Exploring paths towards improving Taiwan's space force

Research Report[1]

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Table of contents

Introduction

Taiwan's political, economic, military and geopolitical interests in space have gained a new significance and urgency amid the shifting security environment in the Indo-Pacific. The topic of becoming a power in space is relevant to the temporary debate on how countries can gain resilience and ensure their own security, in particular if threatened by a major power. This case thus applies in particular to the Republic of China (ROC, Taiwan). The People's Republic of China (PRC) claims the island-state Taiwan and has been ramping up pressure in recent years as the Chinese government is attempting to change the status quo across the Taiwan Strait. The Chinese tactics, also known as grey zone tactics, range from extensive military maneuvers, applying political and economic pressure, to disinformation campaigns and cyber-attacks.

After winning Taiwan's presidential election, William Lai Ching-te from the ruling Democratic Progressive Party (DPP) officially took office on May 20. Over the past months, Beijing fiercely criticized Lai's inaugural address and conducted military drills and patrols around Taiwan to an extend never seen before, and in a bid to "punish" Lai for failing to heed China's preferred positions. All signs point to increasing Cross-Strait tensions over the coming years, and a continuation if not widening of Beijing's grey zone activities.

The space arena too has become an essential domain for China's grey zone activities today. For instance, Mainland's Navigation Satellite System Beidou has already been and can be used to influence Taiwan's communications. Meanwhile, China's Yaogan satellites system, which refers to its military reconnaissance satellites, already monitors aircrafts passing over Taiwan.[3]

China would also have the capability to interfere or destroy a Taiwanese satellite. Experts in the United States have long warned of this capability, as highlighted in a 2023 NBC news report[4]: "China's rapidly growing arsenal of anti-satellite weapons could cripple America's military in a crisis." According to Defense Department officials and experts quoted in this report, "China is testing and developing an array of weapons and tools that could destroy, disable or hijack satellites that the U.S. military heavily relies on to operate around the world". It further warns that "one of the potential challenges for U.S. space forces is a Chinese satellite equipped with a robotic arm that can pull an adversary's satellite out of orbit." In addition, "China has been working on missiles — launched from the ground or in space — to take out enemy satellites or the ground stations that launch them. Beijing also is developing ground or space-based high-powered lasers to destroy or damage enemy satellites."

China's anti-satellite capabilities pose a threat of an attack on GPS in particular. Dana Goward, president of the Resilient Navigation & Timing Foundation, and Martin Faga, former assistant secretary of the United States Air Force, noted recently that China would also be able to damage GPS satellites or deny GPS signals by using its timing (PNT) systems. The authors point out: "Its (China's) terrestrial PNT broadcast network covers

[3] Yaogan satellites are largely known to primarily support the People's Liberation Army's Strategic Support Force (PLASSF).

[4] Courtney Kube, Dan De Luce, "How China is challenging the U.S. military's dominance in space", in: *NBC News*, 13.12.2023, How China is challenging the U.S. military's dominance in space (nbcnews.com).

up to 1,000 miles offshore, including the Straits of Taiwan", which services can still be used "even when its multiple space-based assets are unavailable".[5] Subsequently, Goward and Faga suggest for Taiwan to become part of an allied regional terrestrial PNT broadcast network.

The Russian war of aggression against Ukraine has also had an impact on the strategic thinking of Taiwanese experts and decision-makers on national and defense issues. It is becoming evident that Taiwan has to defend itself already today against Beijing's attacks in a grey zone, but also prepare for different military escalation scenarios. The goal to enhance Taiwan's satellites capacities and expand its networks is part of this preparation, namely to prepare for a disruption of Taiwan's communication systems.

The development of communication technologies gained attention after Ukrainians were able to access the Internet through Space Exploration Technologies Corp (SpaceX) CEO Elon Musk's Starlink satellite service. Ukraine has internet access despite its infrastructure being severely damaged in the war with Russia. Based on the need for access to independent internet, and inspired by the extent to which Ukraine has been able to rely on the Starlink constellation while defending its territory from Russian forces, the Taiwanese Space Agency (TASA) announced in December 2022 that it is planning its own low-Earth orbit (LEO) satellite communications project. Taiwan would benefit from a Starlink-like capability, in particular because the country's communication network relies on undersea cables that could easily be the targeted in an attack.[6]

Taiwan has already made significant advancements in developing its space industry and technologies in recent years, the most prominent space technology being the FORMOSAT satellite series. However, amid high tensions in the Taiwan Strait and the security challenges stemming from China's current grey zone activities, there are also increasing concerns about Taiwan's lack of resilience in space.

During her last term, President Tsai Ing-wen has therefore placed space development as one of the Taiwanese government's top priorities, as demonstrated by the passing of the Space Development Act and a plan to invest US$906.62 million in the space sector over the next decade. Among other goals, Tsai placed space technology at the heart of Taiwan's industrial development plans through enhanced academia-industry-government collaboration. Tsai thus underscored the government's commitment to developing legal frameworks, allocating budgets, and creating a favorable environment for the space industry, by which the country could cement its position in global supply chains. This policy is being carried-on by president Lai Ching-te.

Improving Taiwan's capabilities in space would reduce strategic imbalances further. The question that this author's research aimed to tackle is how Taiwan can improve its resilience via space. Against this backdrop, this report identifies the key achievements made by both, the PRC's as well as Taiwan's space program, leading to the conclusion that Taiwan can only make further major steps in reducing strategic imbalances by expanding its collaboration with international partners.

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[5] Dana A. Goward and Martin C. Faga, Defending Taiwan by countering *China's biggest threat*, Opinion in: Space News, May 22, 2023.
[6] See Larry Press, *China and Taiwan Recognize Starlink's Military Value*, in: CircleID, 24. April 2023

China's space program development

The People's Republic of China (PRC) of today is a space faring nation on par with only the United States. From the low to the high orbit, China has developed into a major space power. The Chinese leadership, led by President Xi Jinping, has more ambitions yet. The PRC's ambitions in space exploration are laid out in a number of policy documents, including most notably and recently, the fifth white paper on space, published at the beginning of 2022 by the State Council Information Office of China.[7]

The paper reflects President Xi Jinping's speech at the 20th Party Congress in October 2022, in which he articulated that China should establish itself as the foremost "space power" by 2045 as part of China's overarching vision. The White Paper laid out China's goals, which range from developing its space transportation capabilities, testing new technologies, to embarking on exploration missions, modernizing space governance, enhancing innovation and boosting international cooperation. In short, the scope of the PRC's activities has expanded from low Earth orbit to the Moon and to Mars.

In domestic politics space has become a key component of the Chinese Communist Party's legitimacy. Outwards, space power has become integral to China's strategic competition with the United States. Due to the military nature in pursuing its objectives in space, China's increasing high-profile activities in space have also led to increasing security concerns by the United States and its allies. Indeed, the PRC is increasingly pursuing a policy of projecting its strategic military powers into space.

The China National Space Administration (CNSA) is the governing body of civil space activities, equivalent to NASA, responsible for civil space administration and international space cooperation, but not executing the space program. The China Manned Space Engineering Office, which reports to a major unit within the Central Military Commission (CMC), oversees astronauts (China's manned space program). The People's Liberation Army (PLA) is therefore directly involved in all aspects relating to China's space program, including satellite communications, tracking and guidance systems, rocket design, hypersonic flight and the development of space and lunar stations. The PLA's direct involvement across the Chinese space program means that technologies used for spaceflight and spacecraft could be applied to weapons like intercontinental ballistic missiles, for instance.

Due to the military nature of China's space program, it is thus little surprising that the program is largely driven by state actors. China has been seeking to encourage its commercial space sector as well, which indeed has grown following the opening up of the space sector to private investment in 2014,[8] and made some important breakthroughs (e.g. in satellite launch).[9]

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[7] State Council Information Office of China (国务院新闻办公室) (2022), *China's space program in 2021*, https://www.gov.cn/zhengce/2022-01/28/content_5670920.htm.

[8] National Development and Reform Commission (2015). Document 60 (国发〔2014〕60 号). https://www.ndrc.gov.cn/xxgk/zcfb/ghwb/201510/W020190905497791202653.pdf.

[9] Since 2014/2015, more than three hundred commercial space corporate entities have been established. See Han, Y., Chen, Z., Hu, Y. *et al.* (2023), https://doi.org/10.1057/s41599-023-02274-w, https://www.nature.com/articles/s41599-023-02274-w.

However, due to the sensitivity of China's space program, the private sector remains under state control and a mere appendix to the state-owned space industry. This has been exemplified by the competition for contracts for low-cost cargo supply to the Chinese LEO space station, where all of the four groups selected for the second stage of the process belong to state-owned entities.[10] For the unforeseeable future, China will continue to rely on state-owned enterprises to develop its space programs, with private actors only having minor roles.

Key achievements

China conducts one of the highest numbers of orbital launches each year, and operates a satellite fleet consisting of a large number of communications, navigation, remote sensing and scientific research satellites. According to a United States space force official in an interview in May 2024, "Since the inception of China's military space arm in 2015, the country has seen an 550 percent increase in on-orbit assets"[11]. The launch of its first satellite, Dong Fang Hong 1 in April 1970, aboard a Long March 1 rocket, made China the fifth nation to place a satellite in orbit. Today's third generation of the Beidou navigation satellite system provides full global coverage for timing and navigation along with GLONASS (Russia), Galileo (Europe), and GPS (United States). Beidou also plans a ground station in Antarctica, which could be used for military purposes, including as a precision missile tracking station with global range.

Another achievement includes the completion CHEOS high-resolution Earth observation systems, which aims to build an Earth observation system with high spatial, temporal and spectral resolution in an all-round way. China completed all satellite launch tasks by 2020. The earth observation data collected is used for disaster response and prevention, resource survey, and environmental monitoring. In late 2023, China launched the Yaogan-41 satellite into space and sent into geostationary orbit (GEO), unlike most other satellites into low-Earth orbit (LEO).

According to the Chinese government, the civilian high-altitude optical remote-sensing satellite is intended for crop yield estimation, environmental management, weather forecasting, and disaster prevention. However, as CSIS Expert Clayton Swope notes, "Yaogan-41's increased resolution means that China will be able to more easily identify and track U.S. and allied naval forces in the Indian and Pacific Oceans than it ever could before."[12] This would include surveillance of the Pacific and Indian Oceans, as well as Taiwan and Mainland China. According to Swope, "Western observers assess that Yaogan-41 is primarily a military reconnaissance satellite".[13]

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[10] CMSA (2023). Announcement of the preliminary results of the solicitation for the overall plan of the low-cost cargo transportation system for the China Space Station, https://www.cmse.gov.cn/gfgg/202309/t20230925_54351.html

[11] Audrey Decker, "Chinese satellites are breaking the US 'monopoly' on long range targeting", in: *Defense One*, 2.5.2024, Chinese satellites are breaking the US 'monopoly' on long-range targeting - Defense One.

[12] Clayton Swope, *No Place to Hide: A Look into China's Geosynchronous Surveillance Capabilities*, Washington DC: Center for Strategic & International Studies (CSIS), *Critical Questions,* 19.1.2024, No Place to Hide: A Look into China's Geosynchronous Surveillance Capabilities (csis.org).

[13] Ibid.

With the launch and docking of Shenzhou 15 with the Tiangong space station in November 2022, the CMSA successfully completed all three planned steps of its manned space program. China is thereby the third nation to achieve human spaceflight (after the Soviet Union/Russia and the United States). The construction of the Chinese Space Station officially began in April 2021, with 11 planned missions, which included three module launches, four crewed missions, and four autonomous cargo flights. Since 2022, China has been sending regular, three person crews to Tiangong for roughly six-month-long missions.

China's lunar exploration program has furthermore notable achievements show for. The lunar program started in the late 1990s and envisaged three main stages of development:

- Orbiting around the Moon: Chang'e-1 (2007) & Chang'e-2 (2009)
- Landing on the Moon: Chang'e-3 (2013) & Chang'e-4 (2018)
- Returning Samples from the Moon: Chang'e-5 (2020) and Chang'e-6 (2024).

The PRC has so far conducted the Chang'e (named after the legendary goddess of the moon) series successfully, including the recent demonstration of sample return capabilities. China has now opened a new phase of its lunar exploration program, with the Chang'e-6, 7 and 8 robotic missions to scout the lunar south pole area. On 25th June 2024, China's Chang'e-6 lunar module returned to Earth, after having successfully completing its historic mission to collect the first ever samples (moon dust and rocks) from the lunar far side.

China has also embarked upon an ambitious plan aimed at landing a taikonaut on the moon by 2030 and leading the development of building an International Lunar Research Station (ILRS). The ILRS has been conceived as a complex and multi-purpose experimental research facility to be built on the surface and in the orbit around the Moon, capable of sustaining a (semi)permanent human presence on the lunar surface. Its development is slated to occur over the next 15-20 years.

The lunar south pole, where China and also the United States plan to build a base, is a region believed to contain water ice. The Moon has re-emerged as a key target for human space exploration activities amid the great power rivalry between China and the United States. This rivalry for the moon and in space includes a race to becoming the normative power in space.

Finally, the core of Planetary Exploration of China is a complex mission to collect Mars rock samples and deliver them to Earth by building on the successes of recent moon and Mars missions. The Tianwan-1 mission had been inserted into Mars orbit in February 2021, followed by a successful soft landing of the lander and Zhurong rover shortly after. The Tianwen-2 mission could launch as soon as 2028 with the goal of returning samples around 2030. Key technological research is envisaged to further include Jupiter missions.

Taiwan's space program development

Taiwan's space program development went through four stages so far: In its *first stage*, from 1969 to the 1990s, the focus of Taiwan's space development was on missile and radar systems, as well as systems integration for ROC military aircraft and ships, represented by the formal inauguration of the National Chung-Shan Institute of Science and Technology (NCSIST) in 1969. The NCSIST was also, and remains, active in military construction. In 2014, NCSIST was transformed into an administrative corporation by the government.

The *second stage*, between 1991-2006, is more known as the first phase of the "Space Technology Long Term (15 years) Developmental Program", which was approved by the Executive Yuan in 1991. This stage laid the foundation for indigenous space technologies by fostering the talent and skills needed. Also in 1991, the National Space Organization (NSPO) was created, which was tasked with overseeing the implementation of the Taiwanese space program, i.e. developing space technology and industry throughout the following phases of the program.

During this phase, the program was dedicated to building Taiwan's capacities in satellite manufacturing, including bus and payloads, through technology transfers with the United States concerning FORMOSAT-1 and -3, and France (FORMOSAT-2). The FORMOSAT-3/COSMIC constellation, with the United States, put Taiwan's first weather satellite constellation into orbit, comprised of six micro-satellites. Several Taiwanese companies, such as Victory Industrial Corp., Acer Sertek Inc. and Shihlin Electric & Engineering Corp., were involved in the process so as to build indigenous capacities.

The *third stage* from 2004 to 2008, focused on the FORMOSAT-5 and 7 programs. FORMOSAT-5 was Taiwan's first domestically researched and produced high-resolution remote-sensing satellite and marked a turning point of Taiwan's space program. FORMOSAT-7 was developed again in cooperation with the United States. So far, Taiwan has launched 15 satellites between 1999 and 2019, including FORMOSAT satellites 1,2,3,5,7. FORMOSAT 5, and 7 are still in service.

Starting in 2018, Taiwan has entered its *fourth and current stage* (or third phase) of space development, focusing of the diffusion of space technologies, including setting up a space industry, increasing satellite launches, as well as implementing the 10-year National Space plan. According to the Department of Information Service of the Executive Yuan, "an estimated NT$25.1 billion (US$836.8 million) will be invested throughout the decade to push domestic space technology to new heights and meet the challenges of cutting-edge space missions. The program also aims to extend and spread the benefits of the space technology industry, nurture space technology talent, and build a space industry supply chain of Taiwan's own."[14]

In addition, the Space Development Act, which is Taiwan's first law governing space activities and promoting space industry development, was implemented in January 2022, while a national space center establishment act was promulgated in May 2022,

[14] Department of Information Services, Executive Yuan, *Pushing the development of space technology*, 2022-08-02, https://english.ey.gov.tw/News3/9E5540D592A5FECD/46f4d4cc-ccea-4d22-874e-ecb93e5cf1b8 (accessed 20.6.2024).

demonstrating the government's active promotion of space technology capabilities through legislation and the establishment of a dedicated space agency.

Through the establishment of national research institutes in key fields, Taiwan has since tried to attracting the talent the industry needs, while also continually strengthening the partnership between the government and the private sector. Essentially, the government has been and continues to bring Taiwan in line with the most advanced international research and technology in space.

Increasing international cooperation is a must for Taiwan to achieve its goals. Taiwan's ability to reach for the moon, for instance, illustrates the benefit of such synergies. With foreign partners, Taiwan plans to develop a satellite to be placed in orbit around the Moon. And beginning of 2024, Taiwan's National Central University announced the country's first international moon-landing mission, which includes the faculty developing a Deep Space Radiation Probe (DSRP), which was subsequently launched in Japan during the fourth quarter of this year.

Key goals of Taiwan's space development

The fourth phase of Taiwan's space development is much larger and more ambitious than the phases before. Key goals of Taiwan's present and future space development are to establish comprehensive space core competences, which range from sending scientific payloads to the moon, likely around 2026, to implement CubeSat projects, as well as to develop a space industry. One of the most important and prominent goal is set to establish Taiwan's competence to launch satellites, one per year, to be precise.

Satellites

Taiwan's space development has seen an increasing urgency to focus on the ability to launching satellites, because satellites today serve as tools for national security, emergency response, and environmental monitoring, making their development the primary focus of Taiwan. Between 2023-2028, the Taiwan Space Agency (TASA), up until 2023 known as the NSPO, plans to launch the Triton satellite, FORMOSAT 8, FORMOSAT 9, and the B5G LEO Communication Satellite successively. Ten remote sensing satellites are expected to be built in the future. According to the implementation strategy, TASA plans to launch the first and second satellites of FORMOSAT-8 in 2024 and 2025; the third and fourth satellites are then to be launched in 2026 and 2027 (FORMOSAT-9); the fifth and sixth satellites in 2028 and 2029. FORMOSAT-9 will be the first Synthetic Aperture Radar (SAR) satellite in Taiwan's history.[15]

Developing national industrial capability to build Beyond 5G (B5G) communication satellites constellation similar to Starlink is another key part of Taiwan's space program. The goal is to develop high-efficiency LEO communication satellites. It integrates industry-university-research to develop high-performance phased array antennas, wide-bandwidth radio frequency circuits, high-speed digital signal processing and other technologies for communication payloads. B5G is to serve both for national security as well as commercial purposes.

The first B5G satellite was to be launched in 2026, followed by another in 2028. However, TASA has confirmed that the payload design would require more time, thus the first B5G satellite payload would be procured from overseas suppliers through bidding in August 2024, with the launch of the first B5G satellite delayed to 2027. The second B5G satellite, the payload of which will still be supplied by ITRI, would then stick to the 2028 launch schedule. Despite its early successes, Taiwan is at an experimental development stage in its efforts to build new indigenous communication satellites. A Starlink-like constellation would give the Taiwanese state independent access to internet, for instance, in case of a Chinese invasion.

However, experts caution that Taiwan would need hundreds of satellites to establish a comprehensive backup internet access system. As Brad Tucker, an astrophysicist at Australian National University, estimated in a CNN interview, for instance, that Taiwan would need at least 50 satellites to provide "fairly decent" emergency coverage with its

[15] See TASA Space Missions, TASA | FORMOSAT-9 (accessed 20.6.2024).

own satellite constellation.[16] There is also the issue of the high-costs of rockets needed to launch the satellites. Most Taiwanese satellites are launched in the United States. In the past year, Taiwanese research and weather satellites have been launched by the French company Arianespace, as well as SpaceX.

Besides tasking TASA with the satellite project, the Taiwanese government also established a digital affairs ministry in 2022 in order to boost communication resilience. This ministry is, among others, tasked to establish partnerships with overseas satellite service providers and installing new terminal equipment in remote locations of Taiwan to provide connectivity. By the end of 2024, 700 hot spots are meant to be established as to allow for satellite communications during emergency situations.

While Taiwan strives to establish Taiwan-made and -controlled satellite networks, it still needs to access existing satellite networks, which consequently requires international cooperation. As of today, the island has access to satellite signals from Luxembourg-based satellite operator SES as well as from European satellite provider Eutelsat OneWeb.[17] By partnering with more existing satellite communication systems (and also maritime satellite systems), Taiwan could enhance its communication resilience significantly.

Space industry

Just as Taiwan had mastered electronic manufacturing and moving to developing the most advanced semiconductors today, there may be great potential for a thriving space industry in the future. Consequently, the Taiwanese government set the goal to promote the private sector's engagement in the space industry, for instance by assisting private companies in launching satellites.

Presently, more than 40 Taiwanese companies are making parts in the satellite supply chain.[18] With more satellites to be launched into orbit, the more companies will hence be able to test their technology in orbit. Taiwan space industry analyst Aurélie Gillet writes that the island "may soon become a key player in the global space ecosystem." [19]

While Taiwan's space ambitions have been limited to niche technologies, Gillet explains that "the unique development model applied to the Taiwanese space industry has already seen tangible positive consequences, with selected electronics manufacturers having become SpaceX suppliers for example; it is also very likely to enable Taiwanese electronics manufacturers to move up the scale of the global space industrial chain in the near future. Taiwanese commercial space companies, while only emerging, may also benefit from enhanced state support in view of Taiwan's political will to carve a

[16] Eric Cheung, "Developing Taiwan's own 'Starlink' crucial for island-wide emergency, space agency says", in: *CNN*, 4.5.2024, Developing Taiwan's own 'Starlink' crucial for island-wide emergency, space agency says | CNN.
[17] Jake Chung, "Digital ministry touts satellite signal progress", in: *Taipei Times*, 11.6.2024, https://www.taipeitimes.com/News/taiwan/archives/2024/07/11/2003820652
[18] I, in: *New York Times*, NYT 2024: Taiwan Is Building a Satellite Network Without Elon Musk - The New York Times (nytimes.com)
[19] Aurélie Gillet, "Taiwan: A Serious Up-and-Coming Player in the Space Industry", in: *Satellite Markets*, 2022, https://satellitemarkets.com/news-analysis/taiwan-serious-and-coming-player-space-industry.

niche in an up-in-coming industry - despite existing political tensions with China, especially when it comes to the launch sector."

According to Gillet, "Taiwan's space industry seems to have been rather successful in enabling commercial companies to set foot in the global space industry supply chain. Such companies that provide components for SpaceX, for instance, include Microelectronics Technology Inc., which also developed FORMOSAT-1's Experimental Communication Payload (ECP), or WIN Semiconductors Corp."[20]

Subsequently there may be potential synergies between the semiconductors and space industry. Digital Marketing analyst Malika Ajarapu pointed in a recent article out, that semiconductors are a critical component of aerospace technologies.[21] According to her, semiconductors enable "essential functions such as communication systems, navigation systems, avionics controls, and more. They provide high reliability even in harsh environmental conditions encountered during flight - from extreme temperatures to vibrations and radiation exposure." And further: "Semiconductor technologies play an integral role in satellite communication networks, earth observation missions and deep-space exploration endeavors. The need for reliable semiconductor components designed specifically for space applications opens up significant opportunities within this segment of the market."

[20] Ibid.
[21] Malika Ajarapu, The Growing Role of Semiconductors in the Aerospace Industry, via LinkedIn, 7.7.2024, https://www.linkedin.com/pulse/growing-role-semiconductors-aerospace-industry-malika-ajarapu-nuktc.

International cooperation

While TASA's outreach to international partners has reached a new dimension due to the urgency to develop alternative and independent internet access for the island, Taiwan has a long even though modest history of international cooperation.

As pointed out in DigiTimes recently, "In fact, when it comes to satellite communication, Taiwanese armed forces have been relying on the geostationary satellite ST-1, later succeeded by ST-2, from 1998 on. ST-1, jointly operated by Singapore Telecom and Taiwan's Chungwha Telecom, was de-commissioned in 2011, and its successor ST-2 is expected to be replaced in 2029. In early 2023, Chungwha Telecom revealed the intention to cooperate with Singapore Telecom on ST-X, the successor to ST-2, and relevant work will begin in 2026."[22]

Today, TASA actively participates in international collaborative projects, including those with the United States and Japan, among others. Especially successful is the GNSS-R weather monitor program with the United States, where Taiwan used its constellation to monitor the changes of the weather through data variation of radio waves from GNSS satellites. The FORMOSAT-7 project received involvement and resources from the National Oceanic and Atmospheric Administration (NOAA, US), an increased number of satellites, and upgraded electronic wave receivers. Future cooperation between Taiwan and the United States in space could include developing Formosat-8 and other satellite missions, establishing manufacturing bases in Taiwan, exploring deep space in partnership with National Aeronautics and Space Administration (NASA); and promoting space education and cultivating Taiwanese astronauts.

In March 2024, a bipartisan group of American lawmakers introduced a bicameral bill to authorize cooperation between the NASA and Taiwan's national space agency on civilian projects. According to Republican Representative French Hill, one of the bill's co-sponsors, the Taiwan and America Space Assistance Act of 2024, also known as the "TASA Act," would seek to remove restrictions currently imposed by the US government's "one China" policy. Passing the Act would allow the United States to cooperate with Taiwan on civilian space activities, including satellite, space exploration, and atmospheric and weather programs. The TASA Act has also been sponsored in the United States' Senate by Republican Eric Schmitt and Democrat Tammy Duckworth.

In addition, Taiwan is looking to strengthen cooperation with Japan. Cooperation on FORMOSAT-5, which was launched in 2017, included Canada and Japan, and for the microsatellite RISESAT, developed by Tohoku University in Japan and launched in 2019, Taiwan provided an instrument. There is hope in Taiwan, to expand scientific and other cooperation further with Japan, as President Lai Ching-te has also stressed recently.[23] Notably, in February 2024, Taiwan's National Central University (NCU) handed over its

[22] Misha Lu, "Are Taiwan's own LEO satellite programs combat-ready?", In: *Digi Times* 14.5.2024, https://www.digitimes.com/news/a20240513VL205/b5g-defense-leo-moda-satellite.html.

[23] Lai stated on 20th August 2024, "Taiwan hopes to work with Japan and other democratic partners to address the threat of authoritarian expansion", see "Lai urges collaboration with Japan in face of authoritarian threats", in: *Focus Taiwan*, https://focustaiwan.tw/politics/202408200029.

Deep Space Radiation Probe to the Japanese company ispace Inc, ready for it to become the first piece of Taiwanese technology to go to the moon.

Cheng Tzu-chen, a professor in Chinese Culture University's Department of Political Science, highlighted in March 2024 the benefits on cooperating with Japan on space. First, because Japan is one of the few democratic countries in East Asia with launch sites and with the success of Japan's H3 launch, Taiwan could partner with Japan on satellite launches. Second, Japan has initiated some systemic changes to develop its space industries (passing the Basic Space Act in 2008, the Space Activities Act and the Satellite Telemetry Act in 2016, and the Space Resources Act in 2021), therefore, Cheng writes, "Using Japan's space development as a guide, Taiwan can draw lessons from its legislative moves, regulatory loosening and private participation incentives. Taipei can also extend exchanges with Japan through "space diplomacy" — increasing dialogue on the economy, trade, security and technology."[24]

In addition, India appears as an upcoming partner for Taiwan's space development program, as the Taiwan Space Industry Development Association (TSIDA) and the SatCom Industry Association (SIA-India) signed agreement for information sharing, and commercial cooperation in 2022. That same year, INSPIRESat-1, a microsatellite jointly developed by Taiwan, the United States and India, had reached its mission orbit. The constellation was launched from Satish Dhawan Space Centre in India and the satellite carried payloads funded by Taiwan's National Central University and US-based National Aeronautics and Space Administration. The project also marked the first time a Taiwan academic institution has collaborated with the Indian Space Research Organization.

End of 2023, India representative to Taiwan Manharsinh Yadav, emphasized that India and Taiwan should play off each other's complementary strengths, "as Taiwan looks to expand its service sector alongside its manufacturing growth, and as India moves to boost its industry growth together with its service sector, the two countries can use their strengths to "help each other".[25] He highlights India's space industry as a promising field for bilateral cooperation, as the formulation of a new space policy has facilitated the private sector's research across the space economy, including launch vehicles, satellite development, satellite launching, communications, and remote sensing.

Another added value would be the cheap launch of satellites in India and its experience in launching foreign satellites. Taiwan's niche competence in space technology would in turn be attractive to India, in particular Taiwan's optical sensors and its semiconductor chips, which are used by every space-faring nation to get their satellites up into orbit. Indian space startups have already participated in an incubation program hosted by Taiwan Accelerator Plus in partnership with the Ministry of Economic Affairs and other organizations.

However, TASA's goal in concluding partnerships is more ambitious yet. The current list of international cooperation partners includes Sentinel Asia, Japan, Thailand, Philippines, the United States, Paraguay, the United Kingdom, France, Slovakia and possibly Poland. In

[24] Cheng Tzu-chen, "Benefits of working with Japan on space", in: Taipei Times, 6.3.2024, https://www.taipeitimes.com/News/editorials/archives/2024/03/06/2003814506.
[25] Kelvin Chen, "Taiwan-India ties center on 'complementary strengths': India envoy", in: *Focus Taiwan*, 12.12.2023, https://www.taiwannews.com.tw/news/5058014.

particular in Europe, there are a number of future collaboration projects that seem promising for Taiwan.

Europe

The respective representatives from Taiwan have entered regular discussions with the United Kingdom and France on topics of satellite technologies, launch capabilities and industries. Discussions were launched also with Germany on SAR-satellite technology and launch vehicles, and there may be further dialogues with Poland and Slovakia.

TASA works already quite closely with the United Kingdom's Space Agency. In June 2023, TASA's director Professor Wu met the CEO of the UK Space Agency, Paul Bate, to exchanged views on the cross-field integration of space technology and the future direction of space exploration. The UK Space Agency also established an International Bilateral Fund, which is dedicated to building and strengthening international relationships to develop cutting-edge technologies that will advance the United Kingdom's global space capabilities. For instance, satellite manufacturer In-Space Missions will work with a dedicated regional Asia-Pacific Government collaboration (incorporating Singapore, the Philippines, Taiwan, Thailand and Indonesia) to develop Faraday Dragon, a multi-agency accelerator program that will ease the export of novel space technologies and access to space via rideshare missions. This could be seen as another step to strengthen collaboration with Taiwan in the space arena.

Another opportunity is presented by the UK Science and Innovation Network Taiwan (SIN Taiwan), which promotes strategic collaboration between Taiwan and the UK on key science and innovation themes. The small SIN team in Taiwan, based in the British Office Taipei, is set to cover a broad range of themes, among them also space.

Taiwan has also been seeking to build cooperation with Germany and France on space technology, and had sent a delegation of the National Science and Technology Council (NSTC) to Europe in 2022, to explore that possibility. In March 2023, during the visit of German Federal Minister of Education and Research Bettina Stark-Watzinger to Taiwan, the first visit by a German minister since 1997 to the island, the two countries then signed their first Scientific and Technological Cooperation Arrangement (STA). There is hope that more cooperation will materialize with Germany, in particular because launch vehicles are an area of Germany' strength and Taiwan in turn plans a launch facility.

Also in 2023, Taiwan and France signed a Science and Technology Cooperation Convention (STC), which was set to strengthen collaboration focusing on six key areas, space technology. These science and technology cooperation agreements have in addition only been signed with the United States and Australia. It should also be noted that the launch of Taiwan's first locally produced weather satellite, named Triton (Wind Hunter in Chinese), was sent into space in October 2023 aboard a Vega rocket made by French launch company Arianespace.

Special attention should be paid the strengthening ties between Taiwan and Central European countries in recent years, in particular Poland. Deepening cooperation is touching upon the space dimension as well, illustrating the potential synergies that exist between Taiwan and Europe in the area of space. For instance, in January 2022, Taiwan announced the creation of the Central and Eastern Europe Investment Fund with capital

of $200 million to support companies in strategic sectors such as semiconductors, fintech, laser optics, electric vehicles, as well as space.

Poland has been strengthening its relations with Taiwan in the areas of semiconductors in particular. In June 2023, Polish MPs visited, among others, the Hsinchu Science Park, the Semiconductor Research Institute, and the National Space Organization, and participated in talks on cooperation in the parliamentary and technological dimensions. During the MSPO 2023 Exhibition in Kielce, Poland, Polish Chamber of National Defense Manufacturers signed a Memorandum of Understanding with the Taiwan Defense Industry Development Association (TW-DIDA) and the Taiwan Aerospace Industry Association (TAIA). The goal of signing these MOUs was to intensify cooperation between Polish and Taiwanese defense industries.

There may also be some potential opportunities for satellite industrial cooperation, which is an area of strategic interest for both Poland and Taiwan. Poland plans to launch EagleEye, the first satellite designed and built in Poland and also its most advanced and largest, in 2024 for high-resolution earth imaging. In 2025, Poland also plans to launch its first military observation satellites. As a recent DigitTimes article highlighted, there is an opportunity for Poland to build capabilities together with partnering nations, such as Taiwan.[26]

The article quotes Maciej Nowakowski, Director of Operations at the Polish Technological Forum on Photonics (PPTF)[27]: "So far, cooperation with Taiwanese companies is largely confined to simple 'buy and sell', while Polish companies are more interested in actual industrial cooperation in terms of 'building something together based on Polish or Taiwanese components'". And further: "Building capabilities together and developing a technology that will be manufactured both in Poland and Taiwan would be more in line with our needs, instead of buying key components in Taiwan and building important systems upon them."

This view of the necessity to explore more collaboration on space issues with Taiwan as a necessity to meet the needs of European countries amid global security shifts, is spreading.

A 2021 report on behalf of the Netherlands Innovation Network in Taiwan illustrates the need to inform stakeholders, including companies, knowledge institutes and governments about relevant space policies, technologies and projects, which could stimulate knowledge intensive collaboration with Taiwan.[28] According to the report, "Taiwan and the Netherlands have gained complementary knowledge and technologies related to space. They could learn from each other's strategies - and try to implement each other's successes (while preventing the failures)."

Collaboration opportunities identified in this study include developing satellite communication devices; synergies on earth observation, which is the major task in

[26] Misha Lu, "From photonics to defense: more to be done for Polish-Taiwan industrial cooperation", in: *DIGITIMES Asia*, 3.7.2024, https://www.digitimes.com/news/a20240703VL206/aerospace-defense-poland-taiwan.html.
[27] Ibid.
[28] Will Ting, "Overview of Space Developments in Taiwan", the Netherlands Innovation Network at the Netherlands Office Taipei, August 2021, https://www.rvo.nl/sites/default/files/2022-06/Space%20Developments%20Report%20Taiwan.pdf.

Taiwan's Third Space Development Program, while the Netherlands has advanced technologies related to optical payload. Thus, high precision optical instruments could be a possible topic for collaboration between the Netherlands and Taiwan; as well as the area of Satellite Data Application (for agriculture and rainfall predictions).

The report concludes that "Taiwan's space industry has a good foundation with their own satellites, a strong position related to ICT and many products and services suitable for the supply chain in the space industry. The Netherlands on the other hand has a complete space industry ecosystem and has better conditions to attract talents in space. To make collaboration happen, it requires the complementation of technical capabilities, long-term interaction and trust, and more importantly, a clear understanding of the direction and positioning of each other's space industry."

Further studies and analysis on potential collaboration with international partners could reveal further specific areas of mutual benefit and would at the same time present opportunities for Taiwan to advance its space program. The importance of international collaborations in advancing Taiwan's space technology should not be neglected, such as partnerships with established spacefaring nations, research institutions, and private companies. This would not only benefit Taiwan's resilience and stability, but also increase the islands international footprint.

Conclusion

All in all, Taiwan's space program is no match for China's power in space. The Taiwanese launch capabilities are lagging both global and regional standards. While largely state-driven, China has become an important player in the space industry. Nevertheless, the Taiwanese space program has made significant progress in Earth Observation, remote sensing and space science in particular. Taiwan also has an edge when it comes to advanced technologies as a whole, which implies that also Taiwan's space program has much to offer in quality, rather than quantity. Quality standards will likely determine the Taiwanese space industry's future success in the international market.

More precisely, Taiwan has access to the entire supply chain with its mature precision industry and electronics as well as the 5G communications sector. This made Taiwan today a trusted partner in existing, sensitive supply chains involving companies from America, Europe, Japan and India. Its capabilities in advanced testing facilities, which are currently used for advanced medical purposes, could be moved for the use in space manufacturing.

One of the main challenges remains the complex geopolitical position due to Taiwan's relationship to Mainland China. This makes it is more difficult for space actors in Taiwan to collaborate with international partners and space organizations. International partners, which include space organizations, countries and companies alike, are often hesitant to collaborate with Taiwan due to their relationship with China. This, for instance, impacts the access to radio frequencies as well as knowledge sharing.

As Taiwan is not a member of the United Nations (UN), it needs to operate through other UN countries in order to launch a spacecraft, for instance, as a space station needs to undergo frequency coordination by the International Telecommunications Union (ITU), which is a branch of the United Nations. Likewise, orbital slots for satellites are also regulated by the ITU. Helping Taiwan to gain an albeit limited seat in international fora to be part of the agenda-setting in space would help improving Taiwan's capabilities in space as well as reducing strategic imbalances.

Through active participation in international collaborations, both, space faring nations as well as Taiwan, could benefit from knowledge exchange, technology transfer, and joint research initiatives. Increasing Taiwan's international participation would enhance Taiwan's visibility and facilitate collaborations with leading spacefaring nations and institutions. In particular, strengthening Taiwan's indigenous satellite development programs can only succeed in frame of international partnerships.

There is much that Taiwan could offer in turn. For instance, providing satellite images to the respective international institutions or organizations. This way, Taiwan could also contribute to disaster management across the globe.

No doubt Taiwan's space program needs to be viewed not only in context of Cross-Strait relations but also through the lens of the global strategic competition between the United States and Mainland China. The importance of collaborating together with Taiwan in the area of science and technology thus also presents an opportunity for the United States to shift the competition in its favor. This may be interesting in particular with view to the rivaling lunar initiatives by China, represented by the ILRS initiative, and the United States,

represented by Artemis. These initiatives are not only about putting boots on the moon first (once more), but, much more boadly, about becoming the main normative power in space.

China has signed various agreements with third countries consistently since 2021, as of July 2024 it apparently has attracted 10 countries to join its ILRS initiative. China also announced the creation of the International Lunar Research Station Cooperation Organization (ILRSCO) based in Hefei in October, 2023. Although not publicly depicted as such, the ILRS initiative can be understood as an alternative to the US-led Artemis programme. Meanwhile, the Artemis Accords, which elaborate on the norms expected to be followed in outer space, have been signed by 43 countries as of June 2024. Having Taiwan join Artemis would bolster the US-led initiative on the one hand, and help Taiwan implement its modest lunar projects on the other hand.

Besides the promising deepening of relations between Taiwan and the United States as well as other likeminded countries across Asia, it would be also sensible for Europeans to offer assistance to Taiwan as it tries to be part of international organizations' activities relating to space. Participation in international dialogues on space is often only possible for Taiwan if it is appearing under a different name.

Some first steps have been taken so far to enter into a broader dialogue with Taiwan. For instance, the May 2023 EU-Taiwan Space Opportunity Symposium, which convened leading players in Taiwan's satellite industry to explore cooperation opportunities with the European Union, is a good starting point for further collaboration.

In June 2024, a TASA delegation was then invited for the first time to join the 7th Prague Space Security Conference, held in Prague, Czech Republic, and organized by the Prague Security Studies Institute (PSSI). On this occasion, TASA's Director Dr. Wu expressed Taiwan's hope for alliances that transcend the influence of authoritarian regimes. In essence, Dr. Wu described one of the main issue Taiwan faces in the international flora, as he welcomed Taiwan's inclusion in international space affairs based on the shared values of peace and democracy.

European states could bolster collaboration with Taiwan in the area of space in particular among space industry actors, given that this sector is being expanded in Taiwan, as evident in the Cabinet's "Space Industrial Development Plan" in 2022, which combines the resources of the National Science Council, MOEA, the Ministry of Digital Affairs (MODA), the Ministry of Education (MOE), and other ministerial departments. All three targeted main axes for development, namely, industrial development promotion, talent cultivation, and advanced technology, are highly attractive to European space industry actors.

In Europe, the space industry is indeed currently witnessing a surge in activity and governments as well as companies alike are looking to bolster the industrial competitiveness and promote synergies with other space domains (e.g., industrial capability as part of security policy). In the European context alone, it has been estimated that the implementation of a major space exploration programme would generate a GDP multiplier effect of >5x the overall budget, with estimated benefits stemming from the

investment amounting to a cumulative GDP impact of at least €260 billion and an average of 90,000 jobs created between 2025 and 2040.[29]

It could therefore be beneficial to both sides to bring Taiwan's and Europe's innovative talents in space research and technology together. Such a talent program now already exists in the area of semiconductors in context of the investment by Taiwan's chip manufacturer TSMC, a global leader in the semiconductor sector, in Dresden. The "Semiconductor Talent Incubation Program" is a Saxon-Taiwanese program, which was jointly initiated by the Free State of Saxony, TU Dresden and TSMC. It includes a study program and practical training at TSMC. This program could serve as a model for future space-related talent programs.

There is no illusion among space actors in Europe that their domain has become increasingly important. As stated by the High-Level Advisory Group (HLAG) on Human Space Exploration, which was set up by the European Space Agency (ESA), in a report titled *Revolution Space 2023*: "space is undergoing a revolution comparable to the growth of the Internet 20 years ago. Like the Internet, the space revolution will affect all domains of life".[30] In short, from climate change to national security, passing through mobility, energy and connectivity, the already important contribution offered by space assets and services, such as in telecommunications, Earth observation or navigation, will become even more fundamental and all-pervasive. Given the significance of space technology to all these topics, it therefore only seems beneficial to Europe to work more closely with a likeminded partner such as Taiwan, and thereby also helping Taiwan to improve its resilience via space.

The topic of eliminating strategic imbalances, which are key to deterring military threats and ensuring regional stability, is gaining relevance as geopolitical tensions threaten the stability in the Indo-Pacific. Not least, because over the next years, Beijing will likely continue to probe Taiwan's implicit boundaries, seeking opportunities to advance China's political agenda and shift its political narratives to its advantage. As tensions rise, so does the risk of unwanted conflict. Increasing cooperation in such an important domain such as space will thus help Taiwan's leaders to further strengthen the island's democracy and resilience.

[29] ESPI/BCG, *More than a Space Programme: The Value of Space Exploration to Empower the Future of Europe*, 16.11.2023, https://www.bcg.com/publications/2023/italy-more-than-a-space-programme.
[30] High-Level Advisory Group (HLAG) on Human Space Exploration for Europe, *Revolution Space*, 2023, accessed 20 July 2023, at https://esamultimedia.esa.int/docs/corporate/h-lag_brochure.pdf.