

# China leading the Global Space race to build Moon bases, harness it's mineral resources and helium-3, an ideal fuel for future nuclear fusion power plants

China will send lunar probe Chang'e 5 to land on the moon and return with samples in the second half of 2017, in first such attempt, officials said. It will be the first time a Chinese probe would land on the moon, collect samples and return to Earth, and the third stage of China's lunar exploration endeavour, according to the State Administration of Science, Technology and Industry for National Defence (SASTIND).

Exotic materials including helium-3 and the potential for solar power could prove invaluable for humankind, said Prof Ouyang Ziyuan of the department of lunar and deep space exploration.

Space agencies in China, Japan, Europe, Russia, Iran and a few private companies all hope to send people to the moon by as early as 2025.

They're talking about building bases, mining for natural resources, and studying the moon in unprecedented detail. A key figure at the European Space Agency says we must look at how we exploit the moon's resources before it is too late, as missions begin surface mapping.

NASA's Catalyst program is urging companies to make "soft landings" on the surface with probes and ships. NASA calls for bids to mine in space.

# **Moon has abundance of invaluable materials**

The moon has abundant of invaluable materials; an acronym KREEP signifies the richness of geochemical components potassium (K), rare-earth elements (REE) and phosphorus (P) in lunar rocks. The lunar orbiters from Europe, China, Japan, India and US have also pointed to the presence of minerals and related geologic processes.

The moon is also rich in helium-3, gold, cobalt, iron, palladium and tungsten. The soil samples collected by Appolo 17 mission had confirmed the presence of helium-3. Helium-3 can fuel non-radioactive nuclear fusion reactors in the future to produce safe, efficient and clean energy, vital to our energy security. Scientists estimate that the moon could contain approximately 1 million tons of helium-3, enough to power the entire earth for 10,000 years.

NASA's Moon Mineralogy Mapper, known as M3, carried on India's Chandrayaan-I, found many mineral concentrations and even presence of water on the surface of the moon. Water on the moon is strategically important for life support, energy storage and as propellant.

Rare earth elements, called rare because of their low abundance on earth, are essential ingredients of many modern consumer and defense products including wind turbines, glass for solar panels and guided missiles.

# International Initiatives

## China

China is taking another step in its space exploration programme, starting a trial scenario for a permanent Moon station. Four postgraduate students from the astronautics university of Beihang moved into the cabin, ambitiously called the Yuegong-1, or Lunar Palace in English. They will stay in the cabin for 60 days, followed by another group who will stay for 200 days. The first four will then return for yet another 105 days.

According to state news agency Xinhua, one of the main elements of the experiment is to explore how a space mission could be entirely self-contained over a long period of time. Human waste will undergo a bio-fermentation process, and crops and vegetables are to be grown with the help of food and waste by-products. The model Moon station has two plant cultivation modules and a living cabin housing four bed cubicles, one common room, a bathroom, a waste treatment room and a room for raising animals.

China successfully landed a spacecraft – the Chang'e 3 – on the moon in December 2013, becoming only the third nation after the United States and Russia to land on the moon's surface. The Chang'e 3 mission, included lander and China's first lunar rove called Yutu ("Jade Rabbit"), which successfully soft-landed on the Moon.

The country will also unveil a new generation of carrier rockets including Long March 5 and 7 in 2016, along with other new satellites and spacelabs.

China's growing space ambitions are targeted towards future economic development and strategic advantage. Ouyang Ziyuan, a prominent Chinese geologist and chemical cosmologist, was among the first to advocate the exploitation not only of known lunar reserves of metals such as titanium, but also of helium-3, an ideal fuel for future nuclear fusion power plants.

China's official news agency Xinhua reported that China will start its third phase in 2017 by launching the Chang'e-5 spacecraft. Its mission includes orbiting, landing on the moon and then returning to earth. After making a soft landing on the moon, the lander will dig and collect rock samples from up to two meters below the surface.

## **China first to explore 'dark side' of the moon**

China has confirmed it plans to send a spacecraft to land on the moon's "dark side" before 2020, state media reports – a mission, which, if successful, would make it the first country to do so.

The mission will be carried out by the lunar probe Chang'e-4, Zou Yongliao, a scientist at the Chinese Academy of Sciences said at a deep space exploration forum on Tuesday. In May, Wu Weiren, the chief engineer for China's Lunar Exploration Program told state-run broadcaster CCTV that China would send the Chang'e-4 spacecraft to orbit the moon before sending a rover to the surface.

“We probably will choose a site on which it is more difficult to land and more technically challenging... Our next move will probably see some spacecraft land on the far side of the moon,” Wu said.

When the Apollo astronauts visited the moon in the late 60s and early 70s, “they covered two parts in one million of the lunar surface,” David Kring of the Lunar and Planetary Institute said. The far side of the moon and its polar regions remain untouched.

Johann-Dietrich Wörner director general of European Space Agency asserted that a far-side outpost on the moon offers a number of “drivers,” including cosmological research. For instance, the lunar far side is shielded from radiation-chatter broadcasts from Earth, allowing radio telescopes built there to survey the universe with very little background noise, he said.

## **Chinese Ambitions**

Prof Ouyang Ziyuan of the department of lunar and deep space exploration explained that there were three motivations behind the drive to investigate the Moon. “First, to develop our technology because lunar exploration requires many types of technology, including communications, computers, all kinds of IT skills and the use of different kinds of materials. This is the key reason,” he told BBC News.

“Second, in terms of the science, besides Earth we also need to know our brothers and sisters like the Moon, its origin and

evolution and then from that we can know about our Earth. “Third, in terms of the talents, China needs its own intellectual team who can explore the whole lunar and solar system – that is also our main purpose.”

**A rationale for this long-term programme is that “there are many ways humans can use the Moon”.** With no air on the Moon, solar panels would operate far more efficiently, he believes, and a “belt” of them could “support the whole world”. The Moon is also “so rich” in helium-3, which is a possible fuel for nuclear fusion, that this could “solve human beings’ energy demand for around 10,000 years at least.

Prof Ouyang highlighted the combination of an extremely thin atmosphere and massive temperature extremes offering a unique possibility for manufacturing that does not exist on Earth. “The Moon is full of resources – mainly rare earth elements, titanium, and uranium, which the Earth is really short of, and these resources can be used without limitation.

## **Moon Express look toward Lunar Mining**

California-based company Moon Express, which aims to fly commercial missions to the moon and help unlock its resources, has signed a five-launch deal with Rocket Lab, with the first two robotic liftoffs scheduled to take place in 2017.

The 3.9-foot-wide (1.2 m) Electron rocket is designed to deliver a 330-lb. (150 kilograms) payload to a sun-synchronous orbit 310 miles (500 kilometers) above Earth, according to Rocket Lab’s website.

The contract puts Moon Express in position to possibly win the Google Lunar X Prize, a \$30 million competition to land a privately funded robotic spacecraft on the moon by the end of 2017. The first team to do this – and have the craft move 1,640 feet (500 m) and beam high-definition video and images back to Earth as well – will win the \$20 million grand prize. (The second team to accomplish these goals gets \$5 million; another \$5 million is available for meeting certain other milestones.)

Mining the moon for rare minerals is considered an exciting prospect because the supply of resources here on Earth is limited. Given the finite amount of these Earth-based minerals and metals, the cost is astronomically high. Palladium, for instance, which is used for electronics, sells for \$784 per ounce.

Moon Express plans to send its robotic lander, dubbed “MX-1,” to the moon by 2016, aiming to demonstrate safety and reliability of the moon landing. It has already put into test a prototype at the Kennedy Space Center.

Naveen Jain, the co-founder of Moon Express said, that while the first mission of the company’s lander is a one-way trip – which means that MX-1 won’t be traveling back to Earth – the second and third missions could already involve bringing precious minerals, metals and moon rocks back to Earth.

## **Russia plan to place astronauts on the moon by 2029**

“A manned flight to the Moon and lunar landing is planned for 2029,” Vladimir Solntsev, head of Roscosmos Energia (RSC Energia), said in an announcement, reported Russia Today. Also, in the far eastern part of their country, the Russians are building a huge, \$3 billion cosmodrome. Reports indicate that this be a new spaceport specifically designed to send and receive spacecraft from lunar orbit.

After a series of failures, the Russian space industry stands on the brink of new technological breakthroughs in the field of space technology, Deputy Prime Minister Dmitry Rogozin said. According to Rogozin, one of the goals of the Russian space industry today is to build a super-heavy rocket that would ensure the creation of a manned lunar station.

As for the rocket and the spaceship, there are two big issues about it. If it goes about unmanned exploration of the moon, Luna-25 and Luna-26 stations and so on, then these activities are part of the federal space program before 2025 that should be implemented soon, in 2017 and 2018.

“As for a manned flight to the moon, a breakthrough effort is required indeed, because existing launch vehicles and even launch vehicles of the near future are, unfortunately, unable to deliver Russian cosmonauts to the Moon. We need to develop new launch vehicles for the purpose. “There is Angara-A5V launcher, for example. This is a heavy carrier rocket with increased lifting capacity. This rocket could make a lunar mission possible, but this work is outside the federal space



program, but we have the potential.”

“This is part of a larger Putin strategy to reestablish Russia as a significant political player and a major state in international affairs that needs to be taken into account,” Charles Hermann, professor of international affairs at the Bush School said. Hermann said politically and economically, Russia might experience problems in a moon mission. “It’s a long way until 2029, and there is not only the technological challenges of doing this but perhaps even greater is the financial one,” Hermann said.

However, experts point out that some of their rockets are dating back to 1960’s and in historical terms, Russia has not had a successful interplanetary mission since 1984. The Vega 2 to Venus remains their biggest accomplishment since then.

“Russian economy is incredibly dependent on petroleum at this point in time and if they don’t have a stronger economic base than they do now it may be difficult to sustain, to allocate, the kinds of resources to this project that it will require.” Russian Prime Minister Dmitry Medvedev intends to cut funding for the space program by 30%. Russia is now looking for collaboration with Europe for joint moon missions.

## **Russian and European Space Agency Plan Permanent Moon Bases**

Roscosmos, the Russian federal space agency, in partnership with the European Space Agency have planned to cooperate in a sequence of missions to the moon that could lead to a possible permanent human settlement there.

The first mission, dubbed Luna 27 and intended to put a robotic lander on an unexplored area of the moon's south pole, will launch in 5 years' time. The South Pole has been chosen as a landing site because scientists believe many areas of the region which are in constant darkness might harbor ice, which could be a resource usable by future manned missions. ESA will also provide a mini-laboratory, named ProSPA, which will be used by astronauts to evaluate their findings.

"First of all, it goes about the exploration of the Moon itself. The lunar exploration of the past – the flights of US astronauts and Soviet spacecraft to the Moon could give us just a glimpse of the Earth's satellite. Not that long ago, scientists discovered large reserves of water in the lunar soil. This is very important, because, if a lunar station is ever built, it will be possible to extract water and produce oxygen and hydrogen from it. Hydrogen would be used as fuel, so this is a direct way to the development of lunar resources.

"The 21st century will be the century when it will be the permanent outpost of human civilization, and our country has to participate in this process," said mission leader scientist Professor Igor Mitrofanov, of the Space Research Institute in Moscow. "We have to go to the moon."

Building a settlement for a permanent human presence on the moon's surface can provide both scientific and commercial benefits, Mitrofanov says. "It will be for astronomical observation, for the utilization of minerals and other lunar resources and to create an outpost that can be visited by cosmonauts working together as a test bed for their future

flight to Mars.”

“The Moon can also be used for various astrophysical experiments, because there is no atmosphere there, and one can install different radio telescopes directly on the surface of the satellite. Cosmonauts would play the role of both scientists and technical operators in this case.”

## **NASA and Russia to work collaboratively for space station**

At this year’s International Astronautical Congress, NASA and Russia’s space agency, Roscosmos, signed a joint statement expressing their intent to work collaboratively toward the development of a space station further out from Earth, orbiting the Moon, as a staging point for both lunar surface exploration and deeper space science.

This is part of NASA’s expressed desire to explore and develop its so-called “deep space gateway” concept, which it intends to be a strategic base from which to expand the range and capabilities of human space exploration. NASA wants to get humans out into space beyond the Moon, in other words, and the gateway concept would establish an orbital space station in the vicinity of the Moon to help make this a more practical possibility.

“While the deep space gateway is still in concept formulation, NASA is pleased to see growing international interest in moving into cislunar space as the next step for advancing human space exploration,” Robert Lightfoot, NASA’s acting administrator at NASA Headquarters in Washington said in a NASA press release announcing the news. “Statements such as this one signed with Roscosmos show the gateway concept as an enabler to the kind of exploration architecture that is

affordable and sustainable.”

## **USA bypasses Moon mission to Mars Mission**

In 2010, President Obama announced the administration’s decision to cancel NASA’s plans to return to the moon based on financial unsustainability, in favor of ambitious Asteroid Redirect Mission. Obama said that the U.S. would first send astronauts to an asteroid, then to orbit Mars by the 2030s, and finally to land on Mars after that.

NASA is developing the first ever mission to identify, capture and relocate an asteroid to a stable orbit around the moon, and send astronauts to return samples of it to Earth. This Asteroid Redirect Mission (ARM) will greatly advance NASA’s human path to Mars, testing the capabilities needed for future crewed missions to the Red Planet.

An overwhelming majority of the scientific community seems to disapprove of Obama’s change in plans. David Kring of the Lunar and Planetary Institute said he, like many others, believes that a moon mission would serve as a much better precursor for a trip to Mars than a mission to an asteroid. He explained that the moon would allow NASA to develop the skills and technology needed to go to Mars while staying in relatively close proximity to Earth, meaning a quicker recovery time if problems arise, and the ability to do more missions and speed up the learning process.

# Technology Challenges

However, commercial moon mining is so technologically daunting that it may take decades before it can become economically viable. Enough robotic exploration moon missions are required to map the quality, quantity and distribution of these minerals. The potential mining methods, their economic viability and methods to separate the almost similar minerals from the ore need to be studied.

The cost of lunar access and bringing the mined ores back to earth shall need to be reduced drastically through advances in propulsion, avionics, mining robots, launchers and spacecraft design. The technologies like 3D printing could help build infrastructure on the moon, as well as missions which are beginning to map its surface ahead of bids to drill for its resources.

John Junkins, distinguished professor of aerospace engineering, said getting astronauts to the moon and back is no easy feat. "There are many many technical challenges, but the biggest one is attention to detail with a very, very large and complicated effort and to do that over a sustained period of time so that they can get there and back safely," Junkins said.

Junkins said a moon landing involves a mixture of various disciplines. "Everything from life support, to designing the rockets themselves, all of the navigation aspects and control functions, the tremendous attention to detail, to integration of a massive human effort and many technologies, and then the discipline that is required to do this safely," Junkins said.

Worner also proposed a permanent moon station as the successor of ISS, this station should be international, “meaning that the different actors can contribute with their respective competencies and interests.” Wörner said that “the moon station can be an important stepping stone for any further exploration in deep space,” adding that a lunar outpost could help humanity learn how to use resources on-site instead of transporting them.

### **References and Resources also include:**

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