

**JAPAN'S SPACE PROGRAMME:
THE FINAL FRONTIER**

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Executive Summary

1. In contrast to the United States, China, Russia, India and other major space powers, Japan's space programme is mainly civilian in nature as Japan faithfully observes the Outer Space Treaty of 1967.
2. One of Japan's strengths in space technologies is in robotics being the first country to send a robotic astronaut Kirobo to the International Space Station in the Hayabusa mission.
3. Japan is also a leading country in the collection of space debris which is now a global threat to space explorers as debris shrapnel and floating space junks can damage orbiting satellites.
4. By collaborating with major outer space aspirants like Indonesia, Japan is helping countries with no space presence to establish their own capabilities and assets in space.
5. Japan has also shown outer space leadership in working with nine Asian countries and their 16 space agencies/universities to ink the Memorandum of Understanding on the launch of the Asian Micro-satellite Consortium on 18 November 2016.
6. On 9 July 2020, Japan and the United States inked a formal treaty for human exploration in space, making Japan the major partner (after four decades of loyal and friendly ironclad friendship and partnership) in all US space programmes that feature international cooperation.
7. Japan is a major partner of the US NASA Artemis programme that will eventually result in a sustainable permanent presence on the moon.
8. The Japanese Quasi-Zenith Satellite System (QZSS) complements the US Global Positioning System (GPS) as a satellite augmentation system covering the Asia-Oceania area centred on Japan.

9. Japan has multiple access to satellite-generated data including US satellite networks and Asian microsatellite network. Its own GPS-like QZSS system based on regular sized satellite can accurately pinpoint positions up to 10 cm.
10. Tokyo intends to increase its US\$11 billion space programme by 200% in the coming 10 years, setting a part of the budget on landing Japanese/US astronauts on the moon by 2024.

JAPAN'S SPACE PROGRAMME: THE FINAL FRONTIER

LIM Tai Wei*

Japanese Science, Technology and Space Programme

- 1.1 From the modern Meiji Era to Japan's Pacific War defeat, Western science and technology was harnessed for rapid modernisation, national survival, empire-building and war. In post-WWII pacifist Japan, the administrative state encouraged, nurtured, guided and cooperated with private industries to strengthen Japanese technology prowess to remain in the forefront of the technological revolution and a leading economy in global economic competition. Its subsequent "economic miracle" is based on playing the vanguard role in technology for national and corporate interest, wealth and status.
- 1.2 Japan's space programme is hence a sub-set of the Japanese imperative to acquire technology in order to be a leading nation since the Meiji Era. The rise of pacifist Japan after the American Occupation complements this goal. Japan modelled its foreign participation framework after the US model that does not have general rules governing foreign participation in its R&D programmes; in both countries, the bureaucracy keeps the power and discretion to select the R&D programme for opening up.¹
- 1.3 In fact, pacifist and peace-loving postwar Japan has imposed self-constraints on the export of military technology and is excluded from the development of larger and more expensive weapon systems platforms; its government and industry have hence turned to bilateral US-Japan developmental projects, especially in defensive

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¹ Corning, Gregory P, *Japan and the Politics of Techno-Globalism* (New York and Oxon: Routledge ME Sharpe East Gate Book), 2015, [downloaded on 21 August 2020], available at https://books.google.co.jp/books?id=_WWIDAAAQBAJ&printsec=frontcover&hl=ja#v=onepage&q&f=false, un-paginated online version (Chapter 1).

systems like Ballistic Missile Defence interceptors since the 2010s.² This completely complements Japan's strategy outlined by scholars Christopher Hughes and Richard Samuels. Richard Samuels suggested that Japan has not abandoned the Yoshida Doctrine.³ He believed that, since the 1990s, Japan has reinforced its military ties with the United States while Hughes believed that Tokyo simply cannot veer away from US interests.⁴ Samuels and Hughes labelled this as a "dual hedge" strategy of sustaining its lead in technologies by staying with the US alliance and ahead of its competitors through access to advanced US technologies.⁵

- 1.4 Samuels also argued that Tokyo seeks US security reassurances and works carefully with Washington's objectives in extended deterrence and, only if necessary, substitute the military technological gaps with their own capabilities.⁶ He added that the Japanese fully understand the assets of non-material components of military power (e.g. peace-seeking pacifism as soft power) rather than simply looking at defence production and other material indicators.⁷ Simply put, the Japanese government has saved financial resources for developing niche technologies which they cannot acquire while maintaining their record as a pacifist country that does not develop Weapons of Mass Destruction and/or offensive high-tech equipment.
- 1.5 Samuels argued that Japan's defeat in WWII has led to its shift in military industries to civilian and commercial enterprises with full awareness and appreciation of the benefits and convenience of cutting-edge private sector technologies; it has become an ideology to embrace non-military commercial technological applications, giving

² Hughes, Christopher W, "The Slow Death of Japanese Techno-Nationalism? Comparative Lessons for China's Future Defense Production" dated September 2010 in "Study of a Innovation and Technology in China An IGCC", *Project Policy Brief*, No. 13 [downloaded on 21 August 2020], available at <https://escholarship.org/uc/item/3vd8p36b>, p. 3.

³ Hughes, Christopher W, "Japan's Doctoring of the Yoshida Doctrine" dated July 2007 in *Asia Policy*, No. 4 [downloaded on 21 August 2020], available at https://www.nbr.org/wp-content/uploads/pdfs/publications/ap4_japan_rt.pdf, pp. 199 and 202.

⁴ Ibid.

⁵ Ibid.

⁶ Samuels, Richard J, "How Japan Balances Strategy and Constraint" dated July 2007 in *Asia Policy*, No. 4 [downloaded on 21 August 2020], available at https://www.nbr.org/wp-content/uploads/pdfs/publications/ap4_japan_rt.pdf, pp. 205 and 207.

⁷ Ibid.

its private sector a dominant role in it.⁸ Peaceful use of space is in line with this ideology. There is also an element of selective liberalisation of its industries for outside collaboration and investments.

- 1.6 In the early 21st century, with the pre-Abenomics post-bubble economy looming in the background, Japan welcomed foreign direct investments in automobiles and financial services while the bureaucracy focused on working with industries such as satellites, biotechnologies and semiconductors.⁹ Gregory Corning noted that there is a major group of scholars who argues that the pressure for innovation, hollowing out of manufacturing industries, economic/financial challenges and other sort of pressures have resulted in Japan's strategy of "managed globalisation" and "permeable insulation" which is a form of dual-tracked liberalisation of certain industries and managed insulation for others.¹⁰
- 1.7 The Ministry of Education, Culture, Sports, Science and Technology (MEXT) and Ministry of Economy, Trade and Industry (METI) support Japan's economic initiatives in space technology and exploration. Both want Japanese businesses to succeed in the final frontier of space. Like the US military industry complex which is well-known for its military spin-offs to civilian technologies, Japanese are known for their "spin-ons" (potentially using technology from the civilian sector for military use).
- 1.8 The Japanese Prime Minister's Office, Ministry of Defence and Ministry of Foreign Affairs are also interested in security and foreign relations/alliance issues with the United States due to interoperability enhancements. Therefore, different bureaucratic interests with different nuances and interests (known as "*nawabari*") are involved with the single purpose of keeping Japan in the forefront of cutting-edge technologies.

⁸ Samuels, Richard J, "*Rich Nation Strong Army*": *National Security and the Technological Transformation of Japan* (Ithaca and London: Cornell University Press), 1994, p. 341.

⁹ Corning, Gregory P, *Japan and the Politics of Techno-Globalism*.

¹⁰ Ibid.

- 1.9 In the 2010s, Japan's large-scale conglomerates were channelling less funds to the defence manufacturing/production industries and their military production capabilities were structurally dispersed in pockets throughout large-scale civilian firms.¹¹ This allowed individual firms/companies to get out of defence production easily to focus on their core civilian expertise/business when needed.¹²
- 1.10 Richard Samuels articulated this aspect in his book when he argued that Japanese industries are made up of an ecology of subcontractor associations, R&D units, research groups and industrial cooperation agencies.¹³ Their defence and civilian technologies interdiffuse and intertwine/engage or disengage ("spin-offs" and "spin-ons") with comparative ease.¹⁴ Within this ecology, MEXT works with the R&D stakeholders, research groups and industrial cooperation councils to develop cutting-edge technologies.
- 1.11 This arrangement makes civilian and military dual-character Japanese companies very flexible and complement the dual-tracked liberalisation and insulation of selective industries. This also means that it may not be possible for Japan to have (or desire to have) military technological autonomy and collaboration with the US high-tech sector will be a logical and efficient choice. The Japanese Ministry of Defence works closely with its US counterpart in the security arena. Thus, without exception, Japan's space programme inter-operably intertwines with US space programme.
- 1.12 Government bureaucracies and agencies like METI has also opened all its big R&D programmes to external review and at least one third of these science and tech R&D programmes have attracted foreign participation by the early 21st century.¹⁵ In addition to this spirit of openness and embrace of globalisation, as a liberal

¹¹ Hughes, Christopher W, "The Slow Death of Japanese Techno-Nationalism? Comparative Lessons for China's Future Defense Production".

¹² Ibid.

¹³ Samuels, Richard J, "*Rich Nation Strong Army*".

¹⁴ Ibid.

¹⁵ Corning, Gregory P, *Japan and the Politics of Techno-Globalism*.

democracy, Japan subjects its policy to self-evaluation and public scrutiny. Scholars like Christopher W Hughes have argued that Japan's defence production industries are the weakest components of Japan's technological industries, and highlighted that it is dying a self-admitted "slow death" due to defence budget stagnation, imperfect procurement practices and bigger and more diverse collaboration with external parties.¹⁶ This implies that dependence on collaboration with the United States and its industrial networks will remain a necessity in such circumstances.

- 1.13 In stark contrast to Japan's partnership and dependence on the United States, neighbouring China maintains an indigenous space programme. The origins of China's space programme dates back to 1956 in the research facilities of the Fifth Academy of the Ministry of National Defence (now known as China Aerospace Science and Technology Corporation) and its initial goals were ideological spurred by Mao Zedong's 1958 speech that China should catch up with the Soviet Union and the United States in launching a satellite into space, a feat accomplished on 24 April 1970 with the successful orbital launch of Dong Fang Hong 1.¹⁷
- 1.14 A decade thereafter in the 1980s, much of China's space efforts were spent building their own launch sites in Xichang (Sichuan province) and Taiyuan (Northern China) before developing the Shenzhou space module in the 1990s and sending China's first taikonaut Yang Liwei into space in 2003. Much of this development was indigenous with Soviet help in 1960 to develop the CZ (or Changzheng/Long March) rocket and the 1996 procurement of Russian technologies.¹⁸

¹⁶ Hughes, Christopher W, "The Slow Death of Japanese Techno-Nationalism? Comparative Lessons for China's Future Defense Production".

¹⁷ Zhu, Sirui, "China's Long March to Space" dated 27 December 2019 in Reuters [downloaded on 27 December 2019], available at <https://graphics.reuters.com/SPACE-EXPLORATION-MOON/0100B0BH0NZ/index.html>.

¹⁸ New Scientist and AFP, "Timeline: China's spaceflight history" dated 12 October 2005 in New Scientist [downloaded on 1 January 2020], available at <https://www.newscientist.com/article/dn8144-timeline-chinas-spaceflight-history/>.

Peaceful Use of Outer Space

- 2.1 In contrast to the United States, China, Russia, India and other major space powers, Japan's space programme is mainly civilian in nature as the post-war pacifist constitution (especially Article 9 popularly known as the 'Peace Constitution') forbids Japan to settle international dispute by war. Moreover, Japan can rely on its senior security partner, the US superpower for its survival in a nuclear world. Japan faithfully observes the Outer Space Treaty (OST) of 1967 (which states that outer space exploration and utilisation are for "peaceful purposes" only) but it does have strong indigenous capabilities as the fourth nation to send a satellite into orbit after the United States, USSR and France and its own NASDA (National Space Development Agency)-Mitsubishi Heavy Industries Ltd (MHI) H-II rocket series and very soon H3.¹⁹
- 2.2 The major concept behind the Japanese space programme is peaceful use of space. Due to the peace constitution and strong sentiments of pacifism within the population, a resolution on the development of outer space and its basic use was passed by the Plenary Session of the House of Representatives in May 1969. All the applications have a peaceful and pacifist orientation. Based on the 1969 resolution, the Japanese Self-Defence Forces (SDF) are not allowed to conduct R&D on building its own satellites, or owning them for lethal, destructive and aggressive purposes; however, this does not apply to the use of civilian Inmarsat and Intelsat by the SDF for peaceful purposes.²⁰
- 2.3 The peaceful use of space has led the Japanese to enjoy soft power in space diplomacy as countries are keen to cooperate in Japanese space initiatives. While pacifist in space, Japan also enjoys the security guarantee and space defence umbrella afforded previously by the US Air Force and now the newly formed Space Force under the Trump administration. US satellite tracking and space weapons

¹⁹ Vijaykumar, Anupama, "Japan's rise as a space power" dated 28 January 2020 in *Japan Times* [downloaded on 28 January 2020], available at <https://www.japantimes.co.jp/opinion/2020/01/28/commentary/japan-commentary/japans-rise-space-power/>.

²⁰ Akimoto, Daisuke, "The Evolution of Japan's Space Strategy and the Japan-US Alliance" dated 28 August 2020 in PacNet #49 [downloaded on 31 August 2020], available at <https://mailchi.mp/pacforum/pacnet-49-the-evolution-of-japans-space-strategy-1170346?e=1dea89bef7>.

capabilities help Japan defend against the ballistic missile threats of its rogue neighbour of North Korea (Democratic People's Republic of Korea or DPRK).

- 2.4 Due to the peaceful, pacifist and scientific orientation of its space programme, Japan's space programme is almost universally welcome by all, save the DPRK. Pyongyang's state-owned Korean Central News Agency criticised Japan's space force on 18 January 2020 as well as the involvement of 20 Self-Defence Forces staff members: "Japan is madly keen on exploiting even outer space for its sinister purpose of building up its 'defence capacity'".²¹ On the other hand, the international community wonders if the satellite launches of North Korea are disguised missile tests.²²
- 2.5 On 18 May 2020, the Japanese Ministry of Defence (MOD) set up the Space Operations Squadron as part of the Air Self-Defence Force with a staff strength of 20 in Tokyo's Fuchu Base to track space debris and suspicious satellites (more than 500,000 pieces of space debris and 2,000 inactive satellites) that pose a danger to international space assets.²³ The MOD aims to increase Space Operations Squadron manpower strength to 100 and work with the US Space Command/Japan Aerospace Exploration Agency (JAXA) to set up a space monitoring system in 2023 to track outer space activities by hostile nations (potentially Iran, North Korea, Russia, China and so on) that may disrupt US alliance satellite operations through anti-satellite missiles, laser irradiation, communication jamming and/or killer satellites or interfering, disabling or destroying satellites (e.g. GPS).²⁴
- 2.6 China also encourages peaceful utilisation of outer space, a goal announced by China National Space Administration spokesperson Li Guoping in 2018. It has signed 121 cooperation agreements with 37 countries and four international

²¹ Ryall, Julian, "Amid rivalry with China, Japan is aiming for the moon – and beyond" dated 1 July 2020 in *South China Morning Post (SCMP)* [downloaded on 1 July 2020], available at <https://www.scmp.com/week-asia/economics/article/3091367/amid-rivalry-china-japan-aiming-moon-and-beyond>.

²² Jones, Morris, "The "satellite clause" for North Korea's rockets" dated 25 March 2019 in Lowy Institute The Interpreter [downloaded on 25 March 2019], available at <https://www.lowyinstitute.org/the-interpreter/satellite-clause-north-korea-rockets>.

²³ Akimoto, Daisuke, "The Evolution of Japan's Space Strategy and the Japan-US Alliance".

²⁴ Ibid.

organisations and worked with countries like Brazil (earth resources satellites), Algeria (communication satellite launch in 2017), Pakistan/Iran/Turkey/Peru (satellites that track floods and forest fires), Thailand/Laos/Burma/Cambodia (remote-sensing information platform), among others.²⁵

Strong Capabilities

- 3.1 One of Japan's strengths in space technologies is in robotics. It is the first country to send a robotic astronaut Kirobo to the International Space Station (ISS) in the Hayabusa mission. It was also the first spacecraft in the world to return asteroid dust to earth in 2003, allowing Japan to develop capabilities in extracting samples and analysing mineral composition, thermal inertia and surface/subsurface samples from an asteroid.²⁶
- 3.2 Besides humanoids, Japan's strength in robotics is also visible in the utilisation of drones mounted with sensors for ground observation and international joint collection of space data (as well as in Asian consortiums), and for optimising the volume and accuracy of data collected.²⁷
- 3.3 Japanese robotic technologies have many other applications in outer space missions. For example, Hayabusa2 is expected to touch down on Earth with subsurface dust collected by robotic applications from the asteroid Ryugu in December 2020.²⁸ Robotics technologies in space probes are deployed to drill into asteroids and collect samples for analysis. The knowledge gained on outer space and its minerals-rich

²⁵ *Xinhua News Agency*, "China strengthens international space cooperation" dated 23 April 2018 in Space Daily [downloaded on 23 April 2018], available at https://www.spacedaily.com/reports/China_strengthens_international_space_cooperation_999.html.

²⁶ Vijaykumar, Anupama, "Japan's rise as a space power".

²⁷ Hokkaido University, "Asian Micro-satellite Consortium agreement effective from Nov. 18" dated 18 November 2016 in Research Press Release Hokkaido University [downloaded on 1 January 2020], available at <https://www.global.hokudai.ac.jp/blog/asian-micro-satellite-consortium-agreement-to-take-effect-on-nov-18/>.

²⁸ Patelarchive, Neel V, "Why Japan is emerging as NASA's most important space partner" dated 22 July 2020 in MIT Technology Review [downloaded on 22 July 2020], available at <https://www.technologyreview.com/2020/07/22/1005546/why-japan-jaxa-nasas-most-important-space-partner-artemis-moon-gateway/>.

environment can also take the shape of mining asteroids for resources. This kind of emerging technologies can make space exploration commercially profitable and viable, and eventually self-sustaining.

- 3.4 Japan is not the only country that is commercialising dual-use space-based robotic technologies. China Academy of Launch Vehicle Technology, a major manufacturer of carrier rockets, is also working on turning advanced space technologies into commercialised products like industrial-grade space-tech robotic arms for holding things with a precision of 0.1 mm.²⁹ China's domestic industrial robot market is large enough to absorb these technologies derived from space equipment; the industrial parks in Chongqing and Beijing for instance have become ready customers.³⁰
- 3.5 Without a policy of self-reliance, Japan has opted to work with international partners in co-developing its robot systems. Japan has teamed up with Canada and the European Space Agency to construct Heracles robotic transport system to deliver cargo to the moon or extract back valuable mined resources and supporting the US Artemis programme and Gateway at the same time.³¹
- 3.6 While Japan has chalked up achievements in space missions and explorations, it is a community player and subscribes to the idea that space efforts cannot be an exclusive one but one that works with other regional stakeholders. As the global competition in satellite construction, launches and utilisation heats up, Japan and other Asian countries in the Asian Micro Satellite Consortium (AMC) have banded together to form an effective global alignment to collectively utilise cutting-edge satellite bus and sensing technologies to exchange satellite-generated data in order to stay ahead of global economic competition.³²

²⁹ Xinhuanet, "China Focus: China's space tech-based robots find wider application on Earth" dated 22 August 2019 in Xinhuanet [downloaded on 22 August 2019], available at http://www.xinhuanet.com/english/2019-08/22/c_138329594.htm.

³⁰ Ibid.

³¹ Patelarchive, Neel V, "Why Japan is emerging as NASA's most important space partner".

³² Hokkaido University, "Asian Micro-satellite Consortium agreement effective from Nov. 18".

- 3.7 China is also working with other Asia-Pacific countries in managing outer space tracking and surveillance data. China's membership in the Asia-Pacific Space Cooperation Organisation and its surveillance initiative known as the Asia-Pacific Ground-Based Optical Space Object Observation System has seen China generously supplying telescopes to Peru, Pakistan and Iran to track objects in low Earth orbit and geostationary orbit; such data are then fed back to the Chinese Academy of Science's National Astronomical Observatory.³³
- 3.8 Japan is also a leading country in collecting space debris which is now a global threat to space explorers as debris shrapnel (from countries that blow up disused satellites using ballistic missiles as a show of strength) and floating space junks can damage orbiting satellites and hurt astronauts due to their high orbiting speeds.
- 3.9 Japan has developed the electrodynamic tether that can collect space debris and bring it down to the Low Earth Orbit to burn them up upon re-entry into the Earth's atmosphere; a Singapore-based Astroscale private firm (run by Japanese entrepreneur Nobu Okada) has also developed an End-of-Life Service technology,³⁴ which can extract space debris and bring them down to the earth's atmosphere for incineration. The biggest orbital debris cloud in space history was created in 2007 when an old weather satellite in a high polar orbit was hit by a Chinese ballistic missile test, creating 3,000 floating debris in space.³⁵ Japan is working with the international community to eliminate some of these pieces.
- 3.10 Besides activities/collaborations in Singapore, Japan has been actively working with its Southeast Asian friends to develop space mission capabilities. By collaborating with major outer space aspirants like Indonesia, Japan is helping countries with no space presence to establish their own capabilities and assets in space. Indonesia for

³³ Stokes, Mark, Gabriel Alvarado, Emily Weinstein and Ian Easton, *China's Space and Counterspace Capabilities and Activities* (The US-China Economic and Security Review Commission), 2020, pp. 27-28.

³⁴ Vijaykumar, Anupama, "Japan's rise as a space power".

³⁵ Zhu, Sirui, "China's Long March to Space".

example is going full-steam into building the LAPAN A4 microsatellite A-series to launch locally developed network of affordable satellites into space.³⁶

- 3.11 Besides Japan, Indonesia is working with China. China has built the Palapa-N1 communication satellite for Indonesia at the Xichang Satellite Launch Centre in Sichuan in a deal inked between China Great Wall Industry Corp (under the umbrella of China Aerospace Science and Technology Corp) and Indonesian Palapa Satelit Nusantara Sejahtera in May 2017.³⁷ The Indonesian Palapa-N1 satellite was constructed on a Dongfanghong-4 platform built by the China Academy of Space Technology with a Long March-3B carrier rocket mounted by the China Academy of Launch Vehicle Technology that delivers the satellite into space.³⁸
- 3.12 Other Japanese achievements include the HALCA, a pioneering space mission for extremely long baseline interferometry using multiple telescopes to study astronomical objects, and Japanese lunar probe SELENE IKAROS, the world's first successful sail technology in interplanetary space.³⁹ Japan has been a space veteran since 1990 with 12 Japanese astronauts sent into space.⁴⁰
- 3.13 Japan has also shown outer space leadership in working with nine Asian countries and their 16 space agencies/universities to ink the Memorandum of Understanding (MOU) and kick-start the AMC on 18 November 2016, forging a regional consortium to collect microsatellite-generated data on the environment and natural disasters events.⁴¹

³⁶ Goh, Deyana, "Indonesia, Japan to develop world's first microsatellite with SAR" dated 11 September 2017 in Spacetech Asia [downloaded on 11 September 2017], available at <https://www.spacetechasia.com/indonesia-japan-to-develop-worlds-first-microsatellite-with-sar/>.

³⁷ *Xinhua*, "China to launch communication satellite for Indonesia" dated 1 April 2020 in Xinhuanet [downloaded on 1 April 2020], available at http://www.xinhuanet.com/english/2020-04/01/c_138937376.htm.

³⁸ *Xinhua*, "China to launch communication satellite for Indonesia".

³⁹ Patelarchive, Neel V, "Why Japan is emerging as NASA's most important space partner".

⁴⁰ Ibid.

⁴¹ Hokkaido University, "Asian Micro-satellite Consortium agreement effective from Nov. 18".

- 3.14 China is also working with other Asian countries and beyond the region. On 11 January 2018, China Great Wall Industry Corporation worked with the Royal Cambodia Group to build the Techno 1 communications satellite for use by Cambodian Broadcasting Service Company, Cellcard (Cambodia's third biggest mobile operator) and the Cambodian government to manage natural disaster, national security issues and other government services.⁴² China also has a longstanding space programme with Iran. On 7 September 2008, an Iranian-Thai-Chinese collaborative scientific research satellite, Enivornment-1, was launched into space on the back of a Chinese rocket.⁴³
- 3.15 Another longstanding partner with China is Venezuela. In October 2008, China launched Venezuela's first Venesat-1 communications satellite on a Chinese Long March 3B from the Xichang Satellite Launch Centre and in September 2012, another Chinese Long March 2D rocket launched Venezuela's first remote-sensing satellite, the VRSS-1, into space from Jiuquan.⁴⁴ Venezuela's second VRSS-2 remote-sensing satellite was launched into space on a Long March 2D rocket from Jiuquan Satellite Launch Centre; it was designed by China Academy of Space Technology in Beijing with a panchromatic/multi-spectral high-resolution imager and an infrared camera for use in land resources inspection, environmental protection, disaster monitoring/relief, crop yield estimation and urban planning.⁴⁵
- 3.16 China was also Pyongyang's alternative source of space-based technological hardware. According to Reuters, North Korea had, in the recent past, access to Chinese space technologies. The DPRK's transporter-erector-launcher vehicle that transports ballistic missiles and then fires them vertically was cited in the UN's 2013 report as the exact model as that of China's Hubei Sanjiang Space Wanshan Special

⁴² Goh, Deyana, "China to build and launch Cambodia's first satellite" dated 12 January 2018 in SpaceTech Asia [downloaded on 12 January 2018], available at <https://www.spacetechnasia.com/china-to-build-and-launch-cambodias-first-satellite/>.

⁴³ Hanna, Andrew, "Iran's Ambitious Space Program" dated 29 July 2020 in United States Institute of Peace (USIP) website [downloaded on 29 July 2020], available at <https://iranprimer.usip.org/index.php/blog/2020/jun/23/iran%E2%80%99s-ambitious-space-program>.

⁴⁴ Zhao, Lei, "China launches second remote-sensing satellite for Venezuela" dated 10 October 2017 in China Daily [downloaded on 10 October 2017], available at https://www.chinadaily.com.cn/china/2017-10/10/content_33058430.htm.

⁴⁵ Ibid.

Vehicle Company, a subsidiary of China Aerospace Science and Industry Corp, a state-owned enterprise (SOE) that manufactures the Shenzhou space rockets.⁴⁶ The mobile nature of the missile launching vehicle makes detection difficult for the United States and its allies.

- 3.17 Not all of China's space capabilities are delivered for non-Western countries or America's foes. China has developed joint programmes with some European Union (EU) countries. China and France have co-developed an ocean-observing satellite to study climate change while Italy and China have built a seismic-electromagnetic satellite to study seismic precursors to track and forecast earthquake.⁴⁷

Ironclad US Ally

- 4.1 On 9 July 2020, Japan and the United States inked a formal treaty for human exploration in space. This makes Japan the major partner (after four decades of loyal and friendly ironclad friendship and partnership) in all US space programmes that feature international cooperation. Kaitlyn Johnson, an aerospace security expert at the Centre for Strategic and International Studies, noted an elevation in Japan's relationship with US space programmes on par with the Five Eyes intelligence pact nations (the United States, Australia, Canada, New Zealand and the United Kingdom) with Tokyo receiving the highest ally access to intelligence.⁴⁸ US allies depend on defence support programme satellites for tracking ballistic missile launches and operating their ballistic missile defence system, making them common defensive assets that contribute to the alliance network's peace and security.⁴⁹ In the near future, Japan's "multi-domain defence force" is expected to work with the US government in cross-domain operations involving cyber, space, and electromagnetic warfare to ensure regional peace and security.⁵⁰

⁴⁶ Pearson, James and Jack Kim, "North Korea appeared to use China truck in its first claimed ICBM test" dated 4 July 2017 in Reuters [downloaded on 4 July 2017], available at <https://www.reuters.com/article/us-northkorea-missiles-china-truck-idUSKBN19P1J3>.

⁴⁷ *Xinhua News Agency*, "China strengthens international space cooperation".

⁴⁸ Patelarchive, Neel V, "Why Japan is emerging as NASA's most important space partner".

⁴⁹ Akimoto, Daisuke, "The Evolution of Japan's Space Strategy and the Japan-US Alliance".

⁵⁰ Ibid.

- 4.2 For Japan, intelligence is not only restricted to security aspects as in the case of the Western alliance. It also extends to non-traditional security fields with Japan's Asian friends. The 16 stakeholders in the Asian Micro Satellites Consortium include Bangladesh, Indonesia, Japan, Malaysia, Mongolia, Myanmar, the Philippines, Thailand and Vietnam and they are all bound by one commonality. They are in the earthquake, typhoon, volcanic eruption, haze, environmental and tsunami disaster zones so satellite data is crucial as a defensive mechanism to manage such challenges.⁵¹ Satellites help to track weather patterns and extent of environmental damage.
- 4.3 The partnership with the West also moves beyond security issues and into deep space exploration. Japan's solid working relationship with US space agencies will focus on specific ambitious programmes, one of which is the US National Aeronautics and Space Administration (NASA) Artemis programme that will eventually result in a sustainable permanent presence on the moon. In return, Japan can participate in and likely send its own astronauts to the moon via NASA missions, without having to pay for and develop a lunar mission of its own.⁵² In July 2020, the Japanese government and NASA put their signatures on a Joint Exploration Declaration of Intent with NASA to join the Artemis Programme led by the United States, pushing bilateral space relations a step further.
- 4.4 Japan is also working on a cubesat lander OMOTENASHI (Japan's inaugural lunar lander) that can be delivered into space on NASA's first Artemis mission, which is part of the process of building a space station revolving around the moon with manned missions on the moon's (and Mars) surface.⁵³
- 4.5 Another aspect of Japanese space programme is its scientific orientation. Japan launched Spacelab-J in 1992 to conduct scientific experiments as a component of the US NASA's Endeavour Space Shuttle programme before moving on to the

⁵¹ Hokkaido University, "Asian Micro-satellite Consortium agreement effective from Nov. 18".

⁵² Patelarchive, Neel V, "Why Japan is emerging as NASA's most important space partner".

⁵³ Bartels, Meghan, "Japan Sets Sights on Moon with NASA and India" dated 23 October 2019 in Space.com [downloaded on 23 October 2019], available at <https://www.space.com/japan-moon-plans-with-nasa-india.html>.

Japanese Experiment Module (Kibo) in the ISS. The Kibo is the biggest inbuilt module to conduct scientific experiments and a habitation module for astronauts to conduct more scientific experimentation.⁵⁴

- 4.6 Japan's joint programmes with other countries are also peaceful in nature. For example, the Synthetic Aperture Radar (SAR), built by Chiba University's Josaphat Microwave Remote Sensing Laboratory at the Centre for Environmental Remote Sensing run by Indonesia-born Professor Josaphat T Sri Sumantyo, can penetrate clouds, fog and haze for peaceful weather tracking purposes, including tracking groundwater.⁵⁵ This is a technology that is jointly developed with Indonesia as the SAR will eventually be mounted on the Southeast Asian country's LAPAN A5 microsatellite.
- 4.7 In the area of space logistics, JAXA is working closely with NASDA. They have also developed cargo ships to send supplies to the ISS and these agencies are on the verge of using the H3 launcher that carries the cargo transporter HTV-X to send heavier payloads to the ISS (with enhancements for longer-distance deliveries in the future).⁵⁶
- 4.8 The Japanese space programme is simply too big and expensive to be driven by the private sector. The bureaucratic agency driving this programme is JAXA. JAXA was incepted on 1 October 2003 when three organisations (the Institute of Space and Astronautical Science, National Aerospace Laboratory and National Space Development Agency of Japan) were merged by Minister Atsuko Toyama of the MEXT.⁵⁷

⁵⁴ Vijaykumar, Anupama, "Japan's rise as a space power".

⁵⁵ Goh, Deyana, "Indonesia, Japan to develop world's first microsatellite with SAR" dated 11 September 2017 in Spacetechnica Asia [downloaded on 11 September 2017], available at <https://www.spacetechnica.com/indonesia-japan-to-develop-worlds-first-microsatellite-with-sar/>.

⁵⁶ Vijaykumar, Anupama, "Japan's rise as a space power".

⁵⁷ Matogawa, Yasunori, "Please support our newly born JAXA!" dated 1 October 2003 in Japan Aerospace Exploration Agency website [downloaded on 21 August 2020], available at https://global.jaxa.jp/article/interview/no1/index_e.html.

- 4.9 Another of Japan's space agency, the Institute for Unmanned Space Experiment Free Flyer was founded in 1986 as METI's space branch for non-rocket programmes. It has adopted budget reduction and privatisation of the Japanese space industry for its operating philosophy, therefore specialising in dual-use technologies.⁵⁸ Its research and prototype outputs are used in both military and civilian sectors.
- 4.10 In terms of space logistics, Japan also has leading technologies in smaller and lighter microsatellites that make it easier to launch and handle. In contrast to microsatellites that can be built in two years, the construction of regular satellites needs a decade while microsatellites, due to their lighter weight (100 kg or less) can be built with less complexities and difficulties, making it only one-hundredth the cost of building large satellites.⁵⁹
- 4.11 Due to the US-Japan alliance, JAXA's autonomous Position, Navigation and Timing (PNT) capabilities is in concert with US network systems. The Japanese Quasi-Zenith Satellite System (QZSS) complements US Global Positioning System (GPS) as a satellite augmentation system covering the Asia-Oceania area centred on Japan.⁶⁰ This is unlike the stand-alone systems of China's Beidou system, Russia's Global Navigation Satellite System, Europe's Galileo system and India's Indian Regional Navigational Satellite System that all act as alternatives to the GPS.
- 4.12 China's Beidou system is a remarkable Chinese space achievement. Beidou will enable China to be self-dependent for earth observation, navigation and remote sensing capabilities and it can generate returns from consumers using its services to the tune of US\$298 billion dollars (RMB2 trillion) with its seven high-resolution satellites of this type in orbit.⁶¹ It can be a commercial windfall for the Chinese space industry.

⁵⁸ Kallender-Umezumi, Paul and Saadia M Pekkanen, *In Defense of Japan: From the market to the military in space policy* (California: Stanford University Press), 2010, pp. 67-68.

⁵⁹ Hokkaido University, "Asian Micro-satellite Consortium agreement effective from Nov. 18".

⁶⁰ Vijaykumar, Anupama, "Japan's rise as a space power".

⁶¹ Stokes, Mark, Gabriel Alvarado, Emily Weinstein and Ian Easton, *China's Space and Counterspace Capabilities and Activities*, p. 11.

- 4.13 However, the US government analyses such capabilities differently, given its dual-use nature. Their extensive report prepared for the US-China Economic and Security Review Commission noted that the People's Liberation Army (PLA) can hit targets at greater range due to PNT services provided by Beidou and greatly widens the operational range of Chinese strategic forces with satellite communications support for long-distance nuclear submarine navigation, strategic bombers and global missile deployments.⁶²
- 4.14 While the Japanese PNT system supplements the US GPS, Japan is also integrated into another network of Asian microsatellites. AMC facilitates the exchange and formatting of data from satellite bus and sensing devices, observational data and data application methodologies that will eventually come from approximately 50 microsatellites belonging to the AMC, facilitating constant tracking/monitoring multiple events/activities including natural disasters.⁶³
- 4.15 In sum, Japan has multiple access to satellite-generated data and US satellite networks and Asian microsatellite network. Japan's own GPS-like QZSS system based on regular-sized satellite can accurately pinpoint positions up to 10 cm.⁶⁴ Though Japan is a close ally of the United States, it is also pragmatic. Besides using the H-IIA and M-3S, it had used Russian rockets for launches. Japanese astronauts had also participated in Russian space programme (Soyuz). Such multilateral, multi-party access and cooperation that cuts across political divides and ideological affiliations is made possible by Japan's peaceful orientation in outer space use and development.
- 4.16 Japan works with other Asian countries in not only the technical hardware aspects but also software optimisation. In Asia, Japan is also leading the standardisation of advanced optical sensors and other important equipment to optimise the accurate collection, estimation and use of satellite data which are crucial for natural disaster

⁶² Stokes, Mark, Gabriel Alvarado, Emily Weinstein and Ian Easton, *China's Space and Counterspace Capabilities and Activities*, p. 20.

⁶³ Hokkaido University, "Asian Micro-satellite Consortium agreement effective from Nov. 18".

⁶⁴ Vijaykumar, Anupama, "Japan's rise as a space power".

relief, international environmental climate change, agricultural work, forestry restoration, sustainable fishing, responsible mining, and air and water pollution prevention.⁶⁵

- 4.17 In hardcore militarised space applications, South Korea and Japan come under the US space defence umbrella. When China's anti-satellite test (ASAT) disintegrated its old satellite in space in January 2007 it sparked the United States and its alliance partners to reconsider ways to protect their assets in space. The White House statement given by the NSC read: China's "development and testing of such weapons is inconsistent with the spirit of cooperation that both countries aspire to in the civil space area".⁶⁶
- 4.18 In this context, Kawamura Takeo, a Liberal Democratic Party (LDP) lawmaker and former minister of MEXT highlighted the need to introduce changes to the 1969 Diet resolution and the Basic Space Law came into effect on 27 August 2008 stipulating that Japan's space policy needs to contribute to international peace and security and the security of Japan in accordance with the constitution and international treaties.⁶⁷ The Basic Space Law does not limit the use of outer space for "non-military purposes" and permits the government to carry out dual-use satellite R&D for the defence of Japan, global peace and security.
- 4.19 The US military establishment is especially anxious about the Russian Nudol ballistic missile that can strike low orbital US (and its allies') satellites, the Ekipazh nuclear reactor that powers a big payload of on-orbit satellite jammers and the IL-76MD-90A transport aircraft-mounted power laser that strikes a satellite or blind it.⁶⁸

⁶⁵ Hokkaido University, "Asian Micro-satellite Consortium agreement effective from Nov. 18".

⁶⁶ Broad, William J and David E Sanger, "China Tests Anti-Satellite Weapon, Unnerving U.S." dated 18 January 2007 in *New York Times* [downloaded 1 January 2020], available at <https://www.nytimes.com/2007/01/18/world/asia/18cnd-china.html>.

⁶⁷ Broad, William J and David E Sanger, "China Tests Anti-Satellite Weapon, Unnerving U.S.".

⁶⁸ Mehta, Aaron, "America's adversaries keep investing in weapons to take out satellites" dated 30 March 2020 [downloaded on 30 March 2020], available at <https://www.c4isrnet.com/battlefield-tech/space/2020/03/29/countries-keep-investing-in-weapons-to-take-out-satellites/>.

- 4.20 The US alliance (Five Eyes, the EU, South Korea/Japan) is also concerned that China's Beidou for example could pose a security risk by allowing the owner to track users through inserting malware in navigation signals or messaging function in satellite communication and then use the system in non-disclosed ways.⁶⁹ The United States is far more worried about the Russian than the Chinese space programmes at the moment. The United States is likely to tap into its allies' expertise to develop satellites that can monitor its rivals' space programmes and weapon system.
- 4.21 As for Japan, China is not necessary a threat in every aspect for Japan's space endeavours. China in fact has been an inspiration to Japanese efforts to push on with space explorations. Hong Kong media *South China Morning Post* reported that Japan's space exploration in fact have been encouraged and motivated by the achievements and success of China's Jade Rabbit lunar rover mission in 2013 which increased Chinese soft power when it exported its space technologies and specialised aerospace engineering training programmes to other countries.⁷⁰ This was not the first time foreign achievements have inspired the Japanese space programme. The 1957 Sputnik 'shock' as well as the successful US Apollo Programme during the Cold War also inspired the Japanese government and industries to catch up with its peers.⁷¹
- 4.22 Meanwhile, in the security arena and in the area of counterstrike, America's rivals are looking at kinetic and non-kinetic weapons like funding laser systems and satellites that can track US space vehicles, currently in development in Russia, China, Iran and North Korea.⁷² The American counterspace programmes are developed to counter some of its rivals' weaponised systems while US allies/friends like Japan and France have also launched their own counterspace efforts as the most

⁶⁹ Halappanavar, Abhilash, "The final satellite in the BeiDou system completes an undertaking 20 years in the making" dated 26 June 2020 in *The Diplomat* [downloaded on 26 June 2020], available at <https://thediplomat.com/2020/06/chinas-answer-to-gps-is-now-fully-complete/>.

⁷⁰ Ryall, Julian, "Amid rivalry with China, Japan is aiming for the moon – and beyond".

⁷¹ Akimoto, Daisuke, "The Evolution of Japan's Space Strategy and the Japan-US Alliance".

⁷² Mehta, Aaron, "America's adversaries keep investing in weapons to take out satellites".

important military alliance in the world, North Atlantic Treaty Organisation, collectively declared space an “operational domain” in December 2019.⁷³

- 4.23 North Korea is the major threat to American and Japanese assets in East Asia. North Korea’s ballistic missile, chemical warheads and nuclear programmes compelled Japan to sign an MOU on joint research of the Theatre Missile Defence system with the United States in 1999. The barrage of North Korean missile tests in 2003 eventually forced Japan to acquire missile defence systems, including Aegis destroyers with high altitude interceptor missiles.⁷⁴
- 4.24 Japan does not have weapons development system that can blow up satellites in space or other offensive displays of power. Even when military systems are considered for joint collaboration with other countries, Japan is careful to look at defensive systems. Together with France and India, Japan is also contributing funds into defensive counterspace efforts in the arena of ballistic missile defensive systems or non-kinetic cyberattacks.⁷⁵
- 4.25 The pullout from the Anti-Ballistic Missile Treaty in 2002 frees the United States to develop a missile defence system to intercept North Korean missiles, Chinese intermediate-range missiles (with conventional and nuclear warheads) and Russian short-range (500 km) Iskandar ballistic missiles. The missile shield covers allies like South Korea and Japan from missile strikes as well.⁷⁶ Jonathan McDowell, an astrophysicist at the Harvard-Smithsonian Centre for Astrophysics, suspected North Korea of having launched solid-fuel KN-23 type tactical guided missiles that are similar (e.g. same diameter) to the Russian-made Iskander type

⁷³ Ibid.

⁷⁴ Sato, Yoichiro, “Missile defense in Japan after the Aegis Ashore cancellation” dated 1 July 2020 in *Japan Times* [downloaded on 1 July 2020], available at <https://www.japantimes.co.jp/opinion/2020/07/01/commentary/japan-commentary/missile-defense-japan-aegis-ashore-cancellation/>.

⁷⁵ Mehta, Aaron, “America’s adversaries keep investing in weapons to take out satellites”.

⁷⁶ Sato, Yoichiro, “Missile defense in Japan after the Aegis Ashore cancellation”.

missile, a development visible in the missile tests on 4 and 9 May 2019, 25 July 2019 and 6 August 2019.⁷⁷

- 4.26 While eschewing offensive military space weaponisation developments, Japan is doing its part for the non-traditional security (NTS) field in no-detriment projects and initiatives. In Southeast Asia for example, the Indonesia-Japan developed LAPAN A5 microsatellite has its own independent light source to operate in the dark to contribute to humanitarian causes like tracking functions for the fishing/marine industries, locating groundwater for farmers and households, and in the NTS field, monitoring terrorist locations.⁷⁸
- 4.27 Study groups within the ruling LDP and more recently by the Minister of Defence Taro Kono articulated that Japan should seriously consider acquiring preemptive first strike capability in the face of an imminent ballistic missile attack by North Korea. North Korean capabilities had greatly strengthened in 2018-2019. It first revealed its solid fuel motor/engine capabilities in February 2018 during the 70th anniversary of the Korean People's Army and integrated it into its KN-23 missiles by 2019, making these missiles easy to deploy as they require no fuelling up and could be deployed once they are placed on the launch pad.⁷⁹ Therefore, these missiles need to be hunted down while they are still on the launch pads. To do this, US Pacific Command, Seoul and Tokyo will need a sophisticated satellite system to search, look and shoot at/down these ballistic missiles.
- 4.28 Acquiring pre-emptive strike capabilities has become an international debate in Japan. Residual pacifism in Japanese society is still strongly against militarism, satellite systems and acquisition of weaponry that make preemptive strikes possible. While the Japanese government and society are wary of acquiring offensive pre-emptive strike capabilities, rising challenges including accelerated North Korean

⁷⁷ Kim, Dong-hyun, "Experts: N. Korea's New Missiles Designed to Dodge Preemptive Strikes" dated 14 August 2019 in VOA news [downloaded on 14 August 2019], available at <https://www.voanews.com/east-asia-pacific/experts-n-koreas-new-missiles-designed-dodge-preemptive-strikes#:~:text=The%20KN%2D23%20has%20quasi,them%20once%20they%20are%20launched.&text=The%20missiles%20North%20Korea%20launched%20July%2031%20and%20Aug>.

⁷⁸ Goh, Deyana, "Indonesia, Japan to develop world's first microsatellite with SAR".

⁷⁹ Kim, Dong-hyun, "Experts: N. Korea's New Missiles Designed to Dodge Preemptive Strikes".

buildup of ballistic missiles under the Kim Jong-Un regime and its development of new types of missiles with complex trajectories that neutralise the Aegis system are putting tremendous pressure on the stakeholders.⁸⁰

- 4.29 The KN-23 flies lower than short-range ballistic missiles and have fins (and possibly precision guidance system) to dodge missile defence systems, making them difficult to track once launched.⁸¹ North Korea has also tested a new “multiple launch (four or more simultaneous launch-ables) guided rocket system” with manoeuvring capabilities launched on 31 July and 2 August 2019.⁸² All these new weaponries can neutralise, overwhelm or outmanoeuvre current Japanese missile defence systems, necessitating their elimination while on launch pads.
- 4.30 On the future role of Japan’s space programme, whether it remains exclusively pacifist or not will be contingent on Japan’s top political leaders of the day and the domestic political balance of power in Japan’s liberal democratic system. Externally, it will also depend on the credibility of the US ally to extend its nuclear umbrella to Japan, and whether Tokyo is fearful of an existentialist/imminent threat from North Korea (and its new weaponries) and the security pressures on the entire Western alliance from a resurgent Russia/China down the road.

Working with Friends and Partners

- 5.1 JAXA is working with the Indian Space Research Organisation (ISRO) on a lunar mission while Kyushu Institute of Technology’s BIRDS project (Joint Global Multination Birds Satellite Project) is assisting Nigeria/Mongolia/Bangladesh/Ghana to launch their cube satellites on Falcon-9 rocket (June 2017) and through JAXA’s Kibo module from the ISS for Bhutan/Malaysia/Philippines/Costa Rica/Kenya in 2018.⁸³ Japan and India are also working towards a six-month moon mission in 2023 with Japan building the rocket and moon rover, and India constructing the lander that

⁸⁰ Sato, Yoichiro, “Missile defense in Japan after the Aegis Ashore cancellation”.

⁸¹ Kim, Dong-hyun, “Experts: N. Korea’s New Missiles Designed to Dodge Preemptive Strikes”.

⁸² Ibid.

⁸³ Vijaykumar, Anupama, “Japan’s rise as a space power”.

will touch ground in a perpetually bright area of the moon's south pole to search for water for future missions to utilise ice as rocket fuel.⁸⁴

- 5.2 The exploitation of outer space resources is also covered in the Japanese Basic Plan on Space Policy which stated that the Japanese private sector will assume more duties and responsibilities in space development. The Policy also calls for strengthened efforts in the use of Japanese space robots for the discovery of frozen water that can support human colonial settlers in a manned moon base, facilitate profitable mining ventures and asteroids mining that can eventually lead to the establishment of a moon base as an intermediate control station on a Mars mission.⁸⁵ In such mining ventures, the Japanese rover can drill into the moon surface up till approximately 1.5 metres, heat up extracted substances to gauge any changes in sizes of extracted substances and study the volatile substances in those moon samples.⁸⁶
- 5.3 In 2013 an MOU between Chiba University of Japan and the Sepuluh November Technology Institute Surabaya was signed to build Indonesia's fifth experimental microsatellite LAPAN A5 owned by the Indonesian space agency LAPAN.⁸⁷ Surabaya is Indonesia's high-tech hub and unofficial Silicon Valley and likely a regional tech powerhouse in the future.
- 5.4 In contrast, China and India are considered as space rivals with different developmental strategies. Commercially, China's rocket launches are targeted at developing economies like Nigeria, Venezuela, Sri Lanka and Pakistan while the United States, the United Kingdom and France have selected India's ISRO rockets to launch their satellites into space⁸⁸ though China and India have equal ambitions to capture the global communication satellite market. Currently, India is behind

⁸⁴ Bartels, Meghan, "Japan Sets Sights on Moon with NASA and India".

⁸⁵ Ryall, Julian, "Amid rivalry with China, Japan is aiming for the moon – and beyond".

⁸⁶ Bartels, Meghan, "Japan Sets Sights on Moon with NASA and India".

⁸⁷ Goh, Deyana, "Indonesia, Japan to develop world's first microsatellite with SAR".

⁸⁸ Kumar, Chethan, "After Asat, Where do India and China Stand" dated 29 March 2019 in the Times of India [downloaded on 29 March 2019], available at <https://timesofindia.indiatimes.com/india/with-asat-india-ups-its-game-in-space-race/articleshow/68612098.cms>.

China in the commercial launch market with capabilities to launch eight to 12 satellites annually, compared to China's 18 to 20;⁸⁹ however, India is seemingly determined to work with the West and Japan to catch up.

Future Capabilities

- 6.1 Tokyo intends to increase its US\$11 billion space programme by 200% in the coming 10 years. Part of the budget will be spent on landing Japanese/US astronauts on the moon by 2024 while the size of its outer space industry will also be increased to focus on extracting outer space resources.⁹⁰
- 6.2 Another capability that Japan is developing is in the area of microsatellites which could be constructed within two years, and are less than 100 kg in weight and relatively affordable (hundreds of millions of yen), making them more economical for Japanese start-ups to launch them.⁹¹ The Japanese-Indonesian LAPAN A5 in progress will be the world's pioneering microsatellite to install a Synthetic Aperture Radar that can work at frequencies in the range of 1-40 GHz and a wavelength of 1cm-1m.⁹²
- 6.3 In terms of near-future space robotics development, JAXA has the capability to supply more moon data to assist future US Artemis missions by working towards safer landings, especially with the use of JAXA's Smart Lander for Investigating Moon mission (ready in 2022) using cutting-edge precision lunar landing tech for enhancing manned and unmanned robotic landers.⁹³

⁸⁹ Kumar, Chethan, "After Asat, Where do India and China Stand".

⁹⁰ Ryall, Julian, "Amid rivalry with China, Japan is aiming for the moon – and beyond".

⁹¹ NHK, "The Forefront of Microsatellite Development *RERUN" dated 28 July 2020 in NHK [downloaded on 28 July 2020], available at <https://www3.nhk.or.jp/nhkworld/en/tv/scienceview/20200729/2015195/>.

⁹² Goh, Deyana, "Indonesia, Japan to develop world's first microsatellite with SAR".

⁹³ Patelarchive, Neel V, "Why Japan is emerging as NASA's most important space partner".

6.4 Japan will be dispatching some scientific payloads on Artemis 1 (an unmanned space mission round the moon) and Artemis 2 (manned space craft).⁹⁴ The United States is tapping into Toyota's expertise to build a pressurised RV-like lunar rover that will be ready by 2029 for manned cruises round the moon and recyclable for future missions.⁹⁵ Japan's foothold in the space industry hence looks bright and optimistic.

⁹⁴ Ibid.

⁹⁵ Ibid.