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China's Manned Lunar Ambitions: Strategic Imperatives and Implications

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ABSTRACT China's space policy planners are convinced that the country should aim for manned lunar landings by 2040. It has already established a sophisticated robotic lunar exploration programme and human landings are perceived as the logical next step. New navigation and communication architectures are being developed for this purpose, in addition to building life support systems and a suitable launch vehicle. However, China's political leadership would require much broader and stronger national goals as imperatives for demonstrating such a mission, rather than pursuing advances in the national space programme alone. Whether the emerging geopolitical competition between the United States and China is a sufficient cause for Beijing to land its astronauts on the Moon needs to be assessed. Since China's comprehensive national power is rooted in economics—and given the mandate to improve the living standards of its citizens—any underlying economic dimension of such a programme also needs to be analysed.

INTRODUCTION

China celebrated its first ever 'Space Day' on 24 April 2016, commemorating the 46th anniversary of the launch of its first artificial satellite Dongfanghong-1, meaning 'The East is Red'. During the celebrations, senior officials of China's space programme responded positively to the idea of landing taikonauts on the Moon in the next 15 to 20 years.[1] The chief designer of China's manned spacecraft at China Aerospace Science and Technology Corporation remarked that the country has acquired the requisite economic and technological potential to conduct this mission and is just awaiting the go-ahead from Beijing.

The Apollo 17 astronauts were the last humans to visit the Moon in 1972, or more than four decades ago. The biggest imperative for the Apollo programme, at the time, was the Cold War strategic competition between the US and the Soviet Union. A similar competition currently unfolding in the Asia-Pacific provides enough motivation for China to accomplish grander space

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missions. At the same time, however, it might also tend to unveil new dimensions of manned lunar missions to ensure maximum returns on its investments.

This paper makes an assessment of the most relevant factors that would affect China's decision-making in this situation, chiefly, the strategic competition with the US and the mandate to ensure economic prosperity of its citizens. The paper also makes the case for human exploration of space despite advances in robotic technology. This argument highlights that the political administrations (taking the example of the Apollo programme) tend to perceive manned missions to space as strategic tools cementing their credibility, both in the domestic and international settings. The paper argues that China will bank on the changing perception of outer space as a reservoir of raw materials to satisfy its domestic audience on the need to allocate huge investments in this mission. It also highlights various implications of this mission on the Asian and global political order as well as in the context of outer space.

CHINA'S PRECURSOR ROBOTIC LUNAR MISSIONS

China has instituted its Chinese Lunar Exploration Programme (CLEP) with the goal to return lunar samples. This will be achieved in three phases – lunar orbiting exploration; soft landing and probing the surface; and returning the samples to Earth.[2] It has been undertaking a series of robotic exploration missions under this programme named after China's Moon goddess, Chang'e.

Chang'e 1 mission placed an orbiter around the Moon in October 2007. It helped create a 120-metre resolution map of the Moon including mapping the distribution of various elements on the lunar surface. Chang'e 2, launched in 2010, obtained a seven-metre resolution full lunar map along with 1.5-metre resolution local maps for identifying possible landing sites for the next mission. It also validated improved navigation solutions, sensors and other key technologies required for the next phase.

The second phase started with the soft landing of Chang'e 3 on the Moon in 2013. China became the third country to achieve this feat after a gap of more than three decades since the Russian Luna 24 in 1976. A small rover called 'Yutu' was also released to probe the lunar surface. This rover was expected to operate for only three months but was active for at least two years despite a malfunction in its motor control.[3] This malfunction, however, has rendered Yutu stationary and unable to utilise solar panels to generate power and heat. The mission nonetheless helped Chinese scientists study the composition of lunar surface and the interior, resulting in the discovery of a new type of Moon rock.[4]

Like any other celestial body, the Moon is a repository of various minerals. There is renewed enthusiasm in mining them for use on Earth, especially with the emergence of commercial space entities in the US supported by national legislation allowing such activities. Dominating this discussion is Helium-3, as it is estimated to generate more energy and less waste, if at all, compared to its terrestrial counterpart, Uranium.[5] China is believed to be targeting the craters on the Moon that have high concentrations of this mineral. The Moon is also a repository of other high-value minerals like titanium.[6]

The next mission, Chang'e 5, expectedly received a lot of spotlight. This mission, expected to be launched in 2017, is the country's first attempt at returning lunar samples (about 2.2 kilograms) and involves complex mission planning and technologies. It has to perform automated rendezvous and docking; safe descent on the Moon; sample transfer in space from the ascent vehicle to the return vehicle; re-entry and safe landing on Earth.

A test mission, Chang'e 5-T1, was conducted in 2014 to validate some of these technologies and manoeuvres. A new launcher—Long March 5—is currently under development and expected to be flight validated by the time of mission launch.

CHINA'S MANNED LUNAR LANDING

This Chang'e 5 robotic sample return mission is the first in the final phase of CLEP, implying that advanced missions are presently under consideration. Accordingly, Hu Hao, chief designer of the CLEP's sample return phase, pointed out that Chang'e 5 is a step towards landing humans on the Moon.[7]

The main challenges of this project are to develop a Saturn V-type launcher for placing the taikonauts and associated equipment on a path to the Moon, and building critical life support systems. Saturn V launched the US Apollo missions into orbit, helping Neil Armstrong become the first person to step on the Moon and showcasing the technological superiority of the US as it concluded that era's 'space race' in its favour.

China is developing Long March 9 for this purpose with a capacity to place 130 metric tonnes into a low Earth orbit,[8] a measure higher than that of Saturn V that could place only 118 metric tons into similar orbit. However, the Long March 9 is still in the development phase and will not be ready until 2030. Meanwhile, China will conduct Chang'e 4 mission that will use the backup lander of Chang'e 3 to land on the far side of the Moon. It will be the first by any country. China may also announce Chang'e 6 mission using the backup for Chang'e 5.

These precursor robotic missions to the Moon are validating the requisite technologies, systems and mechanisms for the first human space mission to the Moon after a gap of more than four decades. China's space station operations in low Earth orbit will help prepare the country's astronauts physiologically and psychologically to finally land on the Moon.

THE HUMAN FACTOR IN SPACE EXPLORATION

The logic of landing astronauts on the Moon still remains an open question; after all, if mining is the objective, then it can be performed by robotic explorers. Indeed, China is fast advancing its robotic technologies and has demonstrated those achievements in outer space. It is also planning to construct humanoid robots to assist in space missions.[9] China's upcoming space station will serve as testing grounds for these technologies.

However, it is interesting to note that even more advanced spacefaring nations like the US envision sending their astronauts to Mars. The American robot technology is generally superior to that of China, especially when artificial intelligence is taken into consideration. The International Space Station features a robotic arm, the station-keeping robot Dextre and a humanoid robot named Robonaut. These robots are already performing mission critical tasks aboard the station and might accompany astronauts to Mars.[10] Despite possessing such advanced technology, the US is still aiming to send astronauts to collect samples from an asteroid boulder redirected to a retrograde orbit around the moon sometime in the next decade.[11] Sending humans on such a mission is more costly, resource-intensive, and riskier than robotic missions.

What then warrants manned missions? Is it that humans can return higher quantity of samples collected with more dexterity than a rover? Six Apollo missions returned a total of 382 kilograms of lunar samples while three of the Soviet Luna missions returned only 0.326 kilograms, less than one-thousandth of Apollo.[12] The fiscal spending between 1959 and 1973 on the Apollo programme adds up to $20.4 billion, while Luna cost $4.5 billion.[13] Adjusting the figures slightly for comparison, Apollo cost five times more but the returns on this were 1000 times more than the sample quantity of Luna. It would thus appear that the cost-benefit analysis favours a series of manned missions over robotic expeditions.

At the same time, such a direct comparison between cost and return sample quantity tends to distort the picture of the overall benefits. The advances in science and technology spurred by a

manned space programme are overwhelming. The Apollo programme continues to inspire generations of space enthusiasts, particularly the NewSpace, within and outside the US. In addition, jobs are created where the personnel acquire highly specialised skills. Therefore, the promising returns across a range of scientific and technological domains could prompt China's government to invest in the manned lunar missions.

But these are merely incentives and the most satisfying rationale behind the 'man in space' quest can actually be found in the thinking of Kennedy's administration that initiated the Apollo programme. Does it have a parallel in China?

THE APOLLO PROGRAMME AND THE COLD WAR

The US Apollo programme was considered a response to the Soviet Union's lead in outer space, which emerged as the new frontier of confrontation during the Cold War. The Soviet Union was the first to place an artificial satellite in outer space in 1957. Thereafter, it launched the first human Yuri Gagarin into space in April 1961. These achievements shifted the strategic balance in the Soviet Union's favour, with the US then scrambling to launch its own manned missions.

Although then US President John F. Kennedy came into office with the idealistic notion of "exploring the stars together", as he declared, Gagarin's spaceflight altered that perception. Just days following this feat, Kennedy asked his administration's 'Space Council' if the US had a chance of beating the Soviet Union in space.[14] After deliberation, the Space Council put forward the strategy of landing a man on the Moon and returning him safely back to Earth.

Kennedy alerted the US Congress of his administration's plans in 1961, saying that the dramatic achievements in space have a high impact on the minds of men everywhere who are trying to determine their own form of political and economic frameworks (read as "Third World").[15] His 1962 Rice University speech pleading with the American public to support this national effort consolidated the Apollo programme. Accordingly, the US initiated human spaceflights with Alan Shepherd's suborbital flight in 1961 and John Glenn's three orbit flight in 1962. That one small step for Neil Armstrong in 1969 was in fact a giant leap for the US.

To be sure, the Apollo programme had its critics, too. Dwight Eisenhower, for instance, called the race to the Moon "nuts".[16] The Republicans were favouring a more militarised approach to outer space by demanding fiscal spending on such assets. The US Congress had cut the National Aeronautics and Space Administration's (NASA) budget by 10 percent in 1963 as a measure of delaying the programme. American space scientists stressed that scientific questions should be regarded as primary motivation for space exploration and deplored the Soviets' attempts to present their space achievements as a matter of national pride and strength.[17]

However, the White House was also viewing outer-space exploration through the same Soviet lens. The James Webb and Robert McNamara duo in the Kennedy Administration recommended in 1961 the Moon landing as a decisive strategy towards enhancing national prestige and "part of the battle along the fluid front of the Cold War".[18] Subsequent events and statements proved that the Cold War geopolitical competition was the overriding force behind the Apollo programme. It was inevitable then that the US will respond proportionally to the Soviet challenge of sending humans into space. With the Soviet Union's Yuri Gagarin providing the trigger, the US successfully landed its astronaut on the Moon. The Webb/McNamara duo stated, as a sort of introspection, that, "It is man, not merely machines, in space that captures the imagination of the world."[19] This paradigm, and the eventual moon landings, consolidated forever the image of 'man in space' as one of the ultimate triumphs of any political establishment.

THE RISE OF CHINA

It has been more than four decades since the last man landed on the Moon. The Cold War ended in favour of the US but the resultant global order is now being challenged by the rising power that is China. China's manned space programme is a critical component of this competition which has been initiated after the refusal of the US to allow it to become part of the International Space Station. Qian Xuesen, the father of China's space programme, was, in fact, an active participant in the American space programme working with Theodore van Karman and instrumental in expediting the process of bringing Wernher von Braun (later architect of Saturn V) to the US.[20] Qian was deported to China under the allegation of working with the Communists where he had set up the initial space laboratories that evolved into a national space programme.

Space cooperation was envisioned between the US and China as part of building trust and confidence following Richard Nixon's visit to China in 1972 and formal diplomatic recognition of the latter in 1979. Later, Ronald Reagan permitted the launch of US made commercial communications satellites on-board Chinese launch vehicles. This general upward trend started to deteriorate with the violent handling of the Tiananmen Square protests in 1989. The US Congress disapproved of China's human rights standards and enacted provisions banning the launch of US satellites on-board China's rockets.

During the 1990s, the US State Department, the US Congress and the White House traded accusations and tried overruling each other over the legal status of satellite components and passing of sensitive information to China. The Cox Commission in 1998 reported that a US company unwittingly helped China improve the design of its ballistic missiles as a result of this complicity.[21] The Congress through its legislations continues to this day to prohibit space cooperation between the US and China. As a result, China was not allowed to join the International Space Station, a project of international space cooperation primarily involving the US and Russia whose negotiations began in the early half of the 1990s. The first module was launched in 1998 and it has been continuously manned since 2000. Therefore, China decided to initiate an indigenous manned space programme Shenzhou with the first taikonaut placed in orbit in 2003 on-board Shenzhou 5. China is proceeding with its plans to construct a manned space station in low Earth orbit by 2022. Reportedly, the next destination for its manned space programme is the Moon.

The characteristic 'national prestige' lens associated with the manned space programmes of the Cold War era is also evident in China's programme. The grandeur of its space projects are associated with 'national rejuvenation' and supporting China 'reclaiming its rightful place in the world order'.[22] The 2011 white paper published by the State Council on China's space activities states "building national comprehensive strength" as one of the main objectives.[23]

The recent references made by Ye Peijian, the chief designer of the CLEP, to prior space firsts of the Cold War era and China's attempts to accomplish a space first point to the fact that such aspirations continue to influence planning of space missions.[24] It can be assessed from these developments that the motivations for China's political establishment do not necessarily deviate from those of the Kennedy administration.

But a manned lunar programme requires significant financial investments upfront and throughout the duration of the programme. China has a huge economic mandate to lift millions out of poverty and become a prosperous nation by the centenary of the founding of People's Republic of China in 2049. Its current efforts to adjust to the 'new normal' and maintain a steady growth to stabilise the economy might get pushed back into the next decade when the political administration will be pressed for a decision on taikonauts landing on the Moon.[25]

IMPROVING PROSPECTS FOR LUNAR MINING

China could tackle this issue by raising the prospects for, and actualising, lunar mining. Although the idea of mining outer-space resources is now charged up, there is certainly an international gap in capabilities and intention with regard to lunar mining.

The US President has signed into law the Commercial Space Launch Competitiveness Act (CSLCA) that contains language allowing its citizens (private entities) to mine and trade outer space resources.[26] But the US companies like Planetary Resources and Deep Space Industries have invested in strategies to mine asteroids rather than the Moon. The NASA has unveiled a strategy for landing humans on Mars, skipping landing on the Moon in the process. The private entity, Moon Express, is aiming to extract resources from the celestial body, but China has the lead in terms of programmatic, financial and technological maturity.

The same can be said about Europe and Russia, which have proposed various designs for landing on the Moon but have got mired in either unconvinced partnerships or mustering finances. Neither India nor Japan has declared such intentions so far. In effect, China is the only state or non-state organisation that is capable of and can be expected to kickstart lunar mining. Outer space is a viable option for China that can help reduce its dependency on conventional fuels. It is considering establishing a solar power station in outer space that can beam down electric power, and lunar mining fits very well into this perspective.[27]

The increasing tendency to adapt to alternative sources of energy will impact the foundational structure of the current global economy which is built upon oil and gas resources, exported predominantly from West Asia. The changes being contemplated, such as lunar mining, will be profound with the changing mindset about the exploitation of outer-space resources. The global economy is so far reliant on space services for facilitating transportation of raw material and finished goods across the globe. But the emerging technologies and innovation is changing this situation where the outer space itself is being perceived as a source of raw material for manufacturing requirements on Earth. The requisite technologies are being tested and the US has already set the legal precedent.

THE IMPLICATIONS

Like the US and the Soviet Union/Russia, China also perceives outer space as the commanding height in the international strategic competition and an arena for strengthening national prestige and winning over the hearts and minds of its neighbours. Although China is already considered as a top-tier space power owing to its advancing capabilities, its accomplishments are still dwarfed by the American, European and Russian missions. These four space powers can be placed in a hierarchy within the top tier with the US standing at the pinnacle and China at the bottom. Before China can successfully rival the US, it should aim to elevate its standing in this hierarchy.

The ambition to land on the Moon is therefore logical in this context. The idea of Moon landings still commands the same enthusiasm, pride, debate and claims of superiority from terrestrial political peers as it did in the 1960s. With the American, European and Russian human space programmes currently limited to low Earth orbit, landing on the Moon allows China to at least bring parity in the human space domain with the US. With regard to Asia, such a feat will solidify its predominance in the Asian space race and thereby the geopolitical competition.

However, as economics assume a central role in China's 'national rejuvenation' mission and geo-economics being a foreign policy priority, it would be hard to promote the idea of Moon landings purely on the basis of geopolitics. Hence the extensive studies by the robotic missions of the lunar surface and the interior as well as targeting mineral rich sites for possible

extraction. In addition, the growth in the number of jobs in the supporting industries that are still being established is a huge benefit. The launch vehicle and sensitive technologies being developed for this purpose can be adopted for a range of other missions as well as developing products useful in other sectors. The communication and navigation techniques, in addition to the scientific and engineering advances in this mission, can be used for military purposes given the role of China's armed forces in the space programme.

CONCLUSION

As much as China has emerged as a peer competitor to the US, its capabilities and capacity are easily overwhelmed by the latter. The US intends to land on Mars by the end of 2030s and, therefore, China would like to, at a minimum, land on the Moon in that decade to maintain its place in the global space order. The Chang'e programme is laying the groundwork for this mission, helping China's space scientists identify potential landing sites and its engineers design robust communication network, practice deep space navigation and create sophisticated sensors. In addition, China's space station programme is providing valuable insights into the physiological and psychological effects China's lunar astronauts have to endure during their trip as well as help design better life support systems for crew safety.

The soft power potential of China's human lunar mission can be realised by assessing the political and ideological imperatives that propelled the Kennedy Administration to launch the Apollo programme. The human lunar mission could be a strategic asset for China competing with the US for primacy in the Asia-Pacific. However, mustering the financial resources and convincing the domestic audience about this mission will require China to adopt an innovative strategy covering the energy and economic domains. Lunar mineral prospecting is one of the primary objectives of its robotic programme which can be expected to also form the basis for manned missions.

If successful in this endeavour, China would ascend in the global space order, dwarfing Russia and Europe while posing a challenge to the US. While there are economic benefits resulting from such a mission, it could not be guaranteed that the sophisticated technologies being developed will not be diverted for military purposes. More details are yet to emerge about China's manned lunar mission but the country has definitely set its sights on the Moon owing to the strategic and economic benefits that can be accrued from such a mission. ORF

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ENDNOTES

1 Lei, Zhao. "Senior Officer Expects Moon Visit by 2036." People's Daily Online. April 29, 2016. Accessed June 3, 2016. http://en.people.cn/n3/2016/0429/c90000-9051633.html

2. "Chinese Lunar Exploration Programme." United Nations Office for Outer Space Affairs. June 2014. Accessed June 3, 2016. http://www.unoosa.org/pdf/pres/copuos2014/tech-06.pdf

3. Greshko, Michael. "China's 'Jade Rabbit' Moon Rover Declared Dead." The National Geographic. August 4, 2016. Accessed June 5, 2016. http://news.nationalgeographic.com/2016/08/china-moon-rover-jade-rabbit-dead-yutu-space-science/

4. Radford, Tim. "New type of moon rock discovered by Chinese lunar lander." The Guardian. December 22, 2015. Accessed June 5, 2016. https://www.theguardian.com/science/2015/dec/22/new-type-of-moon-rock-discovered-by-chinese-lunar-lander

5. Basulto, Dominic. "An audacious plan to mine the surface of the moon." The Washington Post. March 19, 2015. Accessed June 6, 2016. https://www.washingtonpost.com/news/innovations/wp/2015/03/19/an-audacious-plan-to-mine-the-surface-of-the-moon/#

6. Mortier, Jan and Finnis, Benjamin. "China Leads Race to the Moon." The Diplomat. January 7, 2015. Accessed June 6, 2016. http://thediplomat.com/2015/01/china-leads-race-to-the-moon/

7. Jones, Andrew. "China's 2017 lunar sample return is step towards astronauts on the Moon, scientist says." GB Times. March 4, 2016. Accessed June 7, 2016. http://gbtimes.com/china/chinas-2017-lunar-sample-return-step-towards-astronauts-moon-scientist-says
8. Perrett, Bradley. "Chinese Super-Heavy Launcher Designs Exceed Saturn V." Aviation Week. September 30, 2013. Accessed June 7, 2016. http://aviationweek.com/awin/chinese-super-heavy-launcher-designs-exceed-saturn-v
9. Zolfagharifard, Ellie. "The real Chinese 'Iron Man': Nation reveals superhero robot designed for space travel." Daily Mail. February 16, 2016. Accessed June 8, 2016. http://www.dailymail.co.uk/sciencetech/article-3311220/The-Chinese-Iron-Man-Nation-reveals-superhero-robot-designed-space-travel.html
10. "Not So Little Helper: Robot Built to Aid Astronauts Nearly Ready for Mars." Sputnik News. May 5, 2016. Accessed June 8, 2016. http://sputniknews.com/europe/20160505/1039133202/mars-mission-humanoid-robot.html
11. "Asteroid Redirect Mission." National Aeronautics and Space Administration. Accessed June 9, 2016. https://www.nasa.gov/content/what-is-nasa-s-asteroid-redirect-mission
12. "Soviet Union Lunar Sample Return Missions." National Aeronautics and Space Administration. March 16, 2010. Accessed June 9, 2016. http://www.nasa.gov/mission_pages/LRO/multimedia/lroimages/lroc-20100316-luna.html
13. "Luna Programme." BBC. Accessed June 9, 2016. http://www.bbc.co.uk/science/space/solarsystem/space_missions/luna_programme
14. Orloff, Richard and Harland, David. Apollo: The Definitive Sourcebook. New York: Springer, 2006. pg. 12
15. "NASA - Excerpt from the 'Special Message to the Congress on Urgent National Needs'." National Aeronautics and Space Administration. May 24, 2004. Accessed June 10, 2016. https://www.nasa.gov/vision/space/features/jfk_speech_text.html#.V2Us1CH09tp
16. Logsdon, John. "Perspective: John F. Kennedy's Space Legacy and Its Lessons for Today," Issues in Science and Technology, 27, no. 3 (Spring 2011). Accessed June 11, 2016. http://issues.org/27-3/p_logsdon-3/
17. "America Starts for the Moon: 1957-1963." National Aeronautics and Space Administration. Accessed June 11, 2016. https://www.hq.nasa.gov/pao/History/SP-4214/ch1-3.html
18. Erickson, Mark. Into the Unknown Together: The DOD, NASA, and Early Spaceflight. Alabama: Air University Press, 2005. pg. 216. Accessed June 12, 2016. http://www.au.af.mil/au/aupress/digital/pdf/book/b_0098_erickson_into_unknown_together.pdf
19. O'Gorman, Ned. The Iconoclastic Imagination: Image, Catastrophe, and Economy in America from the Kennedy Assassination to September 11. Chicago: University of Chicago Press, 2015. pg. 108.
20. Impey, Chris. "China Makes Its Move to the Moon [Excerpt]." Scientific American. July 17, 2015. Accessed June 12, 2016. http://www.scientificamerican.com/article/china-makes-its-move-to-the-moon-excerpt/
21. "Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China." United States House of Representatives. May 25, 1999. Accessed June 12, 2016. http://www.house.gov/coxreport/chapfs/ch6.html
22. Knipfer, Cody. "The "Asian Space Race" and China's solar system exploration: domestic and international rationales." The Space Review. June 13, 2016. Accessed June 12, 2016. http://www.thespacereview.com/article/3007/1
23. "China's Space Activities in 2011." Xinhua. December 29, 2011. Accessed June 13, 2016. http://news.xinhuanet.com/english/china/2011-12/29/c_131333479_2.htm
24. Jones, Andrew. "Top space engineer on China's mission to Mars, the Moon and deep space exploration." GB Times. April 4, 2016. Accessed June 13, 2016. http://gbtimes.com/china/top-space-engineer-chinas-mission-mars-moon-and-deep-space-exploration
25. Tiezzi, Shannon. "China's 'New Normal' Economy and Social Stability." The Diplomat. November 24, 2015. Accessed June 14, 2016. http://thediplomat.com/2015/11/chinas-new-normal-economy-and-social-stability/
26. "H.R. 2262 - U.S. Commercial Space Launch Competitiveness Act," United States Congress, Accessed June 14, 2016. https://www.congress.gov/bill/114th-congress/house-bill/2262/text
27. Jayalakshmi. "China plans massive solar power station in space by 2050." International Business Times. March 31, 2015. Accessed June 15, 2016. http://www.ibtimes.co.uk/china-plans-massive-solar-power-station-space-by-2050-1494250

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