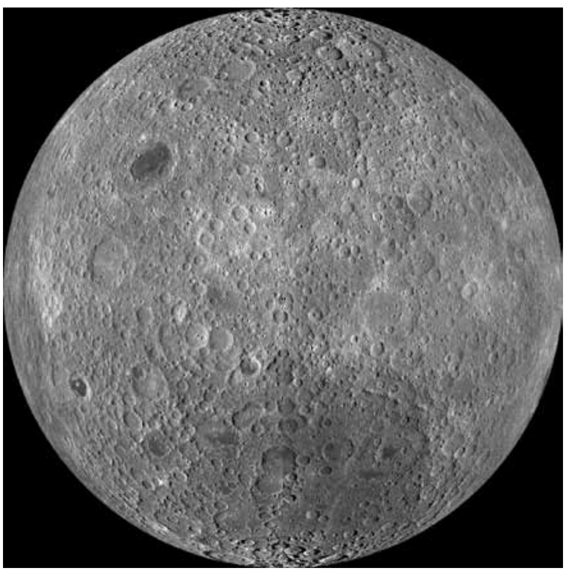
Beyond the landing on the far side of the Moon, an even more ambitious possible future lunar mission has recently been proposed by scientists, this time to use the Moon to study the Earth.

A group of leading Chinese scientists is conducting a feasibility study of building a manned radar station on the Moon, reported the Aug. 21 *South China Morning Post*. The project was launched earlier this year, according to the National Natural Science Foundation of China, with funding for the study of about $2.6 million. Last month, the group met to hold a two-day "brainstorming session."

As noted by the scientists, this project would be a massive undertaking, with many challenges. The lunar-based radar would generate high-intensity beams that could reach the Earth, and the signals received back to the lunar station could provide data on extreme weather conditions, global earthquake activity, the polar ice caps, and other changing features. The advantage of a lunar station over a set of orbiting satellites, explains team leader Prof. Guo Huadong, is that it would provide a wider view than those from the specific locations of orbital satellites. In addition, the Moon is a stable platform, and would have "unlimited durability," in that it could be visited by people, and maintained or repaired.

In order to generate high-intensity radar beams to reach the Earth, a station would need an enormous amount of power, which is one challenge, Guo said in a paper proposing the project three years ago. One reason to have it manned, is that the radar would generate so much data bouncing back from Earth to the lunar station, that it would exceed the long-distance communications bandwidth capability that is now available. On site, astronauts could process the information before sending it back to Earth. At a meeting of the project team in April, the article reports, Chai Yucheng, from the National Science Foundation, said that the government expects a "significant breakthrough" in this proposal by 2020, when the team is to submit its final report.

One broad area of space activity that until recently had



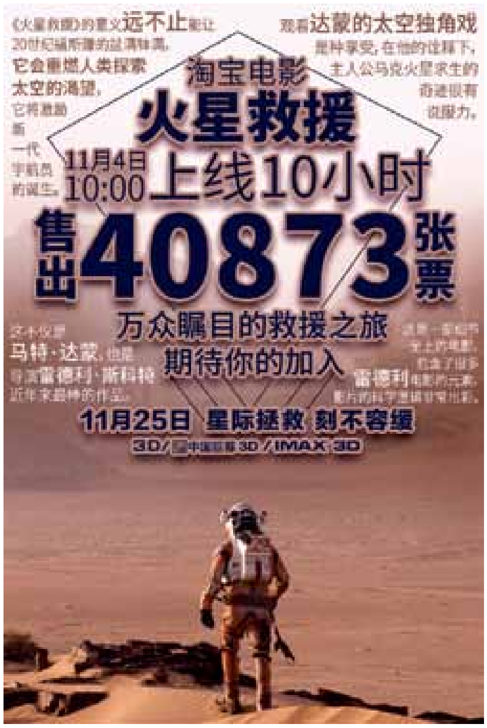
NASA

No spacecraft has ever landed on the far side of the Moon, which is never seen from the Earth. In this photograph taken by NASA's Lunar Reconnaissance Orbiter, it is easy to recognize that this is not the face we see. Littered with craters and lacking the familiar dark maria, or basaltic "seas," the far side could hold the key to the early evolution of the Earth and the Solar system. Radio astronomy from the electromagnetically quiet far side, will open a new window on the Universe.

In 2020, China will stretch its astronautical reach further, with its first planned mission to Mars. This model of the lander was recently made public. The mission will include an orbiter, lander, and rover, all on the very first mission to Mars.

not received very much support, is the deployment of scientific satellites, for studies in astronomy, astrophysics, cosmology, biology, and other scientific fields. In 2011, the Chinese leadership, for the first time, authorized a multi-year space science initiative to be carried out during the 12th Five-Year Plan, through 2016. The Strategic Pioneer Research Program in Space Science consists of the development and deployment of up to five space science missions over five years.

As China readied the launch of the first in this series of satellites, in early November last year, Wu Ji, director of the National Space Science Center under the Academy of Sciences, said, "China is the world's second-largest economy, and a major player in space. We should not only be the users of space knowledge, we should also be the creator of space knowledge." Wu added: "China should not only follow others in space exploration; it should set some challenging goals that have never been done by others, such as sending the Chang'e-4 lunar probe to land on the far side of the Moon."



The release of the film "The Martian" in China generated great excitement, as it presented an optimistic view of how man can overcome challenges, and is a call for international cooperation, as it is a Chinese ship that rescues the stranded American astronaut. It is collaboration in Earth-bound great economic projects, and in challenging space missions, the Chinese believe, that will bring mankind into the future.

China's first space observatory, and the first science satellite in the series, the Dark Matter Particle Explorer (DAMPE) was launched last December, and will observe the direction, energy, and electrical charge of high-energy particles in search of dark matter, chief scientist Chang Jin explained. It is described as encompassing the widest spectrum of highest-energy resolution of any dark-matter probe. DAMPE is designed to operate for three years, and will also study the origin of cosmic rays and observe high-energy gamma rays.

The second in the space science series was the launch in April of the Shijian-10. Its capsule, which contained 20 scientific experiments, was returned to Earth for examination of the effects of microgravity.

The ground-breaking Quantum Science Satellite, the third in the series, was just launched on Aug. 16 to test an experimental quantum communications satellite. The Hard X-ray Modulation Telescope, for astronomical studies, is slated for launch this year.

As China explores the Moon, deploys scientific observatories, exploits extraterrestrial resources, such as helium-3, and creates the basis for ambitious manned missions, it has recently also approved its first robotic mission to Mars.

In mid-August, China's space officials released new artists' drawings, a model, and more details about the Mars mission they plan to launch in 2020. Andrew Jones, China space writer for *gbtimes* reported on Aug. 23, that in a press conference in Beijing, the chief architect of the mission, Zhang Rongqiao, described it as "complex and ambitious," which is, in fact, an apt description of all of China's deep space missions. This will be China's first mission to Mars, and rather than follow the path of other countries, which carried out a succession of increasingly-complex Mars projects starting with an orbiter, China plans to deploy an orbiter, a lander, and a rover, all on the first mission.

The purpose and scientific goals of the mission are very broad: to use a suite of instruments to study the Martian topography, soil, atmosphere, and water ice. The rover will have a ground-penetrating radar, similar to that on the lunar rover Yutu, and will examine the internal structure of the planet. Lunar mission scientist Ye Peijian reports that the Mars rover is being developed by the same team that carried out the Chang'e-3 lunar lander/Yutu rover mission. Jones reports that Zhang said that this ambitious mission will also be a demonstration of the technology needed for a Mars sample-return mission around 2030.

During the favorable 2020 launch opportunity to Mars, missions will be launched by the United States, and by Russia for Europe. Japan will launch a small craft for the UAE. NASA and ESA missions that are now in development, aim to gather samples on Mars, as the first step to eventually returning the rocks and soil to Earth in the future. As China has the same goal, this is exploration that is ripe for international cooperation.

China's goals for its space exploration programs are no less, and no different fundamentally, than those of other nations. What is unique about China's space program, however, is the way it is seen by the country's political, as well as scientific, leadership. China's space programs are being pursued as a leading feature of a multi-decade thrust into the future, which will be shaped by the pace of advancements in science and technology.

While other efforts in human space exploration have languished in the wake of the world financial crisis and ensuing social chaos in many parts of the world, China is pointing the way forward in the "new frontier" of space. Chinese efforts have already generated great enthusiasm worldwide for manned space exploration. The world is waiting for the United States, the first nation to put a man on the Moon, to grasp the supreme importance of cooperating with China and other nations, in expanding the realm of human activity into the galaxy that is our common home.