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China's **bold** lunar plan

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China's bold lunar plan

Astronauts Buzz Aldrin of Apollo 11 and Eugene Cernan of Apollo 17 tell *Aerospace America* that engineering details emerging from China's first robotic Moon lander suggest it is a formal precursor to a manned lunar module that would carry Chinese astronauts to the surface of the Moon around 2030. In their view, the time may be right for NASA to begin direct cooperation with China on the return of humans—both Chinese and American—to the Moon as a prelude to international manned missions to Mars.

The 308-lb Chinese rover, seen in images circulated online, appears to be inspired by U.S. work on another celestial body: Mars. The rover sitting atop the lander has major components that look identical to those developed and flown a decade

ago by NASA's Mars Exploration Rover program. "It's remarkable that from a robotic rover design standpoint China wants to duplicate, with a lookalike on the Moon, what Spirit and Opportunity did on Mars," notes historian and author Andrew Chaikin.

Designated Chang'e 3, the mission's potential science return is already being questioned, at least outside of China. "Except for a ground-penetrating radar on the rover, none of many science instruments on the lander/rover are expected to discover much new on the Moon," says a U.S. lunar scientist who worked on Apollo and other lunar programs but is not authorized to speak on the record about the Chinese space program.

"The Chinese are carrying instruments that are a lot like instruments flown on the Soviet Luna and the U.S. Surveyor lander

by Craig Covault
Contributing writer



Information from previously secret photos and documents reveals intriguing details about Chang'e 3, the new Chinese robotic lunar lander. Experts in China and the U.S. say the craft is a precursor to a scaled-up vehicle designed to carry human crews to the

Moon. Other countries will be joining what has turned into a surge in lunar space plans. But if nothing changes, the U.S. will be contributing very little; a fact that two luminaries of the American lunar program suggest NASA should change.

program," he says. "I do not think they are going to find anything beyond what both U.S. and Soviet scientists already knew 45 years ago, even before Apollo 11."

Succeed or fail, the Chinese Communist party appears determined to reap the same kind of public adulation that accompanied the NASA Spirit and Opportunity rovers that landed on Mars in 2004. The government has begun a public contest to name the rover just as NASA did for all four U.S. Mars rovers launched since 1997. And the Chinese government has begun speaking in lofty terms about the project. Zhao Xiaojin, director of aerospace for the China Aerospace Science and Technology Corp., describes the rover as "a high altitude patrolman carrying the dreams of Asia."

The lander/rover combination is sched-

“The Chang’e 3 details tell me that the U.S. now absolutely must start communicating with the Chinese about lunar cooperation,” says Aldrin.

uled for liftoff from the Xichang launch site December 1 on a Long March 3B, China’s most powerful rocket. The unmanned Chang’e 3 is then to land on the Moon using a large descent stage with a powerful new throttling rocket engine—just as six NASA/Grumman lunar modules began doing nearly 45 years ago when they carried 12 U.S. astronauts to the lunar surface. Now it’s China’s turn.

“Seeing the Chinese lander and rover reveals major breakthroughs in Chinese space engineering,” says Aldrin, “and also in what the U.S. knows about the Chinese lunar program.” Aldrin copiled the lunar module Eagle with the late Neil Armstrong on July 20, 1969, during the first manned landing on the Moon.

“This unmanned lander is specifically designed to be scaled up for addition of an ascent stage and crew cabin,” Aldrin tells *Aerospace America*.

Ma Xingrui, head of China’s space exploration body and chief commander of the lunar program, has hinted cryptically at future applications. “The Chang’e 3 mission makes use of a plethora of innovative technologies, ‘secret weapons.’ It is an ex-

tremely difficult mission that carries great risk,” Ma said in Beijing.

“The Chinese robotic lander is much larger than what is needed for the small rover being carried,” notes Cernan, who commanded the Apollo 17 lunar module in December 1972 and was the final Apollo astronaut to leave footprints on the Moon. “It is obvious this thing is a genuine precursor to a Chinese manned version with a scaled-up descent stage,” he says.

The Chinese robotic flights are part of a multinational lunar mission surge with as many as a dozen robotic Moon missions, mostly landers, planned for launch by China, Russia, and India by 2020.

JOINING THE SURGE?

There may be a couple of fragile U.S. commercial landers in the mix as well. But while the Chinese and Russians are carrying out landings and surface operations, the only U.S. contributions will be the rich science data that continues to flow from the \$500-million, 4,000-lb Lunar Reconnaissance Orbiter. Launched in 2009, it is one of NASA’s most productive science and exploration spacecraft.

Russia, however, is also working to rebuild its once highly successful Soviet lunar robotic capability by planning as many as five lunar missions, four of them landers, between 2015 and 2020. How many will actually fly by 2020 is still being determined. All of the landers would aim at the Moon’s south pole to plumb for volatiles like water and other ices, possibly returning cryogenically preserved samples to Earth.

What Aldrin would like to see develop out of the lunar interest spawned by China’s program is a U.S. role in establishing a manned lunar capability at the L1 and L2 Lagrangian points near the Moon. Those locations would help the U.S. build a base efficiently at the resource-rich lunar south pole as a development facility for in-situ resource utilization to make Mars habitation viable in the future.

The U.S. will have scant participation in the lunar surge, although, ironically, it was NASA Ames’ LADEE (Lunar Atmosphere and Dust Environment Explorer) that initiated it. LADEE was launched from the Wallops Flight Center in Virginia on a Minotaur on September 6. Weighing 844 lb, the spacecraft now orbits the Moon in a retrograde trajectory, flying east to west at an altitude of only 31 mi. LADEE is only the seventh NASA robotic lunar orbit mission since Apollo 17.

The Nuclear-powered China Chang’e 3 Moon lander descent stage carrying the piggyback solar array-powered rover is lowered into Beijing vacuum chamber. The Chinese rover appears to copy many NASA Mars rover features and instruments. Credit: China Space News/NASASpaceflight.com/Planetary Society.



The underside of the lander has a nozzle for a large, new throttleable rocket engine and landing gear similar to Apollo lunar modules. The Chinese lander scales to about 40% of an Apollo descent stage and appears to be a formal prototype for eventual scale-up to a manned configuration. Credit: China Space News/NASASpaceflight.com/Planetary Society.





Technicians show the overall scale of the Chinese lander and the boxy design similar to the Apollo lunar module. But unlike Apollo, the plutonium 238 RTG-powered Chinese lander is to survive for an Earth year and carries science instruments including a drill and telescope. Rover is designed to drive up to 6 mi. during three Earth months of operation. Credit: China Space News/NASASpaceflight.com/Planetary Society.

LADEE is designed to capture and analyze lunar dust to determine if rays of light seen by orbiting Apollo astronauts above the Moon's horizon at lunar twilight were caused by a glow from sodium atoms or suspended dust.

India, too, plans to launch a lunar rover sometime during the same period, as part of its own space race with China. India had earlier teamed with Russia on an orbiter/rover plan that Russia scrapped after the loss of its Mars Phobos mission.

THE SECRET IS OUT

Direct proof of China's ambitious lunar surface program comes in the form of previously secret images sent out of China via the Internet.

The images, of the Chang'e 3 lander and rover, first appeared in the restricted Chinese government print publication *China Space News*. A Chinese web user in Hong Kong identified only as 'Galactic Penguin' then sent the pictures to a Chinese space thread on NASASpaceflight.com. From there they were picked up by Planetary Society blogger Emily Lakdawalla in Pasadena, California.

Back when the U.S. was pioneering human lunar exploration, Aldrin and Cernan spent thousands of hours at what was then the Grumman facility in Bethpage, N.Y., understanding the design of the Apollo lunar modules, and at the Manned Spacecraft Center in Houston, where their components were tested and crews were trained.

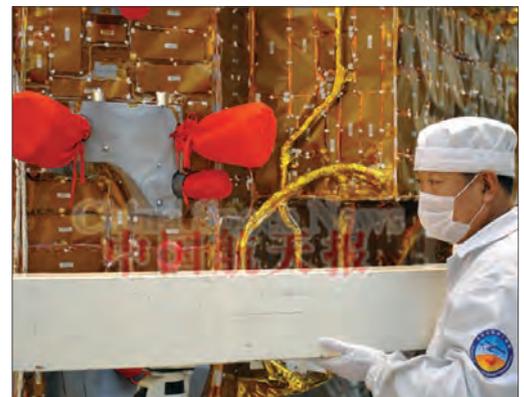
They're sure they know what goes into building a lunar module—and they see one in the Chang'e 3 hardware and supporting documents.

"The Chang'e 3 details tell me that the U.S. now absolutely must start communicating with the Chinese about lunar cooperation," says Aldrin. "The U.S. knows more about the Moon than anyone else, and we know more about bringing together foreign partners, as we did for the International Space Station," he adds.

"With all this experience, why aren't we the ones to form something like a 'manned international lunar outpost authority,' where countries can begin to coordinate and demonstrate on the Moon operations needed on Mars, rather than doing it on an asteroid?" asks Aldrin.

"We are going to need cooperation for any mission to Mars, and lunar cooperation with China is a nice thought," says Cernan, "but we have nothing to deal with, we have no bargaining chips." Aldrin, however, believes the United States and its partners would have leverage if they invited China to participate in the ISS program.

The U.S. has rejected Chinese station overtures for more than a decade, because all of China's manned space operations are



A technician inspects the area around thrusters covered in protective red covers. Credit: China Space News/NASASpaceflight.com/Planetary Society.



The circular 146-mi.-diam. Sinus Iridium is the landing zone for the Chang'e 3. It is easily visible with binoculars at the northwest corner of the Imbrium Basin, the left eye of the 'Man in the Moon' viewed from Earth. Credit: Peter Rosén.

tightly controlled by the People's Liberation Army. Also, the vote must be unanimous among the ISS partners, and Japan and Russia especially may oppose it.

The lander spacecraft is more than 40% the size of a NASA Apollo lunar module descent stage, and the Chinese are building them on an assembly line basis. "This thing is huge!" exclaimed Lakdawalla, a planetary spacecraft expert, in her initial Chang'e 3 blog when she first saw the images.

As many as six Chang'e landers are being designed and built—two landers each with rovers, and as many as four other landers to complete two missions that would each bring back to Earth 4.6 lb (2 kg) of lunar rock and regolith. According to the Chinese, a duplicate lander and rover have been built in tandem with Chang'e 3 to act as a backup or fly as Chang'e 4 in 2015.

"The Chinese will be the next on the Moon, and they are going to be there for a long time, with significant staying power," says Cernan. He and Aldrin believe Chinese manned lunar landings will be possible on larger versions of the Chang'e 3 design within 10 years.

As with U.S. programs, a big challenge

will be launch vehicle development. Liang Xiaohong, the deputy director and Communist Party chief of China's Academy of Launch Vehicle Technology, said early this year that China is beginning formal development of a Saturn-V-class Moon rocket with 11 million lb of liftoff thrust—3.5 million more than the Apollo Saturn V. It is designated the Long March 9.

According to the Chinese, the unfueled descent stage mass of Chang'e 3 is 2,646 lb, which is 42% of the mass and scale of an unfueled Apollo lunar module descent stage that, according to Grumman documents, weighed 6,100 lb. The launch mass of the entire Chinese vehicle will be up to 8,377 lb including a propulsion bus.

The development of a boxy-sided descent stage in which to package descent rocket engine propellant is under way early in the lunar program. This is directly tied to practicing toward creation of a manned landing vehicle, Cernan and Aldrin believe. New technologies evident in the lander and in fact necessary for it to survive on the lunar surface illustrate a breakout capability for China in several areas. These include thermal control, system integration, electrical system design, software, command and control, and propulsion, the two agree.

ROVER REDUX?

A notable feature of the Chang'e 3 lander and its piggyback rover, say Cernan and Aldrin, is that advanced Chinese technology is divided between the two. The lander is packed with it; the six-wheeled, 308-lb rover, by contrast, appears to duplicate the design and engineering of NASA JPL's 400-lb Spirit and Opportunity Mars rovers.

There is solid evidence that the Chinese have done just that with the Chang'e 3 rover, says Aldrin. But it is something you would expect them to do, he notes. Mars mission engineers believe the Chinese saved hundreds or thousands of man-hours in their lunar rover design and testing by using U.S. rover designs, and they wonder how the Chinese got them.

The solar-array-powered rover, like the NASA Mars rovers, has a small extendable arm equipped with an alpha particle X-ray spectrometer, and also an infrared spectrometer that will be placed atop specific rocks for detailed study. Also like NASA's vehicles, the Chang'e 3 rover has two mast-mounted navigation and two panoramic cameras, along with small engineering cameras placed at critical locations.



The 844-lb \$100-million Lunar Atmosphere and Dust Environment Explorer (LADEE) is shown in testing before its September launch to the Moon to collect and analyze lunar dust from a 31-mi. orbit. LADEE is the first to use a Modular Common Spacecraft Bus and the first Ames-designed and developed spacecraft, but it may be the last NASA spacecraft to visit the Moon until the 2020s. Credit: NASA.

LANDING AND EXPLORATION

Once at the Moon the Chang'e 3 will be placed in a 62-mi. equatorial orbit. On touchdown day, the lander, with the rover, will separate from the bus and descend first into a 62x9.6-mi. orbit from which the final descent will be made.

The target landing area is a basaltic lava plain in the northwest corner of the giant Imbrium Basin—the left eye of the 'man in the Moon.' In the northwest corner of the basin is a 146-mi.-diam. circular bay that extends the Imbrium Mare farther northwest. The lander will be targeted to this location, called Sinus Iridium, for potential geologic discoveries.

To map the spot, the Chinese have used the Chang'e 1 and 2 orbiters and probably data released by NASA from the Lunar Reconnaissance Orbiter, as well.

The lander will hover at 328 ft for up to 90 sec while it uses hazard avoidance sensors and software to find a boulder-free area, moving laterally until it does so.

Chang'e 3 will then begin a slow descent to 10 ft. There, the large descent engine will be shut down and only small attitude control thrusters left on through the landing, according to a translation of Chang'e 3 project charts.

Powering the craft will be solar arrays and a plutonium 238 radioisotope thermoelectric generator (RTG) to provide heat during month-long lunar nights. The lander is designed to survive at least one Earth year as a science platform of its own.

Translated Chinese documents say the science instruments on the lander include:

- An optical ultraviolet telescope to observe binary stars, active galactic nuclei, and short-period variable stars. Some informal UV cooperation will be done by the Hawaii-based International Lunar Observatory Association, says Steve Durst, its founding director.

- A second ultraviolet camera to observe the 30.4-nm band radiation from the Earth's ionosphere to monitor the effect of space weather and solar activity on Earth's geomagnetic field. China says that means Chang'e 3, if successful, will be the first observatory on the Moon, although Apollo 16 carried a UV camera.

- A descent camera to watch the landing from the viewpoint of the rover, three panoramic cameras, an extendable lunar regolith probe or drill, and a lander engineering package.



Astronauts John Young and Charles Duke deployed the Far Ultraviolet Camera/Spectrograph, foreground, on the lunar surface during Apollo 16 in April 1972.

The documents say the rover carries:

- Two panoramic cameras, two navigation and engineering camera sets, an arm-mounted alpha particle X-ray spectrometer, plus an infrared spectrometer, the rover engineering package, and a data controller.

- Its most significant instrument is its belly-mounted ground-penetrating radar, designed to show detailed regolith structure down to 90 ft and basic lunar crust structures down to several hundred feet. "Unlike the other instruments, the radar could show 'very meaningful' fine scale information on the depth and structure of the regolith, especially around craters," said the U.S. lunar scientist.

The rover will reach the ground after being lowered on a platform that intersects two ramps on which it will drive down to the surface. Its six metal spoke-type wheels are very similar in design to those used on the two Soviet Lunokhod rovers.

The Chinese rover is designed to survive at least three months (three lunar days and nights). It is equipped with solar arrays and, probably, small plutonium 238 radioisotope heater units like those used on Spirit and Opportunity. Although lighter than these U.S. rovers, it is roughly the same size. It is also designed to travel up to 6 mi. during its mission, under both ground and autonomous control.

The mission will mark the first attempt in 37 years to achieve a robotic lunar landing. Chang'e also will be the first robotic lunar rover sent to the Moon in 40 years. The last one was the Soviets' Lunokhod 2, launched in 1973; the last lander was their Luna 24 sample return in 1976. ▲