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Full Report

Securing Japan

An assessment of Japan´s strategy for space

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1 Introduction

1.1 Background and rationales

For almost five decades, Japan has been the undiscussed space leader in Asia. The development of launchers and state-of-the-art satellite systems, ground-breaking exploration missions and its status as the only Asian country participating in the International Space Station (ISS) venture serve as evidence for Japan's prowess in the space domain.

Since the late 1990s, however, the country has been experiencing a prolonged "space crisis" regarding its strategic direction, management, and level of involvement in space activities. Affected by a decade of economic stagnation and political volatility known as "the lost decade" (*ushinawareta junen*), the political support of space endeavours stagnated and declined: the space budget hardly rose at all from ¥240 billion in 1997 to ¥250 billion 10 years later in 2007, ambitious programmes were drastically downsized, and the space industry entered a period of profound confusion. The string of major failures occurring since the mid-1990s (e.g. ETS-6 in 1994, EXPRESS in 1995, ADEOS in 1996, COMETS in 1998, launch failure of MTSAT in 1999) further underscored a diffuse sense of crisis. At the same time, the evolution of the post-Cold War geopolitical context required a difficult broadening of the activities pursued thus far, which ultimately put the country's space agenda at a crossroads[1].

The ever-growing attention paid to the concomitant ascendancy of China eventually contributed to a ubiquitous global perception of "a wave of *Japan passing*"[2]. This narrative has been particularly evident in the broader geopolitical and economic spheres, but the maxim about "China's rise, Japan decline" has been reflected also in the space arena. Landmark Chinese feats such as the flight of Yang Liwei in 2003, the 2007 ASAT test, or the launch of the first Chinese space laboratory Tiangong-1 in 2011 have for many signalled the passing of the baton to China in the space hierarchy of East Asia.

While these significant advancements have certainly contributed to diverting the focus of international headlines from Japan's ambitions in the space arena, this does not mean that Japan is no longer a protagonist of global space activities. Far from it. Since the enactment of the Basic Space Law in 2008, Japan's space programme has been quietly - yet firmly – undergoing a profound transformation aimed at conferring the country with the tools to reinvigorate its strength, prestige and autonomy in the international space arena. While the process is still ongoing, the key pillars of Japan's grand strategy for space have already emerged in many key policy documents.

Most commentators have rightly emphasized the increased militarization (or more properly normalisation) of the programme[3], yet failed to connect this transition with other substantive goals in the country's strategic profile[4]. A careful examination of Tokyo's strategic posture would reveal that the scope of this transformation is in fact much broader and far-reaching. Indeed, the Japanese space programme is an increasingly complex and multi-layered endeavour that is driven by a wide range of security, commercial and diplomatic considerations. It is hence important to disentangle all these dimensions and identify both the driving forces and objectives that are guiding Japan in its space efforts.

[1] Suzuki, K. (2008). Basic law for space activities: A new space policy for Japan for the 21st century. In: Schrogl, Kai-Uwe, Charlotte Mathieu, Nicolas Peter (eds). ESPI Yearbook 2006/2007: A new Impetus for Europe. Vienna: Springer.

[2] Pempel, T. (2007). The Pendulum Swings toward a Rising Sun. *Asia Policy, 4*, 188-190.

[3] Peoples, C. (2013). A normal space power? Understanding 'security' in Japan's space policy discourse. *Space Policy*, 135-143.

[4] Kallender, P. (2016). Japan's New Dual-Use Space Policy. The Long Road to the 21st Century. *Asie.Visions 88*.

In his renowned book, *Securing Japan*, political scientist Richard Samuels demonstrated how a "persistent and ubiquitous sense of vulnerability has shaped Japanese strategic culture"[5]. In Samuels' view, Japan decision-makers see a myriad of threats – coming from a rising China, the North Korean regime, its alliance with the United States (due to the possibility of entrapment and abandonment) as well as from Japan's own inability to maintain a competitive national economy and regional leadership – arguing that Japan is adopting a Goldilocks strategy, constantly striking a balance between opposite positioning; a strategy that will allow it to exist securely without being either too dependent on the United States (US) or too vulnerable to the threats emanating from the unstable neighbourhood[6].

Remarkably, an analogous line of reasoning can be observed in the space arena, an arena where Japan policy-makers have perceived the threats of an inflexible marginalisation and loss of regional leadership, hollowing of their industrial, technological and economic edge, and even abysmal challenges to the national security and survival emanating from the changing regional and international environments. To comprehensively respond these threats, the past ten years have witnessed the crafting of a multi-pronged space strategy that – premised on the maxims of strength, autonomy and prestige – is aimed at using space to secure Japan from these persistent vulnerabilities.

1.2 Objectives of the Study

The overarching objective of this study is to provide an in-depth investigation of the degree and nature of change in Japanese space strategy, to shed lights on the catalysts of this change and to suggest where Japan space efforts might be heading. To fulfil these objectives, this study will more specifically achieve the following:

- Provide a descriptive overview of the Japanese space programme, including:
  - the organizational framework
  - the policy framework
  - technical capabilities and programmes
- Analyse the evolution of Japan's space strategy, the country's current approach to:
  - Civil space efforts
  - Commercial space efforts
  - Security efforts, in the dimensions of security in space and outer space for security
- Examine the catalysts as well as tools/mechanisms to achieve objectives
- Investigate possible implications of this transformation

1.3 Methodology and Structure of the Report

The study has been primarily prepared on the basis of an in-house analysis featuring a literature review of publicly available documents, external and internal databases, conference proceedings and other bibliographic sources, spanning both space-related and general contributions in the area of Japan studies. The literature review has paid special attention to the sources in the Japanese language. In addition, the research has leveraged external contributions by relevant Japanese and international stakeholders, policy analysts and scholars in the form of preliminary discussions and feedbacks on the study, as well as interviews and expert meetings.

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[5] Samuels, R. J. (2007). *Securing Japan: Toyko's Grand Strategy And The Future of East Asia.* New York: Cornell University Press.
[6] Samuels, R. J. (2010). Japan's goldilocks strategy. *The Washington Quarterly*, 111-127.

A list of interviewees and external contributors is provided in Annex to this report. Finally, a peer review with experts was carried out to validate research findings before preparation of the final report.

In terms of process, the starting point of the report has been to identify the major pillars of Japan's space strategy. Towards this, the study first conducts a combined reading of all policy documents published by Japan over the past decade – which include laws and regulations related to space specifically but also broader security and industry related policies. On the basis of these documents, the major focus-areas and a set of objectives come to the fore, i.e. science & technology, the space industry and space security. The report then shows that these three main pillars of the space programme and the corresponding objectives prove to be highly interrelated – together contributing to the strategy of "securing Japan".

In order to illustrate how Japan arrives at its strategy for space, the paper will systematically explore these three pillars of the programme by first providing insight into the evolution of the pillars in the Japanese space programme, and then assess the drivers of the space policy for the respective pillars. The drivers are diverse, stemming from endogenous and exogenous circumstances and reflect Japan's broadened conceptualization of security and thus address a variety of domains, such as the social and economic dimensions, the military dimensions, well as the political and prestige dimensions.

As a result of these drivers, a set of objectives emerge for each pillar, which in their combined attainment should serve to "secure Japan". Lastly, each chapter will conclude with the array of "tools" Japan employs to reach the objectives identified, which include programmatic tools, legal and regulatory mechanisms as well as cooperation and diplomacy. These three focus areas, related drivers, objectives and tools will be analysed in dedicated chapters.

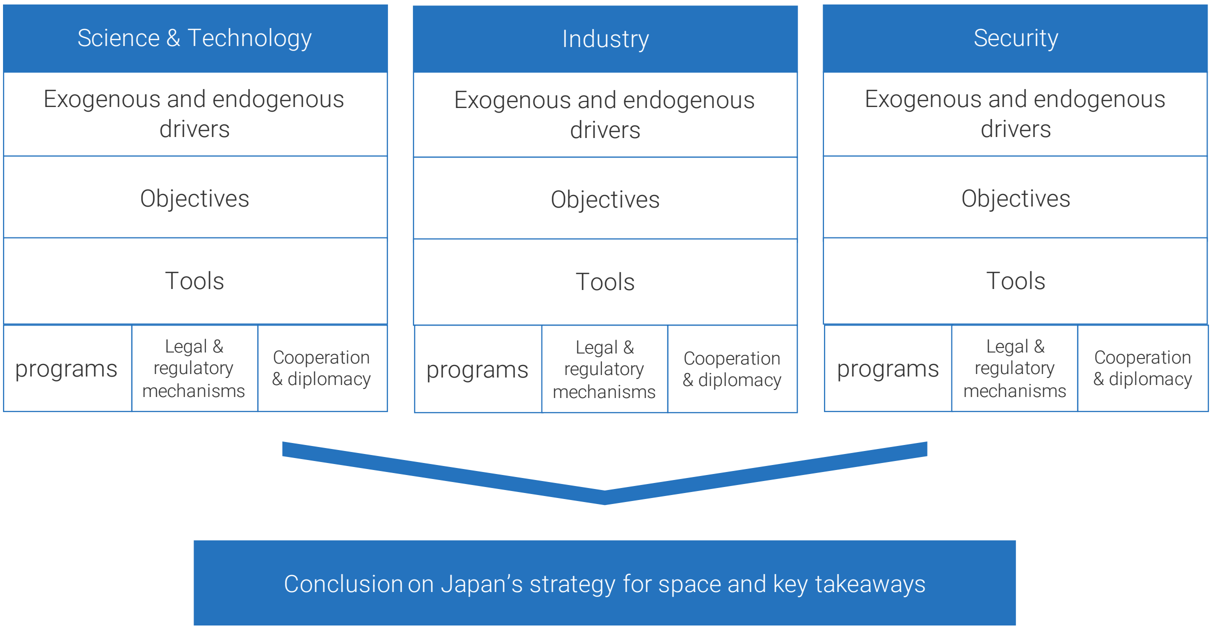

Figure 1: Japan's strategy for space (Source: authors' visualisation)

The study is comprised of six chapters. After elucidating rationales and objectives in the chapter, Chapter 2 will provide a preparatory overview of the Japanese space endeavour. Particular attention will be devoted to shed light on the most recent changes in the institutional set-up, in the policy processes and mode of working of the different stakeholders, before providing a comprehensive description of Japan's technological assets and programmes implemented over the past decade – from space transportation capabilities and application satellites to human spaceflight, space science and exploration. The chapter will then analyse the main policy documents devised by Japan since the enactment of the Basic Space Law in 2008, with a view to determine the core pillars guiding Japan's current strategy in the space arena.

The three subsequent chapters of the report will be structured along the three main pillars of the strategy, covering the civil, commercial and security-related aspects of the Japanese space programme.

Chapter 3 will focus on the first of these pillars: the maintenance and reinforcement of value-producing science and technology infrastructure. Beginning with an assessment of the historical evolution and drivers of Japan's civil space efforts, this chapter will address what the main objectives and directions of Japan's civil efforts are and what programmatic, legal and diplomatic tools the country is deploying to achieve these objectives.

Chapter 4 will analyse Japan's strategy for the vitalisation and growth of its space industry. As with the previous chapter, Chapter 4 will have a threefold structure. First an analysis of the historical evolution and the overarching (endogenous and exogenous) drivers guiding Japan's space industry agenda will be provided. Building on this, the chapter will identify the specific objectives Japan has set forth for promoting the uptake of commercial space activity and the emergence of a robust space economy. Finally, the chapter will disentangle the programmatic, legal and cooperation tools that are being devised by the country's policy makers to fulfil the goals.

Chapter 5 will put the spotlight on Japan's space-related security efforts. In the chapter, the conceptual differentiation between *security in outer space* and *outer space for security* will be maintained. Consistently, the chapter will analyse the evolution of Japan's space security policy, by placing importance on the identification of the exogenous drivers and endogenous drivers behind this evolution. An assessment of Japan's current strategic posture with respect to security in space and outer space for security will be then provided, before analysing the tools to meet the county's evolving security requirements. As in the previous three chapters, these have been categorized in three types of tools: programmatic measures, legal and regulatory measures and diplomacy and cooperation tools.

Finally, Chapter 6 will draw some conclusions on Japan's space strategy.

2 Japan in Space: Actors, Programmes and Policies

When Japan launched its first satellite into space in 1970, it emerged as the first Asian country to complete this feat and only the fourth country in the world to do so after the Union of Soviet Socialist Republics (USSR), the United States and France[7]. Today, Japan's space programme encompasses a wide range of programmes and technological capabilities – including indigenous launch capabilities, an array of satellites in space, a space exploration programme as well as a commercial space sector and military space applications. The institutional framework to run these activities has also evolved over the time, and now encompasses a wide range of institutional and private stakeholders.

This chapter provides an introductory overview of the main actors, programmes and policies that pertain to Japan's space programme. The information given in this chapter will provide a basis of understanding for the subsequent chapters that dive deeper into the civil, commercial and security related aspects of the space programme of Japan – more specifically the respective space policy objectives pertaining to those domains as well as the tools and measures Japan plans to employ in order to reach the objectives.

2.1 The Institutional and Industrial Setting

2.1.1 Institutional Framework

Several government ministries, agencies and offices are involved in the Japanese space programme. Moreover, the Japanese space policy creation process is a multi-stage process which includes the contribution of and exchange between multiple government offices.

The Cabinet together with the Prime Minister and the Ministries makes up the executive branch of the Japanese government. The Cabinet is comprised of the Prime Minister and the Ministers of State who ultimately approve of the National Space Policy. Within the Cabinet sits the "main decision-making body" regarding Japanese space policy: the Strategic Headquarters for National Space Policy (SHNSP*)[8]. It is chaired by the Prime Minister and vice-chaired by both the Chief Cabinet Secretary and a minister level special appointee, which takes the role of the Minister of State for Space Policy. The SHNSP gathers the participation of all ministers and is "authorized to plan and discuss comprehensive national space policy, including the scientific, economic or national security aspects of space"[9]. More specifically, it is responsible for the finalization of the national space policy, the controlling of budgets and then drafts the decisions which are approved by the Cabinet.

Not to be mistaken with the Cabinet itself, the Cabinet Office (CAO) is the Cabinet's administrative agency and supports the SHNSP. Moreover, like other ministries, the CAO runs its own space programme, such as the Quasi-Zenith Satellite System (QZSS)[10]. Within the Cabinet Office sits the Committee on National Space Policy (CNSP), the members of which are appointed by the Prime Minister and includes experts and stakeholders from the commercial sector or academia.

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[7] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[8] Japanese terms or acronyms marked with * are unofficial.
[9] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*, 12.
[10] Kallender, P. (2016). Japan's New Dual-Use Space Policy. The Long Road to the 21st Century. *Asie.Visions 88*.

The "committee studies and drafts the so-called Basic Plan on Space Policy"[11] of which the first draft is provided by the National Space Policy Secretariat of the Cabinet Office (NSPS) – the secretariat of the CNSP as well as the Strategic Headquarters for National Space Policy.

Within the Cabinet Secretariat, there is the Cabinet Intelligence and Research Office which – through the Cabinet Satellite Intelligence Centre – is responsible for the exploitation of the Information Gathering Satellite (IGS) progamme and collection of data. The office also provides support to the Conference on Intelligence of the Cabinet.

The Japan Aerospace Exploration Agency (JAXA) is considered the main implementation agency of the Japanese space programme[12] and is tasked with the development of launch systems and satellite development, launch and operations. It has approximately 1500 employees, around 20 facilities throughout the nation and overseas offices in Washington D.C., Houston, Paris, Moscow and Bangkok[13]. JAXA was created in 2003 through the merger of multiple entities tasked with the execution of the national space programme, namely:

- the Institute for Space and Astronautical Science (ISAS), under the Ministry of Education (MOE)
- the National Space Development Agency (NASDA), under the Science and Technology Agency (STA)
- and the National Aerospace Laboratory (NAL), under STA.

With the merger of NASDA, NAL and ISAS, JAXA became the major institutional entity responsible for the development of space systems. An additional institutional reform in 2012 further changed the role of and regulatory framework surrounding JAXA. Now, JAXA operates under the Ministry for Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Economy, Trade and Industry (METI) and the Ministry for Internal Affairs and Communication (MIC)[14] as well as the Minister for Space Policy of the Cabinet Office. These four ministries oversee JAXA´s activities and formulate and implement specific sectorial strategies[15]. With the 2012 institutional reform, JAXA was also allowed to collaborate with the Ministry of Defense (MOD). A more detailed overview of these key ministries is provided in Table 1 below.

[11] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*, 3.
[12] Cabinet Office of Japan. (2019). *Space Policy*. Retrieved from: https://www8.cao.go.jp/space/english/index-e.html.
[13] Japan Aerospace Exploration Agency. (2019). Field Centres. Tokyo: JAXA. Retrieved from: https://global.jaxa.jp/about/transition/index.html.
[14] La Regina, V. (2015). *The Space Sector: EU-Japan business and technological cooperation potential.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[15] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*.

Ministry	Division/Bureau	Responsibilities
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	Space Development and Utilization Division – Research and Development Bureau	• Oversight ministry for JAXA • Evaluates R&D performance • Plans strategies regarding ISS program
Ministry of Economy, Trade and Industry (METI)	Aerospace and Defense Industry Division – Manufacturing Industry Bureau	• Oversight ministry for JAXA • Promotes the development of the space industry (including production and procurement of launch vehicles and satellite subsystems and components) • Defines space industrial policy • Administrative duties for METI's space programs
Ministry of Internal Affairs and Communications (MIC)	Space Communications Policy Division – Global Strategy Bureau	• Oversight ministry for JAXA • Development of space systems related to utilization of telecommunication and electromagnetic waves
Cabinet Office (CAO)	National Space Policy Secretariat	• Oversight "ministry" for JAXA • Drafting of the Basic Space Plan and budget recommendations • Management of the Quasi-Zenith Satellite System (QZSS) • Planning the QZSS usage

Table 1: Ministry responsibilities related to space (adapted from: Wakimoto, 2019)[16]

Due to being interdisciplinary in nature, the topic of space is also of concern to other ministries and agencies of Japan. Besides the four oversight ministries, other important ministries issuing space budgets requests and playing a role in the programme include:

- the Ministry of Defense (MOD), is involved in space matters mainly through its Strategic Planning Division (Bureau of Defense Policy) for the development of capabilities related to SSA, ISR and C4 capabilities; the Defense Policy Division (Bureau of Defense Policy) for gathering policies and plans related to BMD from each force (Air Staff Force, Maritime Staff Force and Ground Staff Force); and the Defense Planning and Programming Division (Bureau of Defense Build-up Planning) for improving Ballistic Missile Defence (BMD) systems and the space capabilities of the SDF divisions[17].
- the Ministry of Foreign Affairs (MOFA), which is responsible for drafting foreign and national security policies related to space; promoting international cooperation, including supporting Japanese companies in accessing foreign markets; representing Japan in international fora and promoting creation of international norms.

[16] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19.*
[17] Ibid.

- the Ministry of Land, Infrastructure and Tourism (MLIT), which is primarily responsible for developing and operating meteorological satellites to support weather forecasting, typhoon tracking and volcano monitoring services through the Japan Meteorological Agency (JMA). Through its various divisions, MLIT also conducts other activities related to space (e.g. satellite navigation services for air traffic, demonstration of space-enabled mobility services, etc.).
- the Ministry of Environment (MOE), which is responsible for environmental research activities and operates, together with JAXA, the GOSAT satellites for monitoring greenhouse gases.
- the Ministry of Agriculture, Forestry and Fisheries (MAFF), which does not have specified responsibilities within the Basic Space Plan, but whose departments makes extensive use of space-data (in particular remote sensing) to support activities in the field of agriculture and fisheries.
- the National Police Agency, which issues its budget requests as mainly a user of space assets.

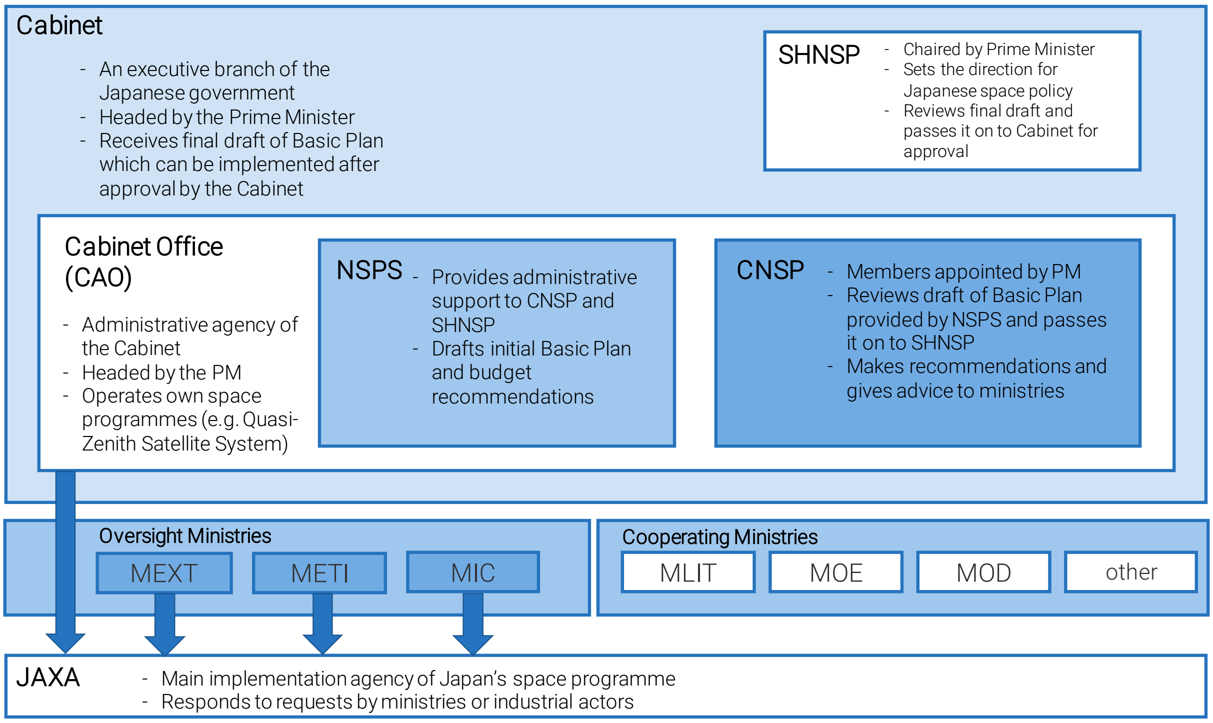

Figure 2: Institutional framework (source: adapted from Wakimoto, 2019 [18]

Besides the governmental stakeholders, in recent years, also several universities and prefectures have started to directly or indirectly engage in the space activities, for instance by providing support to the development of cubesat projects or by supporting the uptake of space services, particularly in the downstream segment.

A number of associations, foundations and non-profit organizations provide recommendations to the government and take part in seminars and symposiums on space[19].

[18] Ibid.
[19] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.

Space policy process

Regarding the specific process of space policy making (see Figure 3), the general direction for Japanese space policy is set at the highest governmental level in the SHSP. This general policy direction is then used by the NSPS to draft a first draft of the space policy. This draft is subsequently discussed and refined in the Committee on National Space Policy (CNSP), which calls on the key ministries for recommendations and advice on the policy as well as budget recommendations. Once finalized, the draft is passed on to the Strategic Headquarters for National Space Policy which allows the Prime Minister and the other ministers to continue discussions on the draft. Upon approval by the SHNSP, the policy is submitted to the Cabinet for final approval and can subsequently be implemented.

The space policy is communicated with the relevant ministries who in turn formulate project requests and pass them to the national R&D agencies – first and foremost JAXA, but also other agencies, such as the National Institute of Information & Communication (NICT) or the National Institute for Environmental Studies (NIES)[20]. These agencies can then turn to the private sector for the "contracting of system development and operation"[21]. While MEXT is primarily responsible for JAXA and provides the budget, JAXA can "flexibly respond to all ministries' demands for Space technology"[22].

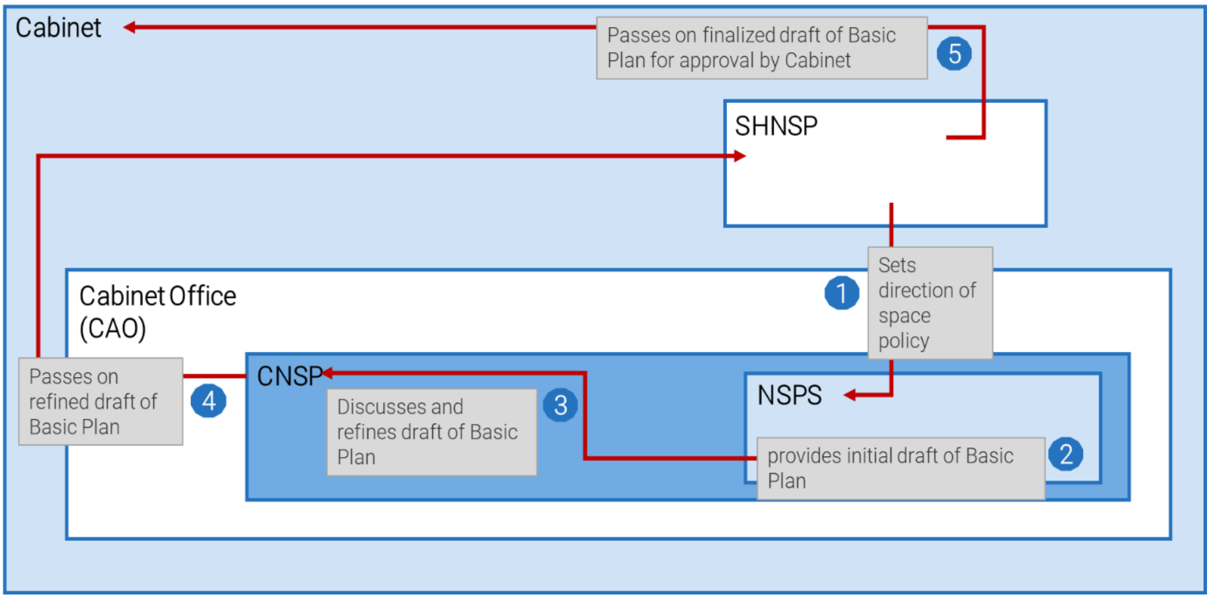

Figure 3: Space Policy Making Process (source: adapted from Wakimoto, 2019)

With regard to the budgetary allocations, annual budget requests are drafted by each ministry (generally in August). The requests are then transmitted to the Diet. The budget is eventually approved in March of the next year, to be used from April onwards. In Japan, the fiscal year (FY) runs from 1st April to 31st March of the following year.

[20] Ibid.
[21] Ibid.
[22] La Regina, V. (2015). *The Space Sector: EU-Japan business and technological cooperation potential.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 40.

2.1.2 Japan´s space industry

To describe the current status of the Japanese space industry, the industrial supply chain taxonomy of "upstream" and "downstream" market segments can be deployed. The "upstream" segment of the space industry largely describes manufacturers of satellite systems, launchers, space equipment and subsystems as well as satellite operators, ground system operators and ground system equipment manufacturers[23]. The "downstream" segment describes "companies providing commercial space-related services and products to the final consumers"[24]. These companies "are generally not connected to the traditional space industry and are only using space signals and/or data in their own products"[25].

Traditional Space Industry

Turning to the Japanese space industry, companies can be categorized to belong to the more traditional space industry or the "New Space industry".

The traditional Japanese space industry is dominated "by giant corporations for whom Space is not the sole market segment"[26]. The most important primes in the "upstream" segment are listed in Table 2Error! Reference source not found.:

Traditional Procurement	Company	Focus/Product/Service
Launchers	Mitsubishi Heavy Industries (MHI)	MHI belongs to the Mitsubishi Group and is the prime contractor, manufacturer and launch service provider to the H-IIA launch system, the H-IIB launch systems as well as the development of the H3 launch system[27].
	IHI Aerospace Co., Ltd	An IHI Corporation subsidiary, the prime contractor, manufacturer and launch service provider to the Epsilon launch vehicle as well as the now retired M-V rocket[28].
Spacecraft	Mitsubishi Electric Corporation (MELCO)	Another Mitsubishi Group company and prime contractor for the H-II Transportation Vehicle (HTV) and the DS 2000 platform[29].
	NEC Corporation	Major manufacturer of spacecraft, particularly the small- and medium bus NEXTAR platform series[30].

Table 2: Traditional space industry (source: authors' visualisation)

[23] OECD. (2014). *The Space Economy at a Glance 2014.* Paris: OECD Publishing.
[24] Ibid. p. 20.
[25] Ibid. p. 20.
[26] La Regina, V. (2015). *The Space Sector: EU-Japan business and technological cooperation potential.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 51.
[27] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 26.
[28] Ibid.
[29] La Regina, V. (2015). *The Space Sector: EU-Japan business and technological cooperation potential.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[30] Ibid.

Furthermore, there are other companies involved in launcher and spacecraft manufacturing as well as a number of companies working as satellite operators, terminal equipment manufacturers and service providers, the most important of which are summarized in Table 3.

Sector	Company	Focus/Product/Service
Spacecraft	Fujitsu	Has developed projects such as the first QZSS satellite, an EO satellite as well as an asteroid probe and a lunar orbiter. Provides "information and communication technologies" which "are used to build the ground-based systems that receive data transmitted from space, track control operations and process observational data"[31].
	Mitsubishi Precision Co., Ltd.	Provides products such as Inertial Reference Units and High Torque Reaction Wheels[32].
	Tamagawa Seiki Co., Ltd.	Provides devices for space components such as a variety of sensors and motors, including angle sensors, actuators, and step motors.
	Meisei Electric Co., Ltd.	Manufactures "communication, electric measuring, information processing machines and other electric and electronic instruments, machineries and parts" as well as "physical and chemical equipment" and computer software[33].
Spacecraft	Kawasaki Heavy Industries, Ltd.	Provides a variety of payload fairings for the H-IIA, H-IIB and Epsilon launch vehicle. Furthermore, the company provides payload adapters and heat shields and technologies for human and space robotics being used on the Kibo module as well as support to ground facilities[34].
	Subaru Corporation	Formerly known as Fuji Heavy Industries, Ltd., Subaru Corporation provides spacecraft bus technology such as tanks used in propulsion, actuators and thermal control structures; as well as antennae for spacecraft payload technology and re-entry and on-board management systems.
	NOF Corporation	Provides different types of solid propellant for a variety of rockets including S-310, S-520, Epsilon, H-IIA and H-IIB[35].
Satellite Operators	SKY-Perfect JSAT Corporation	Operates "the largest satellite communications business in Asia" and runs multiple satellite and network control centres across Japan[36].
	Broadcasting Satellite System Corporation	Operations include "broadcasting services, uplinks, and generation of electronic program guides (EPG) for all broadcasters" through the four broadcasting satellites it operates[37].

[31] Fujitsu Limited. (n.d.). *Contributing to Space Development*. Retrieved from: https://www.fujitsu.com/global/solutions/business-technology/tc/fields/space/.
[32] The Society of Japanese Aerospace Companies. (2018). *Directory of Japanese Space Products & Services 2018-2019*. SJAC.
[33] Meisei Electric Co., Ltd. (n.d.). *About Meisei*. Retrieved from: http://www.meisei.co.jp/english/aboutus/outline/.
[34] The Society of Japanese Aerospace Companies. (2018). *Directory of Japanese Space Products & Services 2018-2019*. SJAC.
[35] Ibid.
[36] SKY Perfect JSAT Group. (n.d.). *Group Mission*. Retrieved from: https://www.skyperfectjsat.space/en/company/mission/.
[37] Broadcasting Satellite System Corporation Profile. (n.d.). *Corporation Profile*. Retrieved from BSAT: http://www.b-sat.co.jp/english/.

	Pasco Corporation	Obtains, processes and provides "image data from optical and synthetic aperture radar (SAR) satellites" from "the leading commercial Earth Observation satellites launched throughout the world"[38].
Terminal Equipment Manufacturers	Mitsubishi Electric Corporation (MELCO)	Capable of manufacturing satellite systems "from designing to assembling and testing" [39] and has contributed to the development of ground systems. Notable projects include the Himawari 8 and 9 satellites, QZSS satellites 2-4 and the H-II Transfer Vehicle (HTV)[40].
	Fujitsu	Has developed projects such as the first QZSS satellite, an EO satellite as well as an asteroid probe and a lunar orbiter. Provides "information and communication technologies" which "are used to build the ground-based systems that receive data, track control operations and process observational data"[41].
Service Providers	Asia Air Survey	Aims to "provide technologies and know-how for acquiring, analysing, and managing a wide range of spatial data"[42].
	Aero Asahi Corporation	"Records, creates and provides highly accurate spatial data" through using surveying technologies that include "aeronautical laser surveying, mobile mapping, submarine topological surveying"[43] and analyses the data subsequently.
	Remote Sensing Technology Center of Japan (RESTEC)	Collects, analyses and distributes remote sensing data and information from "satellites, aircraft, automobiles, observation towers, ships, buoys, and other observation points"[44].
	NTT Data Corporation	Processes data obtained from satellites and has notably produced the "AW3D Standard (2.5m resolution), a highly precise, pre-produced digital-elevation-model 3D map of the world"[45] together with RESTEC.

Table 3: Other space-related companies[46] (source: authors' visualisation)

[38] Pasco Corporation. (n.d.). *Collecting Information*. Retrieved from PASCO: https://www.pasco.co.jp/eng/geospatial/.
[39] The Society of Japanese Aerospace Companies. (2018). *Directory of Japanese Space Products & Services 2018-2019*. SJAC.
[40] Ibid.
[41] Fujitsu Limited. (n.d.). *Contributing to Space Development*. Retrieved from Fujitsu: https://www.fujitsu.com/global/solutions/business-technology/tc/fields/space/.
[42] Asia Air Survey Co., Ltd. (n.d.). *Company Profile*. Retrieved from Asia Air Survey Co., Ltd.: https://www.ajiko.co.jp/en/about/profile.html.
[43] Aero Asahi Corporation. (n.d.). *What we do*. Retrieved from Aero Asahi Corporation: https://www.aeroasahi.co.jp/english/about/.
[44] Remote Sensing Technology Centre of Japan. (n.d.). *Our Business*. Retrieved from RESTEC: https://www.restec.or.jp/en/business.
[45] NTT Data Corporation. (2019, July 1). *NTT Data and RESETEC Launch AW3D Full Global 3D Map with 2.5-m Definition*. Retrieved from NTT Data Corporation: https://www.nttdata.com/global/en/media/press-release/2019/july/ntt-data-and-restec-launch-aw3d-full-global-3d-map#.
[46] The list of companies is not exhaustive. Companies in the table have been selected on the basis of the diversification of products and services identified by the SJAC. Society of Japanese Aerospace Companies. (2018). *Directory of Japanese Space Products & Services 2018-2019*. SJAC.

New Space Industry

Like other countries, Japan is witnessing an emergence of new companies paving their way in the upstream and downstream space sectors due to a disruptive phenomenon coined *New Space*. This change in status-quo of the space industry is characterized by a multitude of coinciding factors including: 1) the expanding scope of space applications; 2) increasing pressures to reduce costs of development; 3) growing private investment; 4) the emergence of new entrepreneurs and companies; 5) and disruptive innovation techniques[47]. Japanese *New Space* actors have emerged in a variety of sectors, as summarised in Table 4.

Sector	Company	Focus/Product/Service
Space exploration	Ispace	founded in 2010, works in the field of space exploration/ exploitation of space resources. By 2040 it aims to provide extraction and transportation services from a lunar platform and has planned intermediate steps until then consisting of the deployment payloads and of lunar rovers. For the intermediate missions, ispace has secured a contract with SpaceX.
Spacecraft/ space tech application	iQPS	founded in 2005, has specialized on manufacturing small constellations of Synthetic Aperture Radar (SAR) satellites, first deployment of satellites is envisioned for 2019 and 2020.
	Axelspace	founded in 2008, has specialized on microsatellites for Earth Observation which it plans on deploying by 2022.
	ALE	founded in 2011, has specialized on provision of outer space entertainment through the creation of on-demand artificial shooting stars and meteor showers.
	Astroscale	founded in 2013, this company aims to provide space debris removal services by 2019.
	Synspective	founded in 2018, aims to utilize its constellation of SAR satellites to collect large amounts of data to be analysed via machine learning for various applications.
Space Transportation	Interstellar Technologies	aims to develop small launchers at a low cost and after two failed launch attempts in 2017 and 2018 continues its work.
	PD AEROSPACE	founded in 2007, is a company specialized on space tourism and plans on manufacturing a suborbital, reusable space vehicle by 2023.
	Space Walker	founded in 2017, this start-up aims to develop a space shuttle for sub-orbital space tourism flights which can also deploy small satellites and begin commercialization by 2027.
Ground Activities	Infostellar	founded in 2016, aims to develop a system to share a terrestrial satellite antenna platform with multiple satellite operators.

Table 4: Selected Japan's NewSpace companies[48] (source: authors' visualisation)

[47] European Space Policy Institute. (2019). *Space Venture Europe 2018: Entrepreneurship and Private Investment in the European Space Sector.* Vienna: ESPI.
[48] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.

Unlike traditional private companies, Japan's New Space companies do not operate as contractors for Japan's institutional programme but try to seize commercial opportunities by building independent business-to-business (B2B) or business-to-consumer (B2C) solutions in which they retain complete control on the design, development, and market delivery. However, on the institutional side there has been a growing support to promote the emergence of this new ecosystem. The specific measures the Japanese government is deploying to foster innovation and the emergence of new entrepreneurs and companies will be investigated in Chapter 4.

Another important feature in Japan's New Space is the entrance of non-space companies in the space ecosystem. Over the past few years, more and more non-space companies have entered the sector by either providing finance to start-ups or developing technical partnerships with JAXA for the exploitation of space solutions or the development thereof. Toyota, for instance, has concluded a research agreement with JAXA to conduct a conceptual joint study on a pressurized crew lunar rover, while the airline company JAL has been providing financial support to the ALE start-up. The most important companies are listed in Figure 4 (see also Chapter 4 for a more articulated overview).

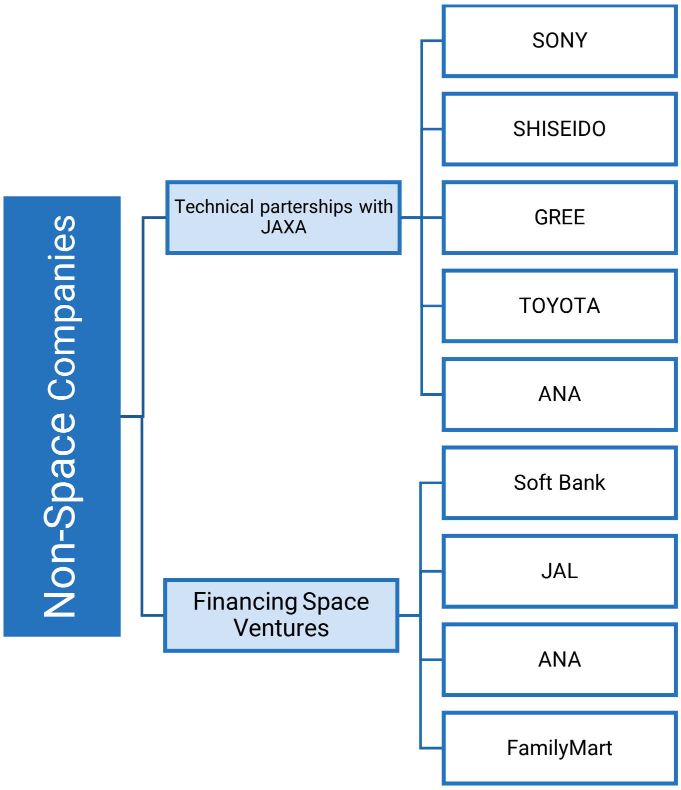

Figure 4: Important non-space companies (source: adapted from Lacaze, 2018)[49]

In terms of investments, the Japanese New Space scene is characterised by the fact that investors are primarily terrestrial corporations, rather than VC. According to the estimates provided by SPACETIDE, out of the 93 investors in Japanese space companies in the period 2014-2019, 41% is represented by corporations. A more detailed overview of the investors' profile is provided in Figure 5, while an overview of the investment level is provided in Figure 6.

[49] Ibid.

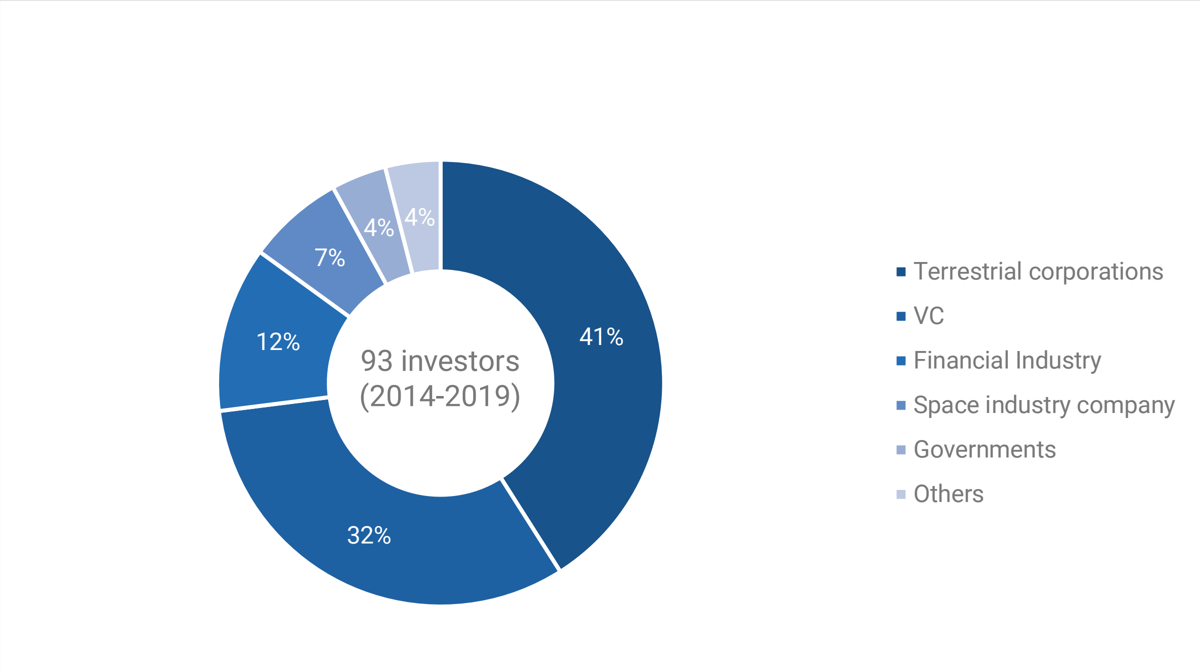

Figure 5: Investors Profile in Japan (source: SPACETIDE, 2020)[50]

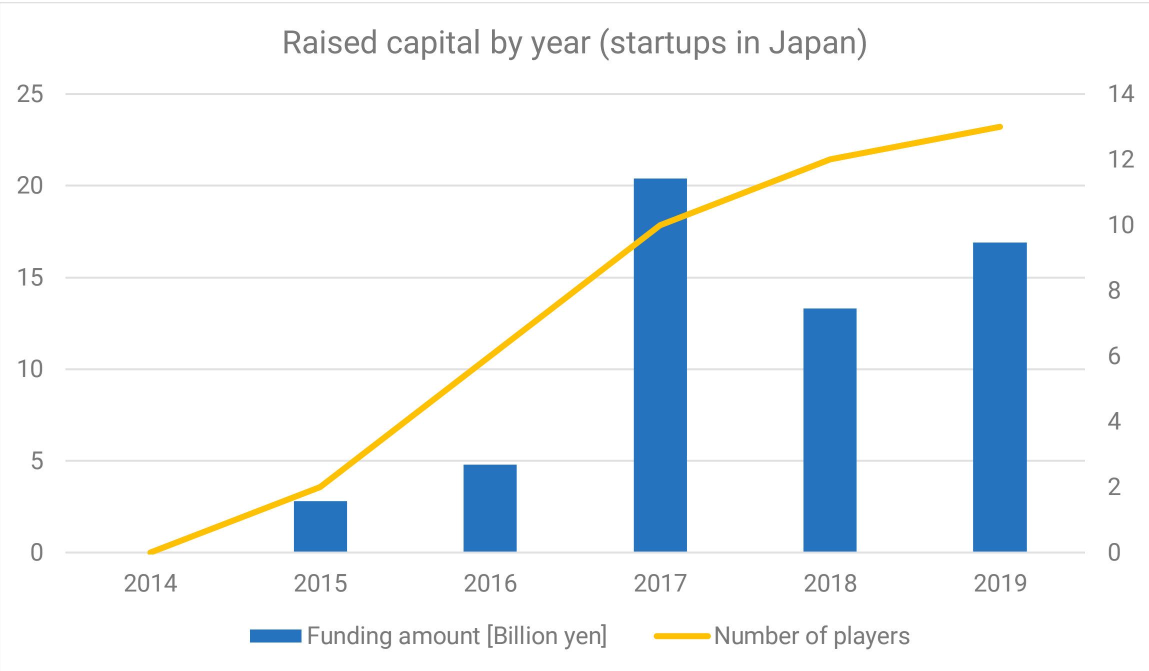

Figure 6: Investment Level in the period 2014-2019 (source: SPACETIDE, 2020)[51]

[50] SPACETIDE. (2020). COMPASS. Vol 2. Retrieved from: https://spacetide.jp/compass/vol_2/Spacetide-Compass-Vol2_en.pdf.
[51] Ibid.

2.2 Budget and Programmes

2.2.1 Space Budget

The governmental budget for space activities is approved on a yearly basis and, consistent with the institutional framework discussed in Chapter 2.1, covers the activities of all the eleven ministries and public agencies involved in space. An initial budget is approved before the beginning of each fiscal year, which runs from 1st of April to 31st of March of the following year, and in case the initial amount is deemed insufficient, the government can request a supplemental budget. The evolution of the budgetary allocation over the past 10 years (2009-2019) is presented in Figure 7.

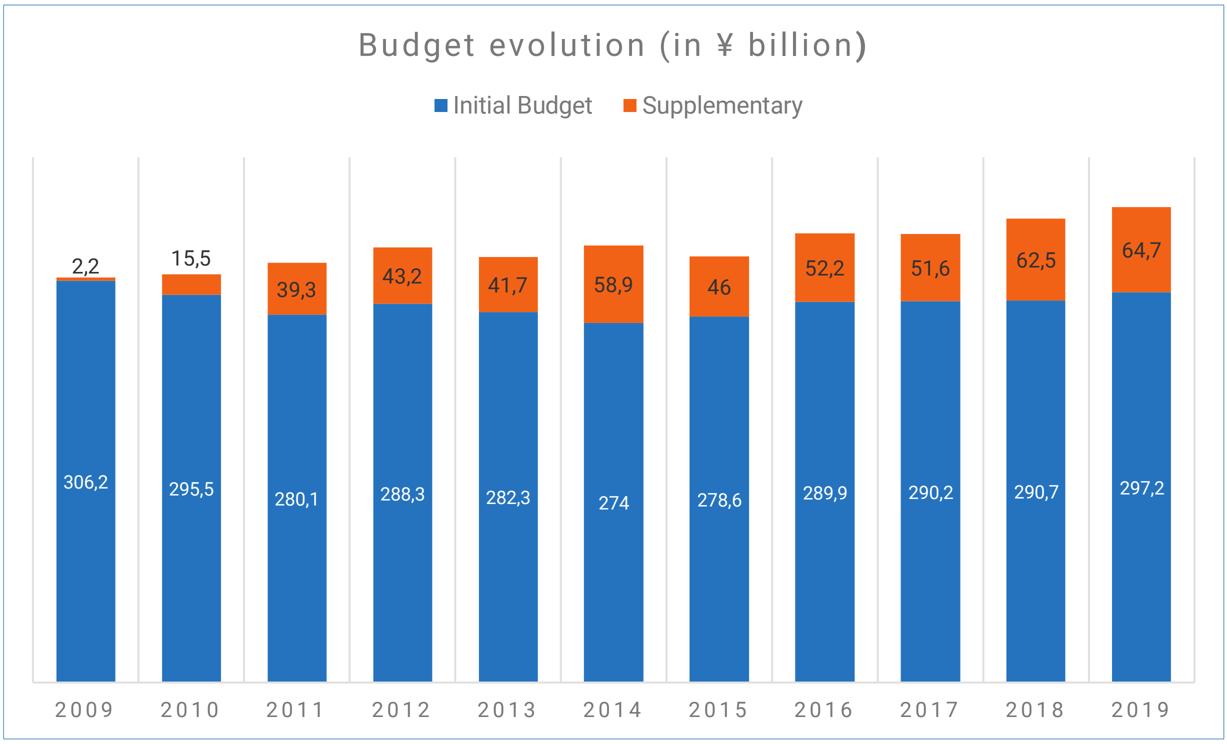

Figure 7: Evolution of the Japanese budget for space (source: Cabinet Office)[52]

As shown in Figure 7, since 2009, the Japanese government has been increasing the supplemental budget while keeping the initial budget stable. With specific respect to the 2019 Fiscal Year (FY), which ran until 31 March 2020, the initial budget of 2019 amounts to ¥297.2 billion, which represents an increase of 2.2% (¥ 6.5 billion) compared to the initial budget of FY 2018. A more specific overview of the budgetary composition for the FY 2018 and 2019 is provided in Table 5 and Figure 8.

[52] Cabinet Office. (2020). 宇宙関係予算について (About the Space Budget). Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/budget/yosan.html.

Ministry	2018 (in ¥ billion)	2019 (in ¥ billion)	Variation (in ¥ billion)
Cabinet Secretariat	62.0	62.1	+ 0.1
Cabinet Office	16.3	27.2	+ 10.9
National Police Agency	0.9	0.9	=
Ministry of Internal Affairs and Communications (MIC)	7.1	7.4	+ 0.3
Ministry of Foreign Affairs (MOFA)	0.3	0.2	- 0.1
Ministry of Education, Culture, Sports, Science & Technology (MEXT)	151.6	152.7	+ 1.1
Ministry of Agriculture, Forestry & Fisheries (MAFF)	0.3	0.3	=
Ministry of Economy, Trade & Industry (METI)	2.8	2.6	- 0.2
Ministry of Land, Infrastructure, Transport & Tourism (MLIT)	5.3	5.5	+ 0.2
Ministry of Environment	3.0	3.3	+ 0.3
Ministry of Defense	41.1	34.8	- 6.3
TOTAL	290.7	297.2	+ 6.5

Table 5: Budget allocation by ministry (source: CAO)[53]

[53] Cabinet Office. (2019). **平成 30 年度補正**予算案**及び平成３１年度当初**予算案における宇宙関係予算について (About space budget - Supplemental budget proposal for the Fiscal Year 2018 and Initial Budget Proposal for the Fiscal Year 2019). Tokyo: CAO Retrieved from: https://www8.cao.go.jp/space/budget/h31/fy30hsei_31yosan.pdf.

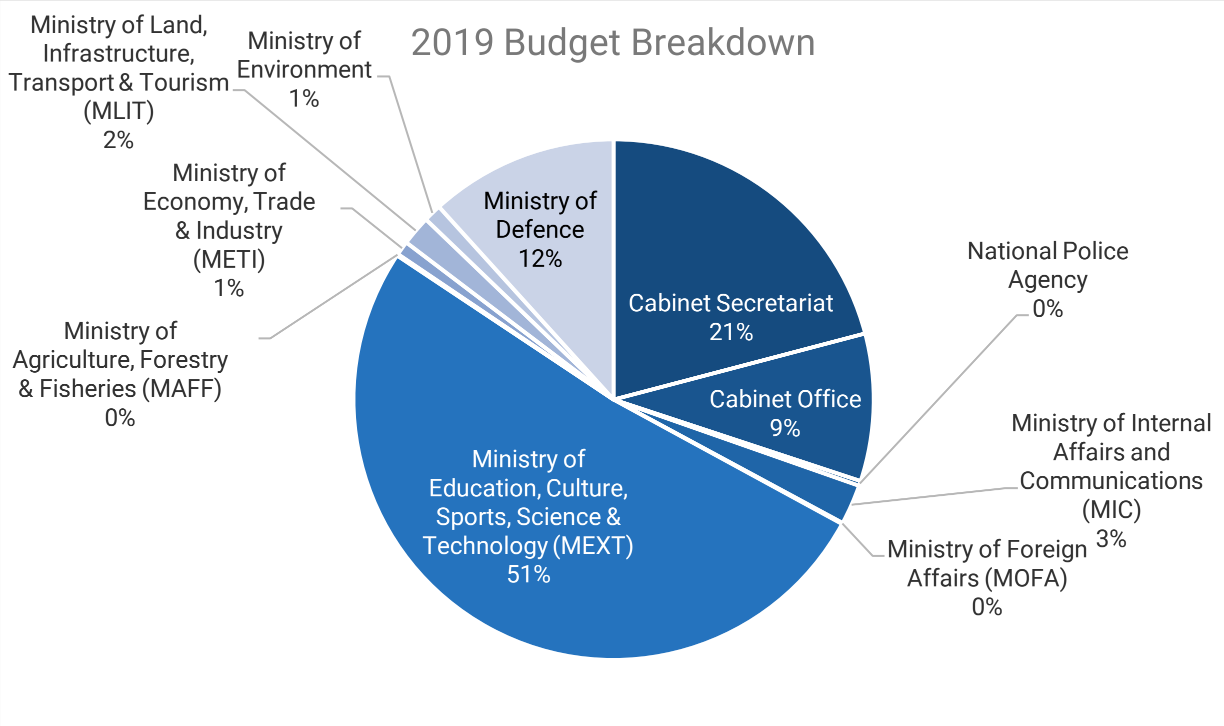

Figure 8: Budget allocation by ministry (source: CAO)[54]

As shown in Figure 8, more than half (51%) of the 2019 budget has been allocated to the MEXT, followed by the Cabinet Secretariat (21%) and the Ministry of Defense (10%). This is because most of the space programmes are executed by JAXA, which is primarily funded by the MEXT.

2.2.2 Space Transportation

Launch Systems

The current space transportation capabilities of Japan consist of a fleet of three orbital launch vehicles (see Table 6).

The H-IIA launch vehicle is a two-stage liquid propellant launch vehicle used for heavier payloads of 10000-15000kg to LEO, 3300-5100kg to SSO and 4000-5950kg to geostationary transfer orbit (GTO)[55]. It is the most important Japanese launch vehicle that has "provided Japan with reliable, independent and guaranteed access to space since 2001"[56]

The H-IIB launch vehicle is another two-stage liquid propellant launch vehicle[57]. Its primary purpose however is to transport cargo on the H-II Transfer Vehicle (HTV) to the International Space Station (ISS). The HTV "carries necessary daily commodities for the crew astronauts, spare parts for the ISS, experimental devices and samples, and other research items"[58].

[54] Ibid.
[55] Japan Aerospace Exploration Agency. (2019). *H-IIA Launch Vehicle.* Tokyo: JAXA Public Affairs Department.
[56] Japan Aerospace Exploration Agency. (2019). *H-IIA Upgrade.* Tokyo: JAXA Public Affairs Department. p.1.
[57] Japan Aerospace Exploration Agency. (2019). *H-IIB Launch Vehicle.* Tokyo: JAXA Public Affairs Department.
[58] Ibid.

Launch Vehicle	Launch service provider	Performance range (kg)			Launch site
		LEO	SSO	GTO	
H-IIA	Mitsubishi Heavy Industries, Ltd. (MHI)	10000 - 15000	3300-5100	4000 - 5950	Tanegashima Space Centre (Kagoshima Pref.)
H-IIB	Mitsubishi Heavy Industries, Ltd. (MHI)	16500		8000	Tanegashima Space Centre (Kagoshima Pref.)
Epsilon	IHI Aeorspace (manufacture)	1200+	590 (optional config.		Uchinoura Space Centre (Kagoshima Pref.)

Table 6: Japanese Launch Vehicles (source: ESPI Database)

The Epsilon Launch Vehicle is the successor to the M-V launch vehicle which was retired in 2006[59]. It is a three-staged solid propellant launch vehicle and exists in a standard and optional configuration – the latter of which has an additional compact liquid propulsion system[60]. The Epsilon Launch Vehicle is used to carry small payloads of over 1200kg to Low Earth Orbit (LEO) and 590kg to sun-synchronous orbit (SSO).

Besides the orbital launch vehicles (HII and Epsilon series), Japan has also a fleet of sounding rockets primarily dedicated to scientific research and technology demonstration. These include: S-310, S-520 and SS-520.[61] The most recent version, the SS-520, is a two-stage rocket capable of reaching an altitude of about 800 km.[62] The SS-520 also aims at "carrying out technological experiments concerning the development of a mini-satellite launch vehicle by adding the third stage atop".[63]

The number of launches from Japanese space centres as well as the number of spacecrafts launched during the last 10 years are detailed in Figure 9 and Figure 10 respectively.

[59] Japan Aerospace Exploration Agency. (2019). *Epsilon Launch Vehicle.* Tokyo: JAXA Public Affairs Department.
[60] Ibid.
[61] Japan Aerospace Exploration Agency. *S-310/S-520/SS-520 (Sounding Rockets)*. Retrieved from JAXA: https://global.jaxa.jp/projects/rockets/s_rockets/.
[62] Ibid.
[63] Ibid.

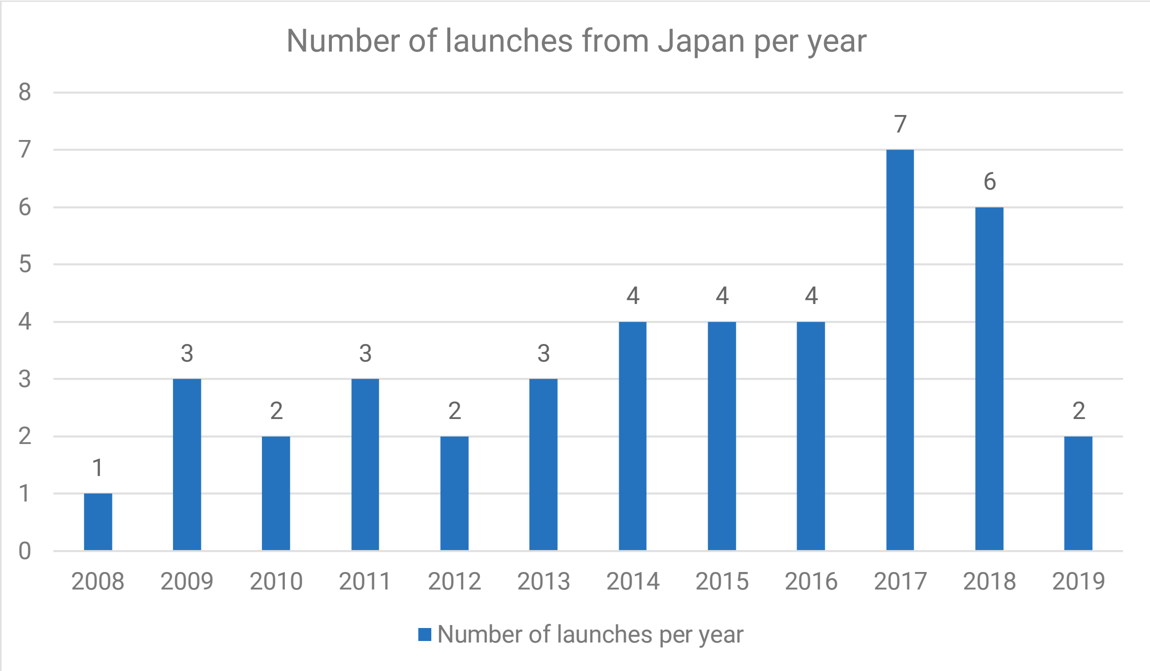

Figure 9: Number of launches from Japan (source: ESPI Database)

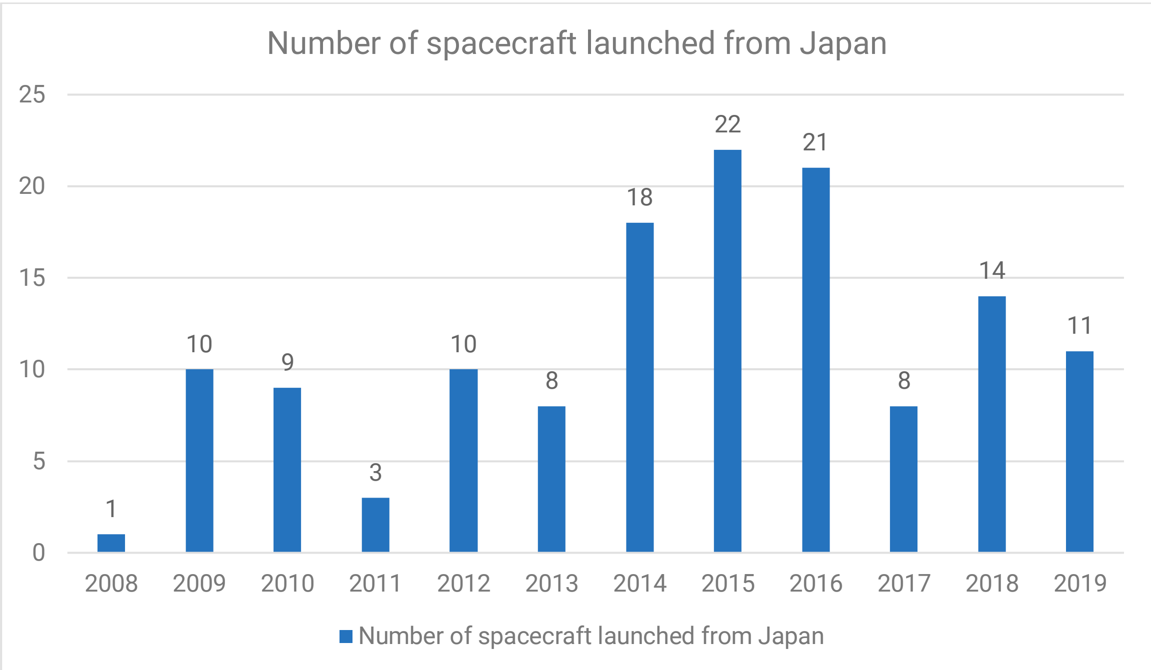

Figure 10: Number of spacecraft launched from Japan (source: ESPI Database)

Launch Infrastructure

Japan has around 20 space-related field centres, including administrative headquarters and overseas centres, research and development centres, ground stations for satellite communication as well as test and launch facilities[64].

The two main test and launch facilities in Japan are Tanegashima Space Centre and the Uchinoura Space Centre.

The Tanegashima Space Centre is the "largest launch complex in Japan" and is located on an island south of Kyushu (Kagoshima-Prefecture) – the most south-western of the four main islands that make up Japan. The centre is run by JAXA and Mitsubishi Heavy Industries acts as prime contractor and launch service provider for the H-IIA and H-IIB launch vehicles. The complex is equipped with facilities to conduct firing tests, as well as assemble and launch vehicles and control their launches[65]. More specifically, the facilities include:

- a Vehicle Assembly Building (VAB), a facility with the capacity to work on the assembly of two launch vehicles simultaneously;
- the Yoshinobu Launch complex, which has two launch pads – one for the H-IIA and the H-IIB launch vehicle each;
- the Takesaki Range Control Centre, the command and control centre for all launches and other systems at Tanegashima Space Centre;
- a Second Spacecraft Test and Assembly Building, where additional preparations for spacecraft are performed.

The Uchinoura Space Centre was established in 1962 and is located in the hillside at the southern tip of Kyushu (Kagoshima-Prefecture). It is the site of Japan's first satellite launch and has "launched over 400 small and large launch vehicles and about 30 satellites and explorers"[66]. JAXA runs the Uchinoura Space Centre and IHI Aerospace is the prime contractor for the manufacturing Epsilon launch vehicle, which is launched from this space centre. The main facilities include:

- The Mu Centre, which includes one launch pad and assembly building for the Epsilon launch vehicle;
- The Epsilon Control Centre;
- The KS centre, which is used for launching sounding rockets;
- Two antennas (20m and 34m respectively), which are used to receive information from scientific satellites.

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[64] Japan Aerospace Exploration Agency. (2019). *Field Centres*. Tokyo: JAXA Public Affairs Department.
[65] Japan Aerospace Exploration Agency. (2019). *Tanegashima Space Center*. Tokyo: JAXA Public Affairs Department.
[66] Japan Aerospace Exploration Agency. (2019). *Uchinoura Space Center*. Retrieved from JAXA: http://global.jaxa.jp/about/centers/usc/index.html.

2.2.3 Space Systems

Japan has at its disposal a diverse fleet of spacecraft with different purposes, which can be examined in Figure 11 and will be discussed in more detail in the following sections.

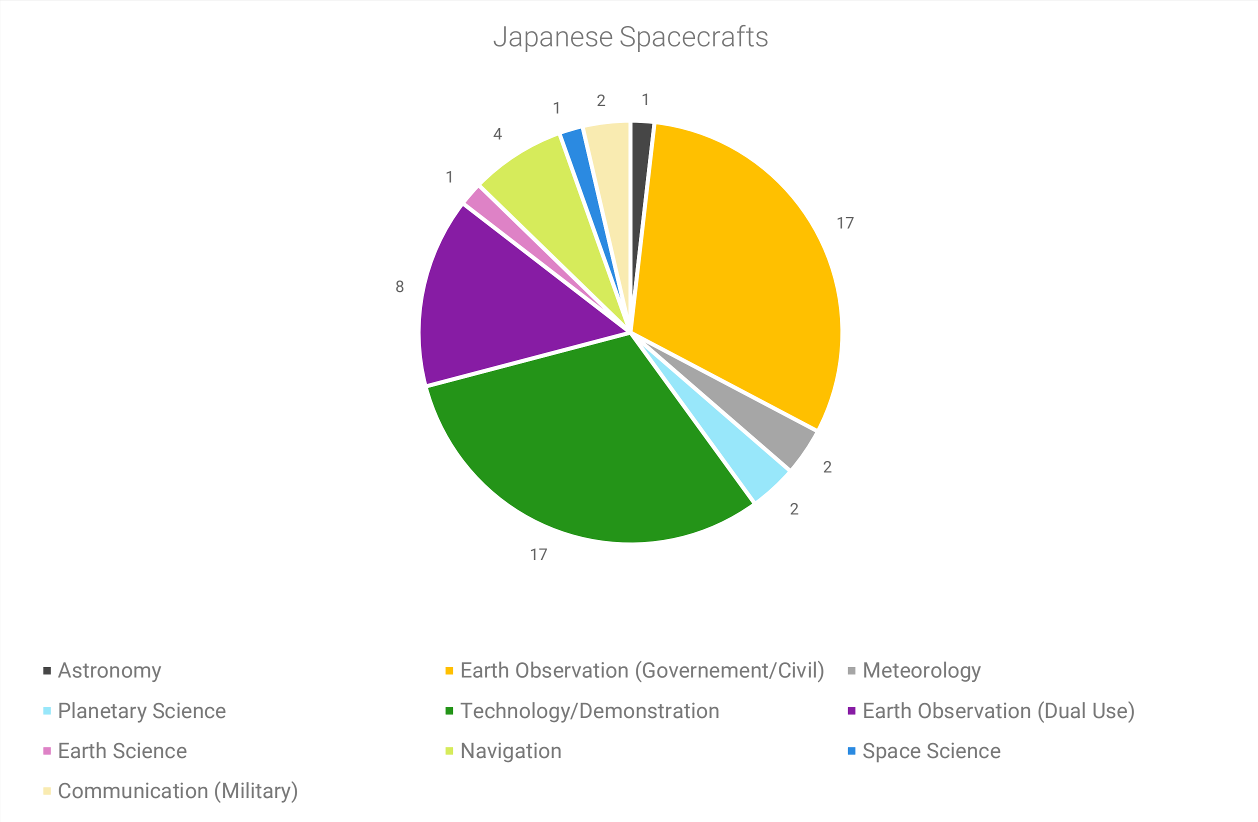

Figure 11: Japanese Spacecraft as of 2019 (source: ESPI Database)

Earth observation and Meteorology

Since the inception of its Earth Observation (EO) programme in the early 1980s[67], Japan has successfully launched satellites collecting data for meteorology, land and ocean observation, environmental change and weather observation[68]. An overview of Japan remote sensing satellites is offered in Table 7.

Satellite Name	Launch Year	Orbit Type	Launch Vehicle	Launch Site	Purpose
"IBUKI-2" (GOSAT-2)	2018	SSO	H-IIA	Tanegashima Space Center	Global Warming Research/ greenhouse gases observation (especially carbon dioxide, methane, carbon monoxide).
"SHIKISAI" (GCOM-C)	2017	SSO	H-IIA	Tanegashima Space Center	Global Change Observation Mission – Climate: understand water circulation mechanisms and climate change. Conduct surface and atmospheric.
"TSUBAME" (SLATS)	2017 Compl.	LEO	H-IIA F37	Tanegashima Space Center	Super Low Altitude Test Satellite: collect technical data related to the atmosphere. Photograph the Earth.
"DAICHI-2" (ALOS-2)	2014	SSO	H-IIA	Tanegashima Space Center	Advanced Land Observation: monitor disaster, update data archives, monitor cultivated areas, global monitoring of tropical rain forests.
GPM/DPR	2012	LEO	H-IIA	Tanegashima Space Center	Global Precipitation Measurement/Dual-frequency Precipitation Radar: determine rainfall distribution
"SHIZUKU" (GCOM-W)	2012	SSO	H-IIA	Tanegashima Space Center	Global Change Observation Mission – Water: observe water-related targets (precipitation, water vapor, sea surface wind speed, sea surface temperature, soil moisture, and snow depth).
"IBUKI" (GOSAT)	2009	SSO	H-IIA	Tanegashima Space Center	Greenhouse gases Observation: measure the concentration of greenhouse gases (CO2, CH4, …).

Table 7: Japanese Earth Observation satellites (source: JAXA) [69]

[67] Shimada, M. (2014, June). JAXA Earth Observation Programs Digest. *IEEE Geoscience and Remote Sensing Magazine*, 47-52.
[68] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[69] Japan Aerospace Exploration Agency. (2020). Utilizing Space Through Satellites – Earth Observation satellites. Retrieved from: https://global.jaxa.jp/projects/sat/index.html. Details about the instruments may be found on: eoPortal Directory. *Satellite Missions Database*. European Space Agency. Retrieved from: https://earth.esa.int/web/eoportal/satellite-missions; Earth Online.

Land and Ocean Observing Satellites:

The Advanced Land Observing Satellite-2 (ALOS-2, also known as Daichi-2) is the cornerstone of JAXA´s EO satellite series responsible for disaster monitoring, land monitoring, and environmental monitoring for sustainability (i.e. forest cover and wetland change, sea ice motion, natural resource exploration)[70]. It was launched on in May 2014 as the follow-on of the ALOS and is equipped with a Panchromatic L-band Synthetic Aperture Radar (PALSAR-2) capable of all-time (day and night) and all-weather observations. ALOS-2 has two core objectives:

- "contribute to disaster management activities of the central and local governments in Japan and foreign countries by observing the disaster-stricken area widely in detail, regardless of the time (day and night) or weather, and establishing a system to quickly obtain, process, and share observation data"[71];
- support "data utilization in various fields with constant observation data to meet user needs such as monitoring public infrastructure (e.g. roads, railroad tracks, and bridges), understanding agricultural conditions, and observing forests"[72].

The ASNARO satellite series – which stands for *Advanced Satellite with New system Architecture for Observation* – is a satellite series developed by NEC and funded through METI which provides high-resolution Earth Observation at a reduced cost[73]. Both ASNARO-1 and ASNARO-2 are mini-satellite bus systems and can be utilized to monitor and gather EO data, e.g. on "rural areas, vegetation and the condition of roads and rivers" as well as "the maturity of crops" and "volcanic eruptions"[74].

Global Environmental Change and Weather Observing Satellites:

In the realm of observing global environmental change and weather changes, Japan's Earth observation fleet currently consists of four main spacecraft:

The Greenhouse Gases Observing Satellite (GOSAT) project, run by JAXA, NIES and MEO, with its satellite GOSAT 1 (Ibuki-1) provides data on "the global distribution and temporal variation of the greenhouse gases, as well as the global carbon cycle and its influence on climate"[75]. Its successor – the GOSAT-2 (Ibuki-2) – provides additional data on carbon monoxide[76].

The Global Change Observation Mission (GCOM) comprise a series of two satellites, GCOM-W (also known as Shizuku) for observing water circulation changes and GCOM-C (also known as Shikisai) for climate changes. The GCOM-W has a microwave radiometer onboard through which it can "observe precipitation, vapor amounts, wind velocity above the ocean, sea water temperature, water levels on land

ALOS Operations. European Space Agency. Retrieved from: https://earth.esa.int/web/guest/-/alos-operations-4208; SPPA. *ESA´s Earthnet Data Assessment Pilot (EDAP)*. European Space Agency. Retrieved from: https://earth.esa.int/web/sppa/activities/edap/atmospheric-missions/GCOM-C; Global Precipitation Measurement. *Dual-frequency Precipitation Radar (DPR).* National Aeronautics and Space Administration. Retrieved from: https://gpm.nasa.gov/missions/GPM/DPR#dprinstrumentdetails.

[70] Shimada, M. (2014, June). JAXA Earth Observation Programs Digest. *IEEE Geoscience and Remote Sensing Magazine*, 47-52.

[71] Japan Aerospace Exploration Agency. (2015). *ALOS-2 ：The Advanced Land Observing Satellite-2 "DAICHI-2"*. Retrieved from JAXA: https://global.jaxa.jp/activity/pr/brochure/files/sat29.pdf.

[72] Ibid.

[73] Shimada, M. (2014, June). JAXA Earth Observation Programs Digest. *IEEE Geoscience and Remote Sensing Magazine*, 52; Sharing Earth Observation Resources. (n.d.). *ASNARO-2 (Advanced Satellite with New System ARchitecture for Observation-2)*. Retrieved from eoPortal Directory: https://directory.eoportal.org/web/eoportal/satellite-missions/a/asnaro-2; Sharing Earth Observation Resources. (n.d.). *ASNARO*. Retrieved from eoPortal Directory: https://directory.eoportal.org/web/eoportal/satellite-missions/a/asnaro.

[74] NEC. (2018). *NEC releases images from the ASNARO-2 radar satellite*. Retrieved from NEC: https://www.nec.com/en/press/201803/global_20180313_01.html.

[75] GOSAT Project. (2019). *Goals of the GOSAT Project*. Retrieved from GOSAT Project: http://www.gosat.nies.go.jp/en/about_1_goal.html.

[76] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 54.

areas, and snow depths"[77].The GCOM-C satellite's purpose on the other hand is "to monitor global climate change by observing the surface and atmosphere and collect data related to the carbon cycle and radiation budget"[78].

Additionally, Japan contributes to the Global Precipitation Measurement (GPM) project under the NASA-JAXA equal partnership. JAXA developed the Dual-frequency Precipitation Radar which is mounted on board of the core satellite provided by NASA. The aim of the GPM is to "make more accurate and frequent observation of global precipitation by expanding the area of observation to include higher latitudes"[79].Through the GCOM and the GPM, Japan is providing data on "disaster management, water cycle and climate monitoring"[80].

Currently also in development are EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) and HISUI. The former is a planned joint European/Japanese mission to observe clouds and aerosols on a global scale to improve the accuracy of climate change predictions[81]. The latter is a hyperspectral Earth imaging system – which is being developed by METI through JSS and NEC[82]. It was deployed to the ISS in 2019[83]. This system aims to "contribute to enabling superior monitoring for oil and mineral exploration as well as environmental monitoring"[84].

Meteorological Satellites:

Japan uses meteorological satellites in order to guarantee the safety and security of Japanese citizens through monitoring "typhoons, severe rainfall, and other meteorological phenomena"[85]. To this end, it employs the so-called *Himawari* satellite series, of which Himawari 8 and Himawari 9 are currently in orbit[86]. The objective of these two satellites is to "provid[e] a reliable, seamless meteorological observation system including backup via in-orbit standby"[87]. They are operated by the Japan Meteorological Agency with Mitsubishi Electric Corporation as the prime contractor and were launched in 2014 and 2016 respectively with the H-IIA launch vehicle[88].

Satellite Systems for National Security:

The Cabinet Satellite Intelligence Centre currently operates a fleet of eight Information Gathering Satellites (IGS) – five of which are radar imaging satellites and three optical imaging satellites[89]. All IGS satellites were launched from Tanegashima Space Center with the HII-A launch vehicle and are orbiting in sun-

[77] Japan Aerospace Exploration Agency (n.d.). *Utilizing Space Through Satellites*: Global Change Observation Mission - Water "SHIZUKU" (GCOM-W): Retrieved from JAXA: https://global.jaxa.jp/projects/sat/gcom_w/.
[78] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 54.
[79] Japan Aerospace Exploration Agency. (2019). *Global Precipitation Measurement (GPM)/ Dual-frequency Precipitation Radar (DPR).* Tokyo: Japan Aerospace Exploration Agency Public Affairs Department.
[80] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[81] Japan Aerospace Exploration Agency. (n.d.). *Utilizing Space Through Satellites*: Earth Clouds, Aerosols and Radiation Explorer (EarthCARE). Retrieved from JAXA: https://global.jaxa.jp/projects/sat/earthcare/.
[82] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 53.
[83] Sharing Earth Observation Resources. (n.d.). *ISS Utilization: HISUI (Hyperspectral Imager Suite)*. Retrieved from eoPortal Directory: https://eoportal.org/web/eoportal/satellite-missions/content/-/article/iss-utilization-hisui-hyperspectral-imager-suite-.
[84] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 54.
[85] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy. p. 22.
[86] Ibid.
[87] Ibid.
[88] Japan Meteorological Agency. (n.d.). *Himawari-8/9 Spacecraft.* Tokyo: Japan Meteorological Agency; Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[89] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.

synchronous LEO[90]. The IGS constellation's main purpose is to "provide early warning of impending hostile launches in Japan's neighbourhood and perform surveillance to collect information necessary for national security"[91].

Initiated in the late 1990s with the purpose of being a "multi-purpose information-gathering program"[92], it quickly became clear that though IGS are able to collect information on natural disasters and other civilian issues, their dual-use nature allowed Japan to use the IGS constellation as military reconnaissance satellites for the Self-Defence Forces (SDF) – and does so to this day[93].

Telecommunication satellites

Japan has at its disposal a fleet of communications satellites (see Table 8) – the majority of which are commercial communication satellites with the exception of Japan's military communication satellites Kirameki 1 and Kirameki 2, launched from Tanegashima Launch Centre in 2018 and 2017 respectively.

The BSAT satellite series, i.e. BSAT-3A, BSAT-3B, BSAT-3C and BSAT-4A, were launched from Guiana Space Centre in the years 2007, 2010, 2011, 2017 respectively and are owned and operated by Broadcasting Satellite System Corporation.

Name of Satellite	Year of Launch	Class of Orbit	Launch Vehicle	Launch Site	Users	Operator/Owner
BSAT-3A	2007	GEO	Ariane 5 ECA	Guiana Space Center	Commercial	Broadcasting Satellite System Corp.
BSAT-3B	2010	GEO	Ariane 5 ECA	Guiana Space Center	Commercial	Broadcasting Satellite System Corp.
BSAT-3C/JCSat 110-R	2011	GEO	Ariane 5 ECA	Guiana Space Center	Commercial	Broadcasting Satellite System Corp./ Sky Perfect JSAT
BSAT-4A	2017	GEO	Ariane 5	Guiana Space Center	Commercial	Broadcasting Satellite System Corp
JCSat 10 (Japan Communications Satellite 10/JCSat 3A)	2006	GEO	Ariane 5	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation
JCSat 110 (N-Sat-110, Superbird-D, Superbird-5, N-Sat-100)	2000	GEO	Ariane 44L	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation
JCSat 13 (Japan Communications Satellite 13)	2012	GEO	Ariane 5 ECA	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation

[90] Information from UCS database.
[91] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 42.
[92] Kallender, P. (2016). Japan's New Dual-Use Space Policy. The Long Road to the 21st Century. *Asie.Visions 88*, 21.
[93] Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press.

JCSat 14 (JCSat 2B, Japan Communications Satellite 14)	2016	GEO	Falcon 9	Cape Canaveral	Commercial	Sky Perfect JSAT Corporation
JCSat 15	2016	GEO	Ariane 5	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation
JCSat 16	2016	GEO	Falcon 9	Cape Canaveral	Commercial	Sky Perfect JSAT Corporation
JCSat 2A (JCSAT 8, Japan Communications Satellite 8)	2002	GEO	Ariane 44L	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation
JCSat 4A (JCSAT6, Japan Communicatoins Satellite 6)	1999	GEO	Atlas 2AS	Cape Canaveral	Commercial	Sky Perfect JSAT Corporation
JCSat 9 (JCSat 5A, Japanese Communications Satellite 9)	2006	GEO	Zepit 3SL	Sea Launch Odyssey	Commercial	Sky Perfect JSAT Corporation
JCSat RA (JCSat 12, Japan Communications Satellite 12)	2009	GEO	Ariane 5	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation
Kirameki 2 (DSN-2)	2017	GEO	H2A	Tanegashima Space Center	Military	Ministry of Defense
N-Star C	2002	GEO	Ariane 5	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation
Superbird 7 (Superbird C2)	2008	GEO	Ariane 5 ECA	Guiana Space Center	Commercial	Sky Perfect JSAT Corporation
Superbird 8/DSN-1 (Kirameki 1)	2018	GEO	Ariane 5	Guiana Space Center	Commercial/Military	Sky Perfect JSAT Corporation/ DSN Corp.

Table 8: Japanese Telecommunication satellites (source: ESPI Database)

The majority of commercial communication satellites – the 10 satellites in the JCSat series, the Superbird satellites and the N-Star C satellite – however are owned and operated by SKY Perfect JSAT Corporation. This corporation was created in 2008 through the merger of three large Japanese communication companies (see Figure 12).

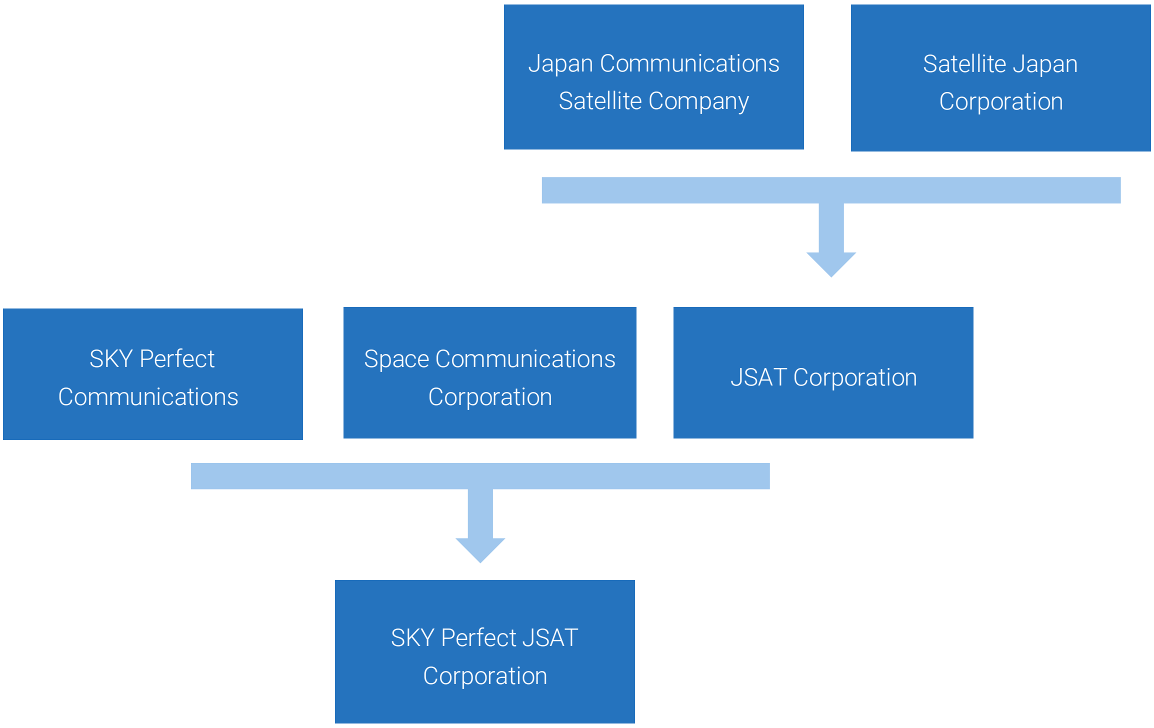

Figure 12: SKY Perfect JSAT Corporation (source: authors´ visualisation)

Navigations satellites

Alongside the existing Global Navigation Satellite Systems (GNSS), i.e. the US Global Positioning System (GPS), China's BeiDou, Russia's Global Navigation Satellite System (GLONASS) or Europe's Galileo system, India and Japan have developed Regional Navigation Satellite Systems (RNSS)[94].

Japan operates a system called the Quasi-Zenith Satellite System (QZSS). Its first satellite was launched in 2010 (QZS-1) and the constellation was increased to a 4-satellite constellation in 2017 with the launches of QZS-2, QZS-3 and QZS-4 and with the aim of increasing the constellation to 7 satellites. The QZSS's aim is to provide "highly precise and stable services in the Asia-Oceania region"[95] and it follows an orbital path above Japan in the shape of an eight. Previous to launching the QZSS, Japan was dependent on GPS satellites for providing navigation and positioning services[96]. The QZSS was developed to provide services where GPS was not able to provide stable and precise positioning[97]. Now, the QZSS is still to an extent dependent on the GPS but also compatible with the constellation and augments it through providing additional satellites and "augmentation signals improving GPS positioning accuracy"[98]. The major specifications of the QZSS are provided in Table 9.

[94] Sitruk, A., & Plattard, S. (2017). *The Governance of Galileo.* Vienna: European Space Policy Institute.
[95] Cabinet Office. (2018, August 16). *[Movie] Quasi-Zenith Satellite System 'QZSS'*. Retrieved from Quasi-Zenith Satellite System (QZSS): http://qzss.go.jp/en/overview/downloads/movie_qzss.html.
[96] Cabinet Office of Japan. (2018). *What is the Quasi-Zenith Satellite System (QZSS)?*. Retrieved from Quasi-Zenith Satellite System (QZSS): http://qzss.go.jp/en/overview/services/sv02_why.html.
[97] Ibid.
[98] Sitruk, A., & Plattard, S. (2017). *The Governance of Galileo.* Vienna: European Space Policy Institute.

QZSS Specifications	
Satellites	• QZS-1 (1st Quasi-Zenith Satellite) • QZS-2 (2nd Quasi-Zenith Satellite) • QZS-3 (3rd Quasi-Zenith Satellite) • QZS-4 (4th Quasi-Zenith Satellite)
Coverage	Coverage of Asia-Oceania region with one satellite in near-zenith position over Japan at all times
Orbit	• QZS-1,2,4 in inclined geostationary orbit in the shape of a figure-eight with north-south asymmetry • Orbit in the northern hemisphere lasts approx. 13 hours and approx. 11 hours in the southern hemisphere • QZS-3 in geo-stationary orbit
Accuracy	• 10m (PNT (with GPS)), • 1m (SLAS for code phase positioning) • 6cm (CLAS for carrier phase positioning)
Navigation Signals & Transmission service	• Positioning, Navigation and Timing Service (PNT) : L1-C/A, L1C, L2C, L5Sub-meter Level Augmentation Service (SLAS) & Satellite Report for Disaster and Crisis Management (DC Report): L1S • Centimeter Level Augmentation Service (CLAS): L6
Design life of satellites	• QZS-1: 10 years • QZS-2～4: 15 years
Master Control Stations	• QZSS Control Center, Hitachi-Ota (main operation site) • QZSS Control Center, Kobe (redundant site)
Number of Satellite Control Stations	7
Number of Monitor Stations	30

Table 9: Quasi-Zenith Satellite System (source: CAO)[99]

2.2.4 Space Science and Exploration

Japan has a world-class space sciences programme and a long-standing experience in robotic exploration. Already in 1990, thanks to the successful launch of its Hiten lunar probe, Japan succeeded

[99] Cabinet Office of Japan. (2018). *What is the Quasi-Zenith Satellite System (QZSS)?* Retrieved from Quasi-Zenith Satellite System (QZSS): http://qzss.go.jp/en/overview/services/sv02_why.html.

in breaking the monopoly on missions to the Moon held by the US and the USSR[100]. Robotic exploration of the Moon continued with the launch of SELENE in September 2007. The probe, also known as Kaguya, impacted on the Moon after the successful completion of its operation in June 2009.

Whilst the country's Mars exploration programme turned to be unsuccessful - the Nozomi (Wish) Mars orbiter launched in June 1998 was in fact unable to reach Mars orbit due to an electrical failure[101] - Japan was also the first country to successfully implement an asteroid sample return mission (SRM). The Hayabusa (Peregrine Falcon) mission, launched in May 2003, explored the Near-Earth Asteroid Itokawa and successfully returned some samples to Earth in June 2010. A second asteroid SMR, Hayabusa-2, was launched in 2014 and in February 2019 it successfully landed on asteroid Ryugu, from which it will return sample to Earth in December 2020.

In addition to these notable exploration missions, over the years Japan has launched a variety of astronomical, space physics and near-Earth observation satellites, an overview of which is provided in Table 10.

Space exploration	Astronomical and Space Physics Observation	Near Earth Space Observations	Experimental and Test Satellites
• Akatsuki • Bepi-Colombo • Hayabusa • Hayabusa-2 • Ikaros • Kaguya • Nozomi • Sakigake • Susei	• Akari • Asca • Hakucho • Haruka • Hinode • Hinotori • Hisaki • Hitomi • GINGA • Suzaku • Tenma • Yohkoh	• Akebono • Arase • Denpa • Geotail • Jikiken • Kyokkou • Ohzora • Reimei • Shhinsei • Taiyo	• Express • Hiten • Ohsumi • SFU • Tansei • Tansei-2 • Tansei-3 • Tansei-4

Table 10: Space Science and exploration missions (source: ISAS)[102]

Japan's space science and exploration programmes are led by the JAXA's Institute of Space and Astronautical Science (ISAS). The stated goals of the programme are "to expand our knowledge of human life in regard to origins of the Earth and the solar system, origins of cosmic space, time and matter and the possibility of extra-terrestrial life and at the same time to lead technology revolutions which will cause a paradigm shift in space engineering"[103]. An overview of the still operational science and exploration missions launched to fulfil these goals is provided in Table 11.

[100] Hiten, was Japan's first lunar probe, the first robotic lunar probe since the Soviet Union's Luna 24 in 1976, and the first lunar probe launched by a state other than the Soviet Union or the United States.
[101] Operation was terminated in December 2003 and the Mars Exploration programme put on hold.
[102] Institute of Space and Astronautical Science. (n.d.). *Current Spacecraft*. Retrieved from JAXA: http://www.isas.jaxa.jp/en/missions/spacecraft/current/.
[103] Institute of Space and Astronautical Science (2020). Vision. Retrieved from: http://www.isas.jaxa.jp/en/about/vision/.

Name	Year	Mission Overview
Magnetospheric Observation Satellite (GEOTAIL)	1992	The "GEOTAIL" is a satellite to study the structure and dynamics of Earth's magnetotail. It is a collaborative project between Japan and the United States.
Technology Demonstator “REIMEI”	2005	Reimei aims to demonstrate of next-generation advanced satellite technologies in orbit, realization of small-scale, frequent scientific observation missions.
Solar Physics Satellite "HINODE"(SOLAR-B)	2006	The "HINODE" (SOLAR-B) is the successor to the orbiting solar observatory YOHKOH (SOLAR-A) to explore the mysteries and mechanisms of the solar corona phenomena and other mechanisms.
Venus Exploration Mission "AKATSUKI" (PLANET-C)	2010	AKATSUKI is a planetary exploration project following the Martian orbiter "NOZOMI" (PLANET-B) to unveil the mysteries of the atmosphere of Venus.
Small Solar Power Sail Demonstrator "IKAROS"	2010	IKAROS is the world's first solar powered sail craft employing both photon propulsion and thin film solar power generation during its interplanetary cruise.
Asteroid Explorer "HAYABUSA-2"	2014	Hayabusa2 will target a C-type asteroid Ryugu to study the origin and evolution of the solar system as well as materials for life by leveraging the experience acquired from the Hayabusa mission.
Spectroscopic Planet Observatory Satellite "HISAKI" (SPRINT-A)	2016	The “HISAKI” (SPRINT-A) observes Jupiter’s Io plasma torus and interaction of the strong solar wind on the atmosphere of an Earth-type planet by the extreme-ultraviolet (EUV) imaging spectrometer. Spectroscopic Planet Observatory for Recognition of Interaction of Atmosphere
Geospace Probe “ARASE” (ERG)	2016	The "ERG" aims at elucidating highly charged electrons that generate and vanish repeatedly along with space storms in the geospace, the region of outer space near the Earth.
Mercury Exploration Mission "BepiColombo" (MIO)	2018	The "BepiColombo," a Mercury exploration project jointly planned by Japan and the European Space Agency (ESA), will conduct comprehensive observations of Mercury's magnetic field and its surface and interior.

Table 11: Operational science and exploration missions[104] [105]

[104] Japan Aerospace Exploration Agency. (n.d.). *Research on Space Plasma, X-Rays, and Infrared-Rays*. Retrieved from: https://global.jaxa.jp/projects/sas/plasma/.
[105] Japan Aerospace Exploration Agency. (2017). *About Research on Lunar, Planetary Science*. Retrieved from: https://global.jaxa.jp/projects/sas/planetary/.

2.2.5 Human Spaceflight

Japan has a long tradition of human spaceflight, with the first astronaut (Mori Mamoru) flying on the Space Shuttle in September 1992. Despite lacking an autonomous human-rated launcher, Japan is the only Asian country which is an owner of a module contributing to the International Space Station (ISS), together with Russia, the United States, Canada and the European consortium. Japan signed the ISS Intergovernmental Agreement (IGA) in 1998. Furthermore, JAXA signed a Memorandum of Understanding (MoU) with NASA and multiple bilateral arrangements related to implementation – these frameworks are intended to distribute the roles and responsibilities on the ISS and set rules for the operation of the ISS[106].

Japan´s participation in the ISS programme has two important cornerstones: exploitation of the Japanese experiment module KIBO (Hope) and the H-II Transfer Vehicle (HTV), the automated cargo spacecraft used to resupply the KIBO and the ISS.

KIBO

Kibo (see Figure 13) was designed and developed to conduct scientific research activities on-board of the ISS. It is the largest experiment module on the ISS and comprises the following six major elements:

- two experiments facilities, a Pressurized Module (PM) to conduct experiments in a microgravity environment and an Exposed Facility (EF) to enable "long-term experiments in open space as well as Earth and astronomical observations"[107].
- two logistics modules, the Experiment Logistics Module in the Pressurised Section (ELM-PS) and the Experiment Logistics Module in the Exposed Section (ELM-ES)
- a robotic arm, the Japanese Experiment Module Remote Manipulator System (JEMRMS)
- an inter-orbit communication system (ICS)

The docking and assembly operations were completed in July 2009 and the exploitation phase followed shortly afterwards. A variety of scientific and educational experiments are being conducted on Kibo, including experiments on material and life science research, medical research as well as extravehicular experiments[108].

[106] European Space Agency. (2019). *International Space Station Legal Framework*. Retrieved from ESA: https://www.esa.int/Our_Activities/Human_and_Robotic_Exploration/International_Space_Station/International_Space_Station_legal_framework.
[107] Japan Aerospace Exploration Agency. (2019). *About International Space Station (ISS) and Japanese Experiment Module "Kibo"*. Retrieved from International Space Station (ISS) and Japanese Experiment Module "Kibo": https://global.jaxa.jp/projects/iss_human/kibo/.
[108] Japan Aerospace Exploration Agency. (2019). *About Space Environment Utilization and Space Experiment*. Retrieved from Space Environment Utilization and Space Experiment: https://global.jaxa.jp/projects/iss_human/research/.

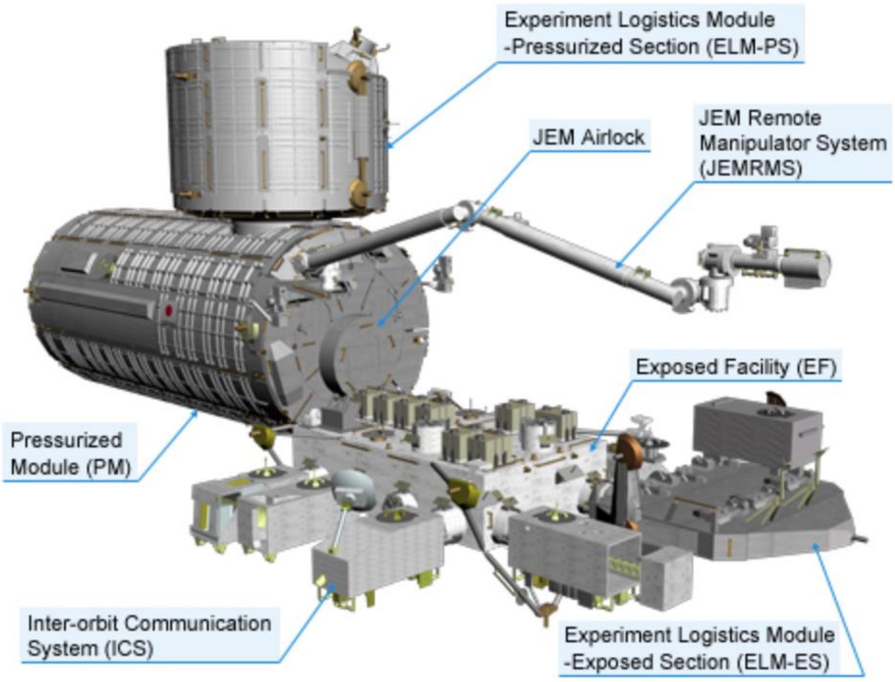

Figure 13: Japanese Kibo module[109]

While the exploitation is primarily entrusted to JAXA, the agency has been inviting universities and other academic institutions to propose experiment topics to be performed on Kibo. Kibo's utilisation has been also opened to international cooperation and, remarkably, the private sector, which can use the module through the payment of some fees. The most prominent example is the JAXA/United Nations Office for Outer Space Affairs (UNOOSA) collaborative project KiboCUBE, which "aims to provide educational or research institutions from developing countries of United Nations membership with opportunities to deploy, from the ISS Kibo, cube satellites (CubeSats) which they develop and manufacture"[110]. Another example is Kibo-ABC, a collaborative initiative established within the APRSAF framework "to promote ISS/Kibo utilization in the Asia-Pacific region and to share and build on the outcomes of Kibo utilization. The objectives of Kibo-ABC include: promotion of Kibo utilization among researchers and engineers in Asian countries, accumulation of experience and enhancement of capacity among participating space agencies through implementation of projects utilizing Kibo, and creation of bilateral cooperation projects on Kibo utilization between member countries and Japan"[111].

HTV

The HTV, also known as Kōnotori (Oriental Stork), is the Japanese automated cargo spacecraft used to resupply the KIBO and the ISS with food, clothes, experiment devices and large equipment, such as International Standard Payload Rack (ISPR) and the ISS batteries, that other cargo spacecraft cannot deliver. With its transport capacity of up to six tonnes, the HTV is the world's largest cargo transporter to the ISS. It comprises three major parts:

- a logistics module to store supplies (and waste) in the front,

[109] Japan Aerospace Exploration Agency. (2008). *About Kibo, Major Component*. Retrieved from: https://iss.jaxa.jp/en/kibo/about/kibo/.
[110] United Nations Office for Outer Space Affairs. (2019, February). *The United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE"*. Retrieved from UNOOSA: http://www.unoosa.org/oosa/en/ourwork/psa/hsti/kibocube.html.
[111] Asia-Pacific Regional Space Agency. (2019). *Kibo-ABC (Asian Beneficial Collaboration through "Kibo" Utilization)*. Retrieved from APRSAF: https://www.aprsaf.org/initiatives/kibo_abc/.

- an avionics module installed in the centre, and
- a propulsion module installed in the rear[112].

The HTV performed its maiden flight to the ISS in 2009, in total providing 9 successful deliveries to the ISS as of June 2020.

Currently, JAXA has a corps of 7 active astronauts performing four major tasks during their stay on the ISS: experiments and research, operation and maintenance of the ISS and KIBO module, robotic arm operations, extravehicular activity[113].

2.2.6 Space Domain Awareness

Japan has built an infrastructure for Space Situational Awareness (SSA) activities, which, in addition to space surveillance and tracking (SST), covers Space Weather (SWE) and Near-Earth Objects (NEOs)[114]. SSA facilities include:

- Kamisaibara Space Guard Centre (radar facility), located in the Okayama prefecture
- Bisei Space Guard Center (optical observation facility), also located in Okayama prefecture
- Tsukuba Space Center (data analysis facility), located in the Ibaraki prefecture

An overview of the capabilities of Japan's current SSA system are provided in Table 12.

SSA Capabilities		
Radar	Observation capacity	1.6 m class (at an altitude of 650 km)
	Number of observable objects at once	Up to 10
Optical telescope	Detection limit grade	1 m telescope: about 18 grade
		50 cm telescope: about 16.5 grade
Analysis system	Number of managed targets	Max 30,000 objects
	Amount of observation data (Radar)	200 paths/day
	Compiling an observation plan etc.	Manual processing

Table 12: Japan's current SSA capabilities (source: JAXA)[115]

With regards to SST, JAXA possesses some relevant software capabilities, in terms of data collection, data processing and data provision. Through its facilities, JAXA performs the following tasks: 1) monitoring space debris, 2) database compilation of debris orbits, 3) analysis of their approach to satellites, and 4) predestination of their re-entry into the atmosphere[116]. SSA activities are implemented also by MOD, with a view to construct an integrated framework among JAXA, MOD and other Japanese

[112] Japan Aerospace Exploration Agency. (2019). *HTV: H-II Transfer Vehicle "Kounotori".* Tokyo: Japan Aerospace Exploration Agency Public Affairs Department.
[113] Japan Aerospace Exploration Agency. (n.d.). *Human Space Activities / Utilization of the Space Environment*: Astronauts. Retrieved from: https://global.jaxa.jp/projects/iss_human/astro/.
[114] Lal, B., Balakrishnan, A., Caldwell, B. M., Buenconsejo, R. S., & Carioscia, S. A. (2018). *Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM).* IDA Science & Technology Policy Institute.
[115] Japan Aerospace Exploration Agency. (2019). *Space Situational Awareness (SSA) System.* Tokyo: JAXA.
[116] Ibid.

governmental institutions. Overall, while Japan can deliver value-added products, it is still reliant on outside capabilities, particularly those of the United States, with which Japan has signed an SSA sharing agreement[117].

With respect to space weather, since 2015, Japan's space weather research is guided by a research framework titled Project for Solar-Terrestrial Environment Prediction (PSTEP). Within this framework, scientists from the National Institute of Information and Communications Technology (NICT), Kyoto University as well as Nagoya University are researching on different topics ranging from magnetosphere and ionosphere dynamics, the solar cycle, solar storms, to the forecasting of space weather[118].

Japan's NICT runs the Space Weather Forecast Centre which "has continuously delivered the space weather forecasting information since 1988"[119]. It contributes to the International Space Environment Service (ISES) by acting as a regional warning centre, delivering an "Operational Space Weather Forecast, ground-based observations, developing original space weather forecasting code"[120]. Through its Space Weather Forecast Centre, Japan makes up one of 16 countries collaborating on space weather research – with ESA contributing through a Collaborative Expert Centre[121]. Japan also continues to collaborate internationally through the Asia-Oceania Space Weather Alliance (AOSWA), which was established in 2010 to facilitate information sharing on space weather in the region[122].

It is estimated that approximately 10,000 asteroids in our solar system are so-called near-Earth Objects (NEOs). NASA has catalogued almost all NEOs with a size of over 1km, "the task of detecting 90 percent of NEOs larger than 140 meters, however, is far more challenging"[123] and although smaller objects than 1km may not "have the potential to threaten civilization"[124], but "are capable of causing severe localized damage if they enter Earth's atmosphere above populated land areas"[125].

Japan has contributed to international efforts to increase knowledge on and monitoring of NEOs. Notable undertakings in this regard are its *Hayabusa* missions. The spacecraft Hayabusa 1 landed on a small near-Earth asteroid "Itokawa" and established "innovative ion engines"[126] and returned to Earth with samples in 2010. Hayabusa 2 – launched in 2014 by an H-IIA launcher – landed on the larger near-Earth asteroid "Ryugu". Like Hayabusa 1, its purpose is to collect samples. However, Hayabusa 2 deployed an impactor which collided with the asteroid, creating a crater from which samples will be obtained "in order to elucidate the origin and evolution of the solar system and primordial materials that would have led to the emergence of life"[127]. Furthermore, asteroid exploration can provide valuable information on how protect Earth from NEOs. Hayabusa 2 is scheduled to return to Earth in 2020.

2.3 Space Law and Policies

Although Japan was the first Asian country and only the 4th country worldwide after the USSR, US and France to launch a satellite into space – thus becoming a spacefaring nation in 1970 – remarkably it took

[117] Sakamoto, N. (2015). *Overview of Space Situational Awareness in Japan*. Office of National Space Policy, Cabinet Office, Government of Japan. Retrieved from: http://www.jsforum.or.jp/debrisympo/2015/pdf/11%20150226_Sakamoto_rev.pdf.
[118] Ishii, M. (2017). Japanese Space Weather Research Activities. *Space Weather,* Vol 15(1), 26-35.
[119] National Institute of Information and Communication Technology (2020). "Space Weather Forecast Center". Retrieved from: http://swc.nict.go.jp/en/.
[120] Ishii, M. (2017). Japanese Space Weather Research Activities. Space Weather, Vol 15(1), 26-35.
[121] Ibid.
[122] Asia-Oceania Space Weather Alliance. (2020). "Introduction". Retrieved from: http://www.ukm.my/aoswa/introduction/.
[123] Secure World Foundation. (2014). *Near Earth Objects: Responding to the International Challenge.* Washington D.C.: SWF. Retrieved from: https://swfound.org/media/170684/swf_neos-responding_to_the_international_challenge_2014.pdf.
[124] Ibid. p.13.
[125] Ibid. p. 8.
[126] Japan Aerospace Exploration Agency. (2014). Hitoshi Kuninaka, Project Manager, Asteroid Explorer Hayabusa2 "A Path Toward Space Exploration" Retrieved from: https://global.jaxa.jp/article/2014/interview/vol88/.
[127] Ibid.

Japan significantly longer to develop comprehensive legislation pertaining to space. In 2007, the Liberal Democratic Party (LDP) and New Komeito – the ruling parties at the time – submitted the "Basic Space Bill" to the Japanese Diet. In 2008, the Basic Space Law was approved and entered into force on 27 August, 2008[128]. The Basic Space Law of 2008 to this day makes up the most important legislative document pertaining to space for Japan and builds the foundation of all space policy, which will be detailed in the subsequent sections.

2.3.1 Basic Space Law 2008

The Basic Space Law's aim is to "stipulate basic principles and basic matters for the realization of the basic principles" in regards to the development and use of outer space[129]. The Law is structured into five Chapters: 1) General Provisions; 2) Basic Measures; 3) Basic Space Plan; 4) Strategic Headquarters for Space Development; 5) Enactment of Legislation with regard to Space Activities.

The first chapter's general provisions contain articles on the purpose of the Basic Space Law in regard to its compatibility with the Constitution of Japan, particularly in regard to the notion of "Peaceful Use of Outer Space". Here it affirms that Japan's use of space falls in line with treaties and international agreements, such as the Outer Space Treaty – thus adjusting its interpretation of "peaceful" to the internationally practiced definition which allows for military use of space.

Furthermore, it contains the Basic Space Law's objectives, which are "the improvement of the Lives of the Citizenry", "advancement of industries", "development of human society", while carrying out the activities with "international cooperation" and the "consideration for the environment" in mind[130]. Moreover, it details the responsibilities of the State and local governments and that the effective use of space shall be promoted through cooperation between all stakeholders, legislative measures and administrative reform.

The second chapter sets out objectives for the Japanese space programme which include how it should serve Japanese people, the industry as well as national security. Some measures mentioned pertain to independent launch capabilities, telecommunication satellites, reliability of space technology, the promotion of the space industry and R&D[131].

Chapter three and four also introduced institutional changes, such as the introduction of the Strategic Headquarters for Space Policy, which is now the political body chaired by the Prime Minister that sets the direction of the national space policy and drafts the Basic Plan on Space Policy[132] – which will be discussed in the next section. Lastly, chapter five provides objectives with which in mind Japanese space legislation should be enacted – i.e. to further the implementation of international treaties and agreements as well as to further Japanese national interests, including its national security interests[133].

2.3.2 Basic Plans on Space Policy

According to Article 24 (2) of the Basic Space Law of 2008, the Basic Plan on Space Policy (BSP) prescribes "the basic policy with regard to Space Development and Use", "the measures the Government shall comprehensively and systematically implement with regard to Space Development and Use" as well

[128] Aoki, S. (2009). Current Status and Recent Developments in Japan's National Space Law and its Relevance to Pacific Rim Space Law and Activities. *Journal of Space Law*, 363-438.
[129] Cabinet Office. (2008). *Basic Space Law.* Tokyo: Cabinet Office. Retrieved from: http://stage.tksc.jaxa.jp/spacelaw/country/japan/27A-1.E.pdf.
[130] Cabinet Office. (2008). *Basic Space Law.* Tokyo: Cabinet Office. Retrieved from: http://stage.tksc.jaxa.jp/spacelaw/country/japan/27A-1.E.pdf.
[131] Ibid.
[132] Ibid.
[133] Ibid.

as "concrete goals and fixed time frames for realizing them"[134]. Indeed, the four BSP released thus far – the first one in 2009, then 2013, 2015 and the most recent one in 2020[135] – are structured along the government's goals for the space policy, concrete approaches and measures planned, programmatic targets and Japan's conceptualization of geopolitical challenges and the role of space plays for Japan. An overview of the 2020 BSP, released on 30 June 2020, is provided in Table 13.

Basic Space Plan 2020
The 2020 Basic Plan on Space Policy is structured around 4 main parts. The first part reflects on the context and the environment in which the space policy functions and points out particular circumstances such as changes in the outer space power balance, the growing importance of space security, the exacerbating risks to the stable and sustainable utilization of outer space, the rise of private space activities, the rapid advances in S&T as well as the spread of worldwide space activities. Part 2 of the policy reflects on the goals of Japan's space policy which are "contributing to national interests" as well as the "maintenance and reinforcement of the space infrastructure, including the industrial, scientific and technological base"[136]. Stated national interests are: • ensure space security, • strengthen disaster countermeasures, national (land) resilience and contribute to addressing global issues, • create new knowledge through space science and exploration, • realise space-driven economic growth and innovation. In Part 3, the Basic Plan on Space Policy continues to state "Japan's basic stance for fostering space policy" which includes guidelines on the prioritizations of certain aspects of the space policy as well as regarding the implementation procedures and concomitant budget allocations. The 2020 Plan in particular puts the spotlight on the following features: • an output-driven space policy based on different user requirements (including security ones), • a space policy providing investment predictability through long-term planning, • a space policy making efficient and effective use of various resources (including financial and human resources), • a space policy oriented towards cooperation with allies and trustworthy nations. Lastly, the fourth part of the Basic Plan on Space Policy includes "Japan's concrete approach to space policy", which outlines specific programmatic measures Japan plans to employ to reach the objectives detailed in the policy.

Table 13: The 2020 Basic Space Plan

As can be ascertained from Figure 14, each subsequent space plan took over from and replaced the preceding Plan. Additionally, the government has released so-called "Implementation Plans of the Basic Plan on Space Policy", which detail concrete programmatic targets and their implementation timelines[137]. The Implementation Plans do not replace the Basic Plan on Space Policy, but rather work in conjunction

[134] Cabinet Office. (2008). *Basic Space Law*. Tokyo: Cabinet Office. Retrieved from: http://stage.tksc.jaxa.jp/spacelaw/country/japan/27A-1.E.pdf.
[135] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf
[136] Ibid.
[137] As officially named by the Cabinet Office, although the Japanese word "工程表" is also often translated as roadmap.

as the main plan that sets out the measures used to reach the objectives envisioned in the Basic Plan on Space Policy.

2.3.3 Implementation Plans

A notable policy document functioning in parallel to the Basic Plan on Space Policy is the aforementioned

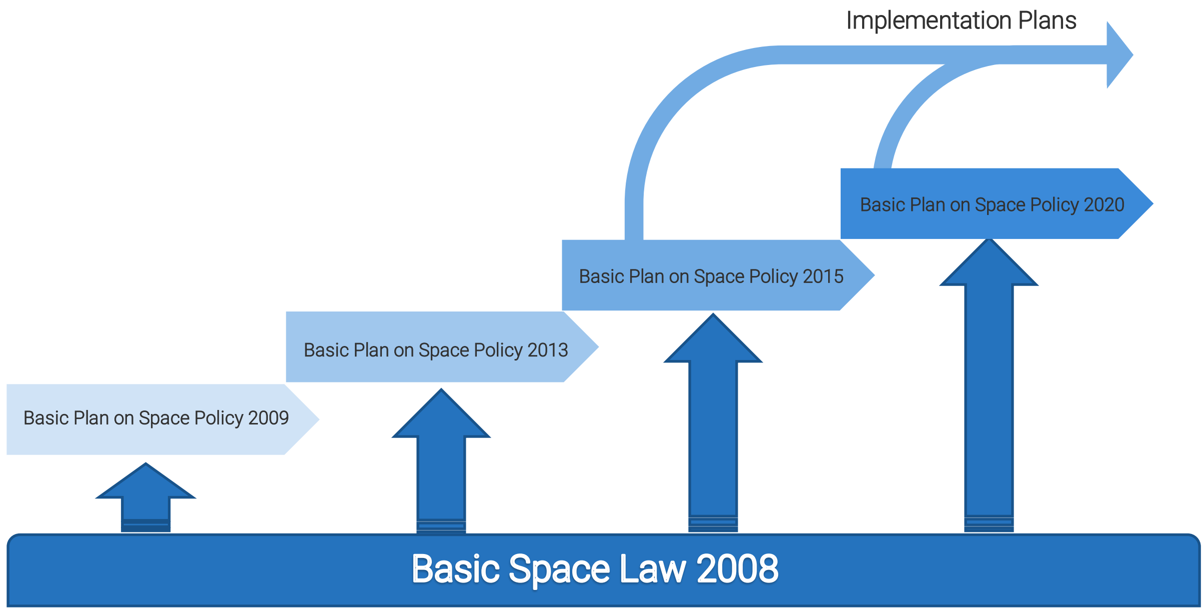

Figure 14: Evolution of Japan's space policy

Implementation Plan of the Basic Plan on Space Policy. This plan lays out how the objectives set in the Basic Plan on Space Policy will be implemented in a practical manner and details programmatic targets and timelines for a variety of components of the Japanese space programme. The plan is updated every year, with the latest version released on 13 December 2019[138].

Firstly, the Implementation Plan provides specific measures in the domains of: satellite positioning, satellite remote sensing, satellite communications and satellite broadcasting, space transportation systems, Space Situational Awareness (SSA), Maritime Domain Awareness (MDA) and other Early Warning functions. Furthermore, it illustrates the "measures and projects to strengthen the science and technology industrial base and infrastructure", which include measures which aim to foster the industry and new commercial space actors, those that can foster "environmental improvements for facilitating the stable supply of core components for space systems" and "initiatives aimed at expanding further space utilization"[139].

There are a number of measures Japan sets out to employ in order to "strengthen systems and frameworks supporting the development and use of space as a whole", including the improvement of laws and policy promotion, organizational functions as well as "domestic human capital and increase of public awareness"[140].

[138] Cabinet Office. (2019). 宇宙基本計画工程表 (Implementation Plan of the Basic Plan on Space Policy). Tokyo: CAO.
[139] Ibid.
[140] Ibid.

Lastly, as space diplomacy is crucial for Japan's space programme, the Implementation Plan sets out to promote not only international space cooperation but also international rule of law and the sharing of space systems with other countries[141] .

2.3.4 Other Policy and Legal Tools

In addition to the Basic Space Law, the Basic Plan on Space Policy and the Implementation Plan, Japan has enacted a number and thematic policies (e.g. vis-à-vis space transportation, industry and space exploration, etc.) special laws, regulations and guidelines to deal with specialized thematic issues pertaining to space – thus creating a comprehensive regulatory framework.

These laws have been adopted on the basis of Article 35 of the Basic Space Law, which stipulates that "The Government shall carry out the enactment of legislation on necessary matters comprehensively, systematically and promptly, in order to implement treaties and other international agreements with regard to regulations on space activities as well as other Space Development and Use. The enactment of legislation prescribed in the preceding paragraph shall be carried out in order to advance the national interests of Japan in international society and to contribute to the promotion of Space Development and Use by the private sector"[142]. The regulatory framework includes:

- the Act on Launching of Spacecraft, etc. and Control of Spacecraft (Act No. 76 of 2016)[143]
- the Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (Act No. 77 of 2016)[144]
- Manual for Procedures regarding International Frequency Allocation for Small Satellite Constellations

As for the thematic policies, the most important include:

- The *Space Industry Vision 2030* of 2017, aimed at expanding the private space sector[145]
- The *Long-term Vision for Space Transportation Systems* of 2014[146]
- *Strategy on Space Parts and Component Technical Development of 2018*[147]
- *Vision for Enhanced Human Resource Bases in the Space Industry* of 2018[148]
- *Japan National Defense Program Guidelines for FY 2019 and beyond*[149].

A more detailed overview of these legal tools and policy documents will be provided in the following chapters.

[141] Ibid.
[142] Cabinet Office. (2008). *Basic Space Law.* Tokyo: Cabinet Office. Retrieved from: http://stage.tksc.jaxa.jp/spacelaw/country/japan/27A-1.E.pdf.
[143] Cabinet Office of Japan. (2016). *Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (Act No. 77 of 2016).* Tokyo: Cabinet Office.
[144] Cabinet Office of Japan. (2016). *Act on Launching of Spacecraft, etc. and Control of Spacecraft (Act No. 76 of 2016).* Tokyo: Cabinet Office of Japan.
[145] Cabinet Office. (2017). 宇宙産業ビジョン 2030 (Space Industry Vision 2030). Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/vision/mbrlistsitu.pdf.
[146] Committee on National Space Policy. (2014). 宇宙輸送システム長期ビジョン (Long-term Visions on the Space Transportation System). Tokyo: CNSP. Retrieved from: https://www8.cao.go.jp/space/comittee/kettei/vision.pdf.
[147] Ministry of Economy, Trade and Industry. (2016). 宇宙用部品・コンポーネントに関する 総合的な技術戦略 要旨 (Summary of Comprehensive Strategy on Space Parts and Components' Technical Development)- Tokyo: METI. Retrieved from: http://www.meti.go.jp/policy/mono_info_service/mono/space_industry/pdf/buhinsenryaku.pdf.
[148] Ministry of Economy, Trade and Industry. (2018). 宇宙産業分野における人的基盤強化のための検討会 報告書概要 (Summary of the Report of the Study Group for Strengthening the Human Resource Base in the Space Industry). Tokyo: METI. Retrieved from: https://www.meti.go.jp/english/press/2018/0501_002.html.
[149] Ministry of Defence (2018). Japan National Defense Program Guidelines for FY 2019 and beyond (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf.

2.3.5 International Agreements and Frameworks

Japan has ratified and is participant of important international treaties, conventions, inter-agency agreements and various other arrangements as can be seen in Table 14.

Inter-agency agreements	International laws/regimes	Space-related organizations
• ESA • NASA (US) • CSA (Canada) • ASI (Italy) • CNES (France) • DLR (Germany) • ROSCOSMOS (Russia) • NSC (Norway) • NSO (Netherlands) • SNSA (Sweden) • ISRO (India) • LAPAN (Indonesia) • VAST (Vietnam) • KARI (South Korea) • ANGKASA (Malaysia) • Kazcosmos (Kazakhstan) • Etc.	• Outer Space Treaty • Liability convention • Rescue Agreement • Registration Convention • Partial Nuclear Test Ban Treaty • Comprehensive Nuclear Test Ban Treaty • ITU Convention • Missile Technology Control Regime • Wassenaar Arrangement • International Code of Conduct against Ballistic Missile Proliferation • International Charter "Space and major disasters" • Treaty on the Non-Proliferation of Nuclear Weapons • The ISS Intergovernmental Agreement	• APRSAF • AARS • UNCOPUOS • ICG • Committee on Earth Observation Satellites (CEOS) • Coordination Group on Meteorological Satellites (CGMS) • Group on Earth Observations (GEO) • International Space Exploration Coordination Group (ISECG)

Table 14: Japan's participation in international agreements and frameworks (source: ESPI Database)

Japan ratified most of the main international treaties governing space activities and is part of a number of arrangements relevant to space. Japan has also been an active participant in a variety of multilateral fora and space-related organisations, including the United Nations Committee on the Peaceful Uses of Outer Space (UN-COPUOS), the Committee on Space Research (COSPAR), the International Telecommunication Union (ITU), the Space Frequency Coordination Group (SFCG), the International Committee on Global Navigation Satellite Systems (ICG) the Committee on Earth Observation Satellites (CEOS), the Inter Agency Debris Coordination Committee (IADC), the Coordinating Group on Meteorological Satellites (CGMS), International Space Exploration Coordination Group (ISECG), International Global Observing Strategy (IGOS), the Asian Association for Remote Sensing (AARS), International COSPAS-SARSAT system for search and rescue operations, International Astronautical Federation (IAF), International Academy of Astronautics (IAA), International Institute of Space Law (IISL) and International Space University (ISU). Furthermore, Japan is also a member and founder of the Asia Pacific Regional Space Agency Forum (see Table 15).

The Asia Pacific Regional Space Agency Forum APRSAF
Japan proposed the inception of the Asia-Pacific Regional Space Agency Forum (APRSAF) in 1993 with the intention of creating "an open and flexible regional cooperation mechanism aimed at responding to the diversity of needs in the region"[150]. Since then, APRSAF is held every year, co-organized by MEXT, JAXA and a country from the Asia-Pacific region. About 500 participants from around 30 countries and region participate on a voluntary basis, including space agencies, governments, IOs, universities, research and private institutions, and cooperate on four primary matters: space applications, space technology, space environment utilization and space education[151]. The Executive Committee coordinates the work of APRSAF to "uphold principles, shape the agenda and help achieve objectives and implement decisions of APRSAF"[152]. APRSAF holds an annual meeting during which the different working groups report to the members of APRSAF about their progress in their various projects. The Space Applications Working Group runs two projects – Sentinel Asia and SAFE (Space Applications for Environment). The former is an international collaborative project that aims to support natural disaster management in the Asia-Pacific region, as this region is heavily affected by various natural disasters. SAFE on the other hand is "a voluntary initiative to encourage environmental monitoring in the long term to understand environmental changes"[153]. The Space Environment Utilization Working Group runs the KIBO-ABC Project (Asian Beneficial Collaboration through "Kibo" Utilization"). This project aims to "promote ISS/Kibo utilization in the Asia-Pacific Region"[154]. Furthermore, APRSAF aims to contribute to the sustainable societal and economic development in the Asia-Pacific region through space cooperative activities, including promoting space utilization for solving societal issues, enhancing participation of new players such as industry and young generations, and advancing capabilities in space policy implementation in the region. As one of these recent activities, APRSAF has been promoting the space policy community building in the Region and established a new initiative, "National Space Legislation Initiative[155].

Table 15: APRSAF Overview (source: authors' visualisation)

In terms of government-to-government cooperation, bilateral agreements have been signed with the space agencies of over 15 countries, including Australia, Canada (CSA), Italy (ASI) France (CNES), Germany (DLR) Russia (ROSCOSMOS), Norway (NSC), Netherlands (NSO), Sweden (SNSB), India (ISRO), Indonesia (LAPAN), Vietnam (VAST), South Korea (KARI), Malaysia (ANGKASA), Kazakhstan (Kazcosmos) and the United States (NASA), as well as with a number of multinational bodies, including the European Space Agency (ESA), and the European Organisation for Exploitation of Meteorological Satellites (EUMETSAT)[156].

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[150] Aliberti, M. (2013). *Regionalization of Space Activities in Asia?* Vienna: European Space Policy Institute.
[151] APRSAF. (2019). *About APRSAF*. Retrieved from Asia Pacific Regional Space Agency Forum: https://www.aprsaf.org/about/.
[152] APRSAF. (2019). *About APRSAF*. Retrieved from Asia Pacific Regional Space Agency Forum: https://www.aprsaf.org/about/.
[153] APRSAF. (2019). *About Initiatives*. Retrieved from About APRSAF: https://www.aprsaf.org/initiatives/about/.
[154] Ibid.
[155] APRSAF. (2019). *National Space Legislation Initiative*. Retrieved from APRSAF: https://aprsaf.org/initiatives/national_space_legislation/
[156] Japan Aerospace Exploration Agency (n.d.). *International Cooperation*. Retrieved from JAXA: https://global.jaxa.jp/activity/int/index.html.

2.4 From Policy to Strategy

After having assessed the current state of the Japanese space programme – including its industry, policy, institutional framework and programmes – it is this report's aim to disentangle Japan's space policy to reveal the strategy underpinning the national space efforts.

Analysts, historians and diplomats have historically either perceived the absence of a coherent Japanese strategic posture or have used descriptors such as *naïve*, *sterile*, *irrational*, *lacking*, *idealistic*, *and uninformed*. This sentiment is reflected in the perception of Japan's space efforts, which Pekkannen and Kallender describe as only becoming "anything like a coherent national strategy" with the Basic Space Law of 2008[157]. While many important policy developments in fact precede this event, with the passing of this law and subsequent space policy efforts, however, a more coherent and comprehensive strategic posture began to emerge.

In order to identify the major pillars of this space strategy, this report conducted a combined reading of all relevant policy documents published by Japan – which include laws and regulations related to space specifically but also broader security and industry related policies. More specifically, on the basis of these documents, three major focus-areas and a set of strategic objectives come to the fore, as summarised in Table 16.

Security	Industry	S&T
Ensure national and international security *through* and *in* space	Invigorate space industry growth and the emergence of sizeable space economy	Leverage the science and technology edge through progress in frontier areas

Table 16: Japan's space policy objectives (source: authors' visualisation)

The policy documents also show how these three main pillars of the space programme and the corresponding objectives are highly interrelated and build a response to a changing environment– together contributing to an overarching strategy of "securing Japan".

In order to illustrate how Japan arrives at this specific strategy for space, the three subsequent chapters of this report will systematically explore the three pillars of the programme, covering the civil, commercial and security-related aspects of the Japanese space efforts. Thus, the details of Japan's objectives regarding those domains will be covered in Chapters 3 (civil space programme), 4 (commercial space efforts), and 5 (space security).

Each chapter will first provide insight into the evolution of the pillar in the Japanese space programme, and continue to assess the drivers of the space policy for the respective pillars. The drivers are diverse, stemming from endogenous and exogenous circumstances and reflect Japan's broadened conceptualization of security and thus address a variety of domains, such as the social and economic dimensions, the military dimensions, well as the political and prestige dimensions.

As a result of these drivers, a set of objectives emerge for each pillar, which in their combined attainment should serve to "secure Japan". Lastly, each chapter will conclude with the array of "tools" Japan employs to reach the objectives identified, which include programmatic tools, legal and regulatory mechanisms as well as cooperation and diplomacy.

[157] Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press. p. 1.

3 Leveraging the Science & Technology edge

Starting with the first pillar of Japan's space policy – science & technology – this chapter will explore the evolution and drivers of Japan's civil space programme, the objectives of its civil space strategy and the tools to implement these objectives.

3.1. Japan's civil space programme: evolution and drivers

Japan has a rich history of civil space development – with researchers and space policy analysts calling it the "most accomplished space power in Asia," referring to its achievements in human spaceflight, the development of launch vehicles, satellites and robotic devices[158]. In fact, from the moment of its inception after World War II, the Japanese space programme followed an almost exclusively "science and technology (R&D)-oriented space policy"[159]. Shaped by the US occupation of Japan and a strong US influence on the post-War politics of the country as expressed in the adoption of its peace-oriented constitution, the Japanese space programme's near-exclusive focus on its civil space programme endured for half a century[160].

A significant factor contributing to this unique focus on the purely civil use of space is the "Peaceful Purposes Resolution" (PPR) of 1969, which was passed by the Japanese Diet only two years after signing the Outer Space Treaty of 1967. This resolution's interpretation of using space exclusively for "peaceful purposes" expanded beyond the internationally accepted interpretation of "non-aggressive" to one of "non-military" use of space[161]. Effectively, this barred the military from being involved in or exploring opportunities in space, i.e. using space for reconnaissance, surveillance, communications and early warning purposes[162]. It also prevented commercial actors from developing space technology with an explicit military purpose[163]. Instead, the Japanese space policy centred on "technological development and space science"[164].

While having made some advancements in the development of propellant, guidance and flight stabilization technology in the inter-war period and during World War II, the first achievement was reached in 1955 with the horizontal launch of the small "Pencil" rocket in 1955. Although only measuring 23 cm in length and 200g in weight, the development and launch of this rocket was the first significant post-war step towards the development of solid-propellant rocket technology[165].

This achievement was followed by the development of different rocket series – Baby, Kappa, Lambda – over the next 15 years which were multi-stage rockets able to carry progressively heavier payloads at increasingly higher altitudes and more sophisticated fuel technology. The Baby and Kappa rocket series in particular were constructed with the goal to participate in the International Geophysical Year (IGY), which Japan achieved in 1958 with the construction of the K-6 rocket – a two-stage rocket able to reach the threshold altitude of 100 km required for participation in the IGY. With the sophistication of Japan's rocket programme grew the need for a "new and more permanent site to accommodate the increasingly

158 Moltz, J.C. (2012). *Asia´s Space Race. National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press. p. 43.
159 Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 3.
160 Moltz, J.C. (2012). *Asia´s Space Race. National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press. p. 43.
161 Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press.
162 Peoples, C. (2013). A normal space power? Understanding 'security' in Japan's space policy discourse. *Space Policy*, 135-143.
163 Suzuki K. (2015) Space Security in Japan. In: Schrogl KU., Hays P., Robinson J., Moura D., Giannopapa C. (eds). *Handbook of Space Security*. New York: Springer.
164 Kallender, P. (2016). Japan's New Dual-Use Space Policy. The Long Road to the 21st Century. *Asie.Visions 88*.
165 Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press.

large and powerful rockets"[166] and thus, launch facilities were built in Kagoshima in 1962, which are now known as Uchinoura Space Center (USC)[167]. In parallel, while scientists were already working on the Lambda series and conducting various tests with increasing altitudes, Japan ratified the Outer Space Treaty in 1967 and adopted the aforementioned Peaceful Purposes Resolution (PPR) in 1969; thus, cementing the Japanese space programme's focus on science and technology. The development of the Lambda rockets series continued with a succession of failed launches of its new four-stage L-4S rocket but finally yielded results with the successful launch of the 24 kg heavy satellite Ohsumi in 1970 by the solid-fuel rocket L-4S-5. This development officially made Japan the fourth country in the world to launch a satellite into space. It did so with the parallel space programmes of the National Aerospace Laboratory (NAL), established in 1955, the Institute of Space & Astronautical Science (ISAS), established in 1964, the National Space Development Agency (NASDA), established in 1969.

Japan continued its launcher development in the 1970s with the Mu (M) series of rockets, which enabled Japan to launch multiple satellites into space between 1974 and 1979. Significant strides were made due to the introduction of Thrust Vector Control (TVC) technology, allowing for increased "accuracy and performance" [168]. Over the 1980s, Japan developed the fourth generation of Mu series launchers, which reached a level of sophistication to transport probes beyond low-Earth orbit in order to study Halley's Comet on its observable orbit in 1986 – constituting the beginning of the country's exploration of deep space[169].

Unique about Japan's space programme was the near-exclusive focus on and rapid technological progression of solid propellant technology for the Pencil, Baby, Kappa, Lambda, and Mu series of rockets. The country initiated its development of liquid engines in earnest in the late 1960s by signing a technology transfer agreement with the United States in 1969. This agreement allowed Japan to profit off of "the best of both worlds – maintenance of its own solid-rocket development program and acquisition of advanced US liquid technology that kick-started new generations of highly sophisticated technologies"[170]. Japan commenced the development of its Q-series of liquid propulsion Satellite Launch Vehicle (SLV), which was to be "a four-stage rocket using largely solid-fuel stages"[171] but was superseded and replaced by Japan's N-rocket series (Nippon). The N-series was a series of multi-stage rocket with liquid propulsion technology used mainly in its second stage, the technology of which it was provided with by the United States and had the objective of delivering payload to GEO[172]. This feat was accomplished in the 1977 by an N-I class launcher. The N-I class was replaced with the N-II class designed to carry heavier payloads and – with assistance from the United States in its development and manufacturing – Japan successfully demonstrated GTO launch capability in 1981. The N-II class in particular enjoyed a high success rate with eight successful placements of satellites in GEO[173]. By the mid-1980s, Japan was able to create an infrastructure capable of "constructing and launching communications and broadcasting satellites"[174] – which were a priority from the beginning of Japan's space programme[175]. Furthermore, images from Japan's meteorological satellites such as Himawari were used frequently and many sounding rockets had been launched to collect scientific data[176].

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[166] Ibid.
[167] Ibid.
[168] Ibid.
[169] Lele, A. (2013). *Asian Space Race: Rhetoric or Reality?* New Delhi: Springer.
[170] Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press.
[171] Ibid.
[172] Ibid.
[173] Ibid.
[174] Moltz, J.C. (2012). *Asia´s Space Race. National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press. p. 51.
[175] Lele, A. (2013). *Asian Space Race: Rhetoric or Reality?* New Delhi: Springer.
[176] Ibid.

Over the decades of rocket development, Japan greatly depended on manufacturing under US license as well as on the procurement of US technology – with some analysts pointing out that this relationship "has been both a benefit and a crutch" to Japan[177]. Generally, "Japan's space programme initially revolved around technology imported from the United States" in both launch vehicle and satellite development [178] and multiple US policies enshrined a dependence on US technology and lack of progress towards space indigenization and the nurturing of a healthy space industry.

As a result, Japan sought to become a more equal partner and reduce its dependence on the United States, which further strengthened its influence through the 1990 US/Japan Satellite Procurement agreement which forced Japan to open its procurement market to foreign satellites, severely impeding the protection of its own satellite market – a process which will be discussed further in Chapter 4. Through the development of its H-series of rockets, the country eventually achieved technological autonomy with its H-II class – a two stage rocket, the development of which started in 1985 and was in use from 1994 until 1999[179]. It delivered multiple satellites into space successfully and allowed Japan to be free of US licencing agreements, it was replaced by the augmented version H-IIA which had the purpose "of entering the highly competitive global commercial launch service industry"[180] and remains Japan's most important launch vehicle until today. In order to achieve full autonomous access to space, Japan replaced the US-American strap-on boosters it used until 2008. Today, Japan has fully autonomous launch capabilities and a fleet of satellites of various purposes.

Another important part of Japan's civil space programme was put into motion with the establishment of the Space Station Task Force by NASA in 1982. The US approached Canada, European nations as well as Japan to participate and when U.S. President Raegan called for the creation of the International Space Station in 1984, Japan created the "Basic Framework of Participating in the Space Station Program". Over the next years, the preliminary design of the ISS and negotiations were completed and culminated in the signing of a Memorandum of Understanding (MOU) between NASA and the respective countries participating in the ISS project in 1989. Russia joined the group a few years later in 1993 and construction began in 1998 (and was completed in 2011)[181].

The turn of the century also saw many institutional changes, which led to a fundamental change in Japan's civil space programme with the creation of JAXA as the main administrative institution responsible for space through the merger of NASDA, NAL and ISAS – now operating in a more streamlined and less bifurcated way under MEXT[182].

With the enactment of the Basic Space Law in 2008 and later the definition of the Basic Space Policy, a fundamental "paradigm shift" occurred in Japanese space policy, a departure from a purely science & technology focused space policy towards one encompassing three domains, i.e. science and technology, space industry and national security[183]. In order to understand the position of science & technology in Japan's space programme today, it is important to examine the drivers that shape space policy making regarding science & technology for Japan.

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[177] Moltz, J.C. (2012). *Asia´s Space Race. National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press. p. 51.
[178] Lele, A. (2013). *Asian Space Race: Rhetoric or Reality?* New Delhi: Springer.
[179] Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press.
[180] Ibid.
[181] European Space Policy Institute. (2017). *Outcome Report of the 11th Autumn Conference*. Vienna: ESPI.
[182] La Regina, V. (2015). *The Space Sector: EU-Japan business and technological cooperation potential.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[183] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 3.

3.1.1 Endogenous Drivers

One significant domestic driver for the advancement of science and technology identified by all the Basic Plans on Space Policy is the dependence of Japan on space assets for its national infrastructure, industry, and national security – a circumstance that applies to many countries. Applications using information from navigation, communication, broadcasting as well as remote sensing satellites have become ubiquitous and can hardly be divorced from the functioning of Japanese society anymore. Therefore, their continued development, improvement and resilience (particularly vis-à-vis space weather phenomena and purposeful interference) is a significant driver for Japan's civil space policy. Moreover, as detailed in the previous section, Japan has dedicated over 60 years' worth of science & technology research and development to its space programme and significant effort towards achieving technological autonomy and independence from the United States, particularly for its launch capabilities and satellite development. Thus, beyond the need of continued development of space, Japan already in 2015 asserted the need to "maintain the capability to carry out space operations autonomously" with hardware of the highest "technological sophistication"[184] – clearly signalling Japan's perceived fear of losing its science and technology edge and a resulting need to capitalize on past investments in space.

A second driver of Japan's S&T policy for space as identified by Japan's space policy is the shortage of human resources and the lack of a so-called "organic cycle" between science & technology, national security, and industrial vitalization. There are two main factors contributing to this perceived lack of organic cycle: Firstly, Japan has lacked "a stable and vigorous industrial infrastructure underpinning space development and utilization"[185]; and, secondly, Japan for a long time did not provide "an environment conducive to utilization of space for national security purposes, and the relevant R&D has not been conducted to a sufficient level"[186].

As will be discussed in more detail in Chapter 4, the promotion and creation of an industrial infrastructure for space were neglected for decades of Japan's space programme, partially due to Japan's low governmental demand but also impeded greatly by its relationship to the United States. Lele (2013) goes as far as to call it "Japanese space 'apartheid' at the hands of the US"[187]. The United States accused Japan of instituting unfair trading practices and even threatened with sanctions before coming to the 1990 US/Japan Satellite Procurement agreement, which had severe adverse impacts on the nascent Japanese satellite industry[188]. Furthermore, the United States had concerns about Japanese autonomous development of space assets and what it would mean for Japanese militarization and the stability of the Japan-US security alliance and cooperation[189].

Another reason for the lack of industrial development pointed out by Japan in the area of space was the aforementioned national security policy as reflected in the Peaceful Purposes Resolution of 1969, which prevented the Japanese space industry from benefitting from government procurement for military projects and the related civil spin-offs which could have resulted from these applications until the enactment of the Basic Space Law in 2008. Clearly, a significant driver for Japanese S&T policy is its contribution to this organic cycle and the linkage between "utilization needs and technological 'seeds'"[190], thus the future of Japan's utilization of space and, by extension, the future of Japan's national infrastructure, industry and security.

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[184] Ibid. pp. 6-7.
[185] Ibid. p. 6.
[186] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[187] Lele, A. (2013). *Asian Space Race: Rhetoric or Reality?* New Delhi: Springer.
[188] Ibid.
[189] Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press.
[190] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf.

A further driver for Japan's science and technology related space policy emerges from its perception of threats to Japan's socio-economic wellbeing. The country is experiencing a significant demographic change towards an increasingly aging population, thus creating fears for the future of the Japanese workforce across all sectors, including the space domain. Japan identifies the need to "cultivate and secure human resources with expertise and specialized knowledge of the space field"[191]. As a high-tech sector, innovation in the field of space science & technology will contribute to a broad strategy to mitigate economic deficiencies resulting from a dwindling labour force through innovation. Moreover, Japan perceives a threat of economic decline and economic hollowing – a matter of concern since the economic downturn in the 1990s triggered by the Asian financial crisis. While Japan avoided economic collapse, the crisis led to what is called "the lost decade". While Japan's space industry makes up but one segment of Japan's economy, the applications and data derived from space assets underpin several domains of the Japanese economy and contribute to the socio-economic wealth of the country through services provided by the government. According to the Organization for Economic Cooperation and Development (OECD) (2019), "the space sector has experienced considerable development throughout the world, with greater impacts on the larger economy boosted by both globalization and digitalization"[192]. With the entrance of new commercial actors to the field of space, "science, research and development (R&D), manufacturing and production processes are all being disrupted"[193]. Thus, boosting space science & technology is a response to challenges to Japan's socio-economic wellbeing and a significant driver for Japan's space policy.

3.1.2 Exogenous Drivers

Whilst advances in space science and technology are primarily seen as a way to cope with the opportunities and challenges emanating from domestic factors, there are also external drivers stemming from regional or international circumstances.

As detailed above, space assets are crucial for the wellbeing of Japanese society through their contributions to national infrastructure, security and industry. However, there is also a growing role of outer space to solve global challenges, such as climate change, logistics of the globalized market, food supply and security, energy needs. Due to Japan's particular geological environment, the detection of imminent natural disasters and the mitigation of their effects on the population is of particular importance to Japan. Moreover, the Ministry of Defense considers the ability to respond effectively to natural disasters, climate change and the competition over resources and energy as contributing substantially "to the improvement of the global security environment"[194]. As various remote sensing satellites are used to detect, possibly prevent or mitigate global challenges, it is imperative that Japan promote and invest in its space R&D to maintain and create new systems to more effectively respond to global challenges.

A further external driver of Japan's science & technology projects is the increased global pursuit of prestigious projects in this domain, including space exploration projects. Japan has accomplished ambitious projects itself – such as the Kibo module on the ISS, the Hayabusa missions as well as a recently announced revitalization of its lunar exploration mission and a new deep space fleet. However, particularly China is exerting regional pressure through its ambitions in science & technology as expressed by projects like its space stations and the lunar exploration program Chang'e, which has completed four successful missions thus far.

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[191] Ibid. p. 21.
[192] Organization for Economic Cooperation and Development. (2019). *The Space Economy in Figures: How Space Contributes to the Global Economy*. Paris: OECD.
[193] Ibid.
[194] Ministry of Defense. (2018). *Defense of Japan 2018*. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2018/DOJ2018_Digest_1204.pdf.

It can be argued that there are three layers to why international pursuit of science & technology projects is threatening to Japan. Firstly, there is international prestige associated with space exploration and human spaceflight and the government notes that "Japan's projects have earned high acclaim from around the globe"[195]. Space science & technology is crucial for Japan to continue to achieve "globally recognized results in the space field"[196].

Secondly, innovation in science & technology enables Japan to position itself as a provider of commercial services and public goods – an area of regional competition identified by Suzuki (2013). Japan's space assets provide data for disaster management, environmental protection or improving productivity in agriculture and other countries, particularly in the region, can seek out Japan as a provider of these services. As Suzuki (2013) states, "Japan is trying to use its advanced technology for regional leadership"[197].

Thirdly, the pursuit of space science and technology projects serves Japan's broader political goals of driving forward its regionalization efforts and acquiring leadership and in East Asia – as demonstrated in the cooperation framework of APRSAF vis-à-vis the Chinese-led Asia-Pacific Space Cooperation Organization (APSCO)[198]. These external drivers force Japan to leverage its edge in space science & technology, which can only be achieved through sustained effort, the promotion of innovation and substantial resources and funding.

A further driver for Japan's civil space policy related the aforementioned perceived a lack of organic cycle between space industry, science & technology and national security. Adding to the domestic pressures, Japan recognizes that other countries' history in space, economic systems and allocated budget differs from its own[199] and that other countries, such as the US or also the EU countries, are building a more robust organic cycle than it has been able to create. According to Japan, other countries' "national defence agencies communicate space-based system needs to R&D institutions, which conduct cutting edge R&D based on these needs, and after the technological fruits of the R&D are applied for national security purposes, they are transferred to the private sector and contribute to the vitalization of the space industry and the advancement and increased efficiency of related industries."[200].

Furthermore, apart from the Western space nations, Japan also observes a "rapid growth in space operations […] driven in particular by emerging nations such as China and India and by the activities of private-sector enterprises"[201]. As many countries in the region "lack domestic space industry infrastructure"[202], there is a clear opportunity for Japan's space industry to seize the demand of these markets – thus requiring a healthy and productive indigenous space industry fuelled by this organic cycle, for which science & technology is a requirement.

The evolution of Japan's civil space policy in has touched upon the complex relationship between Japan and the United States, which can be characterized by both control and cooperation and also forms a driver for Japan's civil space policy. There are many factors as to why Japan never gained equal footing in its relationship to the United States regarding space: Japan's dependence on US technology for launch vehicle and satellite development; the restrictive post-war national security policy heavily influenced by

[195] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 18.
[196] Ibid. p. 18.
[197] Suzuki, K. (2013). The contest for leadership in East Asia: Japanese and Chinese approaches to outer space. *Space Policy* 29(2), 99-106.
[198] Ibid.
[199] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 14.
[200] Ibid. p. 8.
[201] Ibid. p. 4.
[202] Ibid. p. 4.

the United States; trade conflicts and arrangements like the 1990 US/Japan Procurement agreement hindering its space industry development[203].

To this day, Japan perceives the US as "the world's leading space superpower", yet simultaneously observes a continuous prioritization by the US of "partnerships with allies and trustworthy nations as well as private-sector enterprises"[204]. Nonetheless, as Japan depends on the United States in several domains, such as extended deterrence in the region, the threat of excessive dependence on the United States in the realm of space can reduce Japan's autonomy. Therefore, there is a need to strike a balance between autonomy from and cooperation with the US and according to Samuels, "Japan is reacting to these uncertainties by embracing the United States closely while developing capabilities of its own to hedge against the risks of a rapidly changing security environment"[205]. As Japan arduously demonstrated in the area of launchers, science and technology is a way for Japan to achieve and maintain technical autonomy from other countries, including the United States. Although Japan continues to cooperate with the US on a great variety of projects, ranging from military projects related to the exchange of data for early warning capabilities to promoting inter-operability of the QZSS and GPS, the need to maintain a careful balance of dependence and cooperation is a driver for Japanese continued promotion of the development of science & technology for space.

3.2 Japan's civil space programme: strategic objectives

Japan's space policy has experienced a paradigm shift from a policy focused solely on science & technology to a "comprehensive national strategy" for space[206]. Science & technology now make up one of three pillars of the Japanese space policy alongside national security and industrial vitalization. Japan's overall objectives for its current civil space policy are not simply to maintain an edge in science & technology, but more properly to leverage this edge in science & technology to serve the industry, national security and society at large. Four specific objectives come to the fore:

- Stimulate economic growth and innovation and "resolve global challenges, thereby realizing a "safe, secure and prosperous society";
- Boost Japan´s prestige on the international stage;
- Ensure autonomy in the conduct of space activities;
- Embed science & technology into an organic cycle in order to serve industry and national security needs.

3.2.1 Stimulate economic growth and ensure a safe and prosperous society

A further objective of Japan's civil space strategy is to strengthen and expand the integration of the space infrastructure in Japan´s economy and society, and make the best use of this infrastructure as a driving force for Japan's economic growth and societal well-being.

As compared to 2015 edition, the 2020 Basic Space Plan has become even more vocal in stressing the need to leverage space as an engine for socio-economic growth and ensure a safe and prosperous society. Particular emphasis is attached to the efficient use of application satellites (PNT, EO, communication and

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[203] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation; Lele, A. (2013). *Asian Space Race: Rhetoric or Reality?* New Delhi: Springer.
[204] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 4.
[205] Samuels, R. J. (2007). *Securing Japan: Toyko's Grand Strategy And The Future of East Asia.* New York: Cornell University Press.
[206] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf.

broadcasting) which have already become important foundations of economic and social activities, but whose role as an infrastructure supporting economic activities and society is expected to increase further within the so-called Society 5.0.

Focus Box: Society 5.0 and Space

Society 5.0 is a concept introduced in Japan´s 5th Science and Technology Basic Plan to indicate "a human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space"[207]. Society 5.0 follows the hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0) and aims to achieve a high degree of convergence between cyberspace (virtual space) and physical space (real space) where people, things, and systems are all connected. Towards realizing this, Japan seeks to incorporate new technologies such as IoT, robotics, AI, and big data in all industries and social activities so as to simultaneously achieve both economic development and solutions to social problems[208].

Space assets are seen as playing an important enabling role in the realization of the Society 5.0. In this context, the Basic Space Plan highlights that with the advent of Society 5.0, the smooth acquisition and distribution of various types of data will become crucial and that an integration of space systems with terrestrial systems, will be needed to create advanced and secure information and communication networks that will seamlessly connect human activities on the earth, ocean, air, and space[209].

Geospatial information, including satellite remote sensing and PNT data, is also considered the key to support the fourth industrial revolution in a wide range of fields including smart agriculture, disaster prevention, transportation and logistics, living environment, and, more broadly, to realize what the Basic Space Plan calls a "G-space society", i.e. a geospatial information advanced utilization society.

Together with the advanced utilization and integration of geospatial data with other data in various fields, the 2020 Basic Space Plan pays great attention to the integration of non-space industries into the space sector and to a more synergistic use of ground and space technology for the conduct of future space activities such as the lunar exploration activities, which are also deemed important from the perspective of generating economic benefits[210].

A key role in strengthening the national economy is also assigned to the very expansion of the space manufacturing and service industry, both domestically and on the international markets (See Chapter 4). Through this expansion, Japan aims to double the size of its space industry (about 1.2 trillion yen) by the early 2030s, thereby directly contributing to the growth of the national economy.

In conducting all these activities, Japan aims to create a more solid foundation to support Japan's space activities and expand the use of space, while contributing to the broader revitalization of the national economy, by creating synergies with other economic revitalization measures.

A closely related objective in Japan's space policy is the **utilisation of space to resolve global challenges** through the promotion of space utilization in the civil sector.

[207] Cabinet Office. (2020). Society 5.0. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/cstp/english/society5_0/index.html.
[208] Ibid.
[209] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.
[210] Ibid.

Japan indeed sees a strong interlinkage between the affluence of its economy and society and its vulnerability to global challenges such as natural disasters and climate change, disruptions to the global trade or energy and resource shortages – due to its relatively high dependence on imported goods – and thus has a vested interest in the resolve of these challenges[211]. In the Basic Space Plan 2020, addressing these challenges is elevated to a key national interest.

According to the Japanese government, "Japan will utilize various space-based systems in its possession, including positioning satellites, communication and broadcasting satellites, and remote sensing satellites, and work in cooperation with the international community to contribute to the resolution of global challenges"[212]. To this end, it is crucial for Japan to continue to promote and put resources towards the continued innovation in space science & technology, thus proactively contributing as well "to the storehouse of human knowledge"[213] – making the growing role of outer space to solve global challenges a significant driver for Japan's science & technology policy.

Specifically, the 2020 Basic Space Plan recognizes that it is important for Japan's to demonstrate its leadership and make active use of its advanced space systems to help solve increasingly serious global issues such as energy, climate change, environmental issues, food, public health, and large-scale natural disasters, thereby contributing to the achievement of the United Nations Sustainable Development Goals (SDGs)[214].

3.2.2 Strengthen Japan´s international position through progress in frontier areas

Japan has accomplished significant achievements in frontier areas of space since the beginning of its space programme, being the fourth nation and the first Asian country to launch a satellite into space; and one of the first to launch a satellite to Moon and Mars. Throughout the decades, Japan has pursued ambitious projects in space science and exploration, such as its contribution to the ISS with the Kibo module and the HTV, the joint mission with ESA to Mercury (BepiColombo) as well as its more recent success with Hayabusa 2, to name a few. These successes have made of Japan one of the most accomplished space actors in the space community. However, other countries are not sitting idly.

In this respect, the 2020 Basic Space Plan recognises that space arena has shifted from the former "bipolar structure" into a "multipolar structure", with many countries attaining significant achievements and striving for leadership. The document notes that "as more countries become more active in space and global competition in S&T intensifies, Japan needs to undertake efforts to further strengthen its position as an advanced space nation"[215].

Fostering space science & technology thus enables Japan to stay abreast of the newest developments in S&T and keep pace with international ambitions towards more sophisticated and prestigious projects, in particular in the realms of human spaceflight and space exploration. Japan perceives the domain of space science and exploration – including crewed missions – to be a potential source of prestige and international recognition and thus plans on boosting Japan's international presence[216].

[211] Ministry of Defense. (2018). *Defense of Japan 2018*. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2018/DOJ2018_Digest_1204.pdf.
[212] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 8.
[213] Ibid. p. 7.
[214] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/comittee/01-kihon/kihon-dai9/siryou1.pdf. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf
[215] Ibid.
[216] Ibid.

By continuing to prioritize innovative R&D and projects in frontier areas, Japan can leverage S&T to strengthen its position in the international space hierarchy and more specifically serve as a leader in regional space activities – facilitated through positioning itself as a provider of commercial services and public goods as well as through international cooperation frameworks like APRSAF.

3.2.3 Ensure autonomy in the conduct of space activities

Since the beginning of its journey into space, an important goal of the Japanese space policy has been to ensure autonomy in the conduct of space activities, particularly in terms of accessing and using space. Autonomy has been seen as both an objective in itself and an enabler for the fulfilment of key other national interests, including national security and resilience, economic development and societal well-being. This objective continues to remain key for Japan.

In this context, the 2020 Basic Space Plan stresses that in order to contribute to various national interests, Japan needs to "become an independent space power" by strengthening the industrial, scientific and technological infrastructure that supports the independence of space activities. Specifically, building on the recognition that space assets, such as navigation, communications and remote sensing satellites, will play a fundamental role in the future societies as well as an essential role in ensuring national security, disaster response and national resilience, the document highlights that government of Japan should "continue to enhance its ability to independently develop and operate satellites and the space transportation systems required for their launch on the basis of continuous research and analysis of domestic and foreign technologies, markets and policies"[217].

At the same time, the 2020 Basic Space Plan also recognises that Japan´s industrial, scientific and technological base has begun to lag behind Europe and the United States in terms of technology development and response to the profound transformation of the space sector. Traditionally, the volume of institutional demand in Japan's space industry has been insufficient to maintain an autonomous supply chain, including the components industry, and maintaining and strengthening this supply chain has always been a major challenge. In addition, the document recognizes that "with the rapid technological innovation in the world, Japan's vision for the future has not been sufficiently drawn up and the maturation of advanced technology has been stagnant. If the gap in competitiveness is allowed to continue to grow, there is a concern that the space industry, which supported Japan's autonomy in space activities, will be severely affected".

In order to maintain Japan's ability to conduct space activities in an autonomous manner, the government recognizes that the reinforcement of the industrial, scientific and technological base is an issue that cannot be postponed. Towards this, the 2020 Basic Space Plan highlights in particular the necessity to create a new ecosystem for space activities where industry, academia, and government work together; expand domestic demand and capture foreign demand; promote R&D as well as the demonstration of advanced technologies and new concepts for future space transportation and satellite systems such as space optical communications, quantum cryptography, AI and simulation, nano-satellite systems, and satellite constellations; enhance the ecosystem for collecting and analyzing geospatial information, including satellite data; strengthen the ability to work independently on the necessary capabilities for future exploration activities, including manned activities; reinforce human resources, the space industry supply chain and the Intellectual Property Rights (IPR) regime.

[217] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf

3.2.4 Embed S&T into an organic cycle

As discussed in section *3.1.1,* Japan perceives a lack of organic cycle between space science & technology, the space industry and national security, which has resulted in a weakened space industry and poses threats to national security and technical autonomy. Therefore, Japan plans to “identify specific needs with regard to space development & utilization, from the perspective of strengthening our nation’s national security, invigorating industry, improving the Japanese people’s standard of living and promoting the advancement of space science”[218].

The Basic Plan on Space Policy already in 2015 specifies certain questions, that could be asked in this process of identifying the needs of the other domains, such as “(1) Are space-based systems and projects coordinated with existing land, marine and air defence capabilities, and are they capable of providing effective support for these capabilities? (2) Do they contribute to the reinforcement of international competitiveness and overseas marketing capabilities so as to facilitate increased domestic and overseas orders? (3) Are R&D results released and shared with other fields in a timely and appropriate manner, contributing to the invigoration of the space industry and advancement and greater efficiency of related industries, and producing ripple effects such as the generation of new industries, in a natural, organic cycle between utilization needs and technological ‘seeds’?”[219].

In other words, Japan’s objective is not to promote science & technology for science & technology’s sake, but to conduct research and development along the needs identified to serve the industry and national security objectives. Japan will properly prioritize the “maintenance and reinforcement of value-producing science and technology infrastructure”[220] by fostering R&D that provides benefits not only for short-term but also long-term goals through the collaboration between JAXA and the space industry. This approach will allow Japan not only to build resilient space systems and avoid shortages of key components, but also to look further into the future and promote S&T in frontier areas. The interplay between the three pillars of Japan’s space policy can be examined in Figure 15.

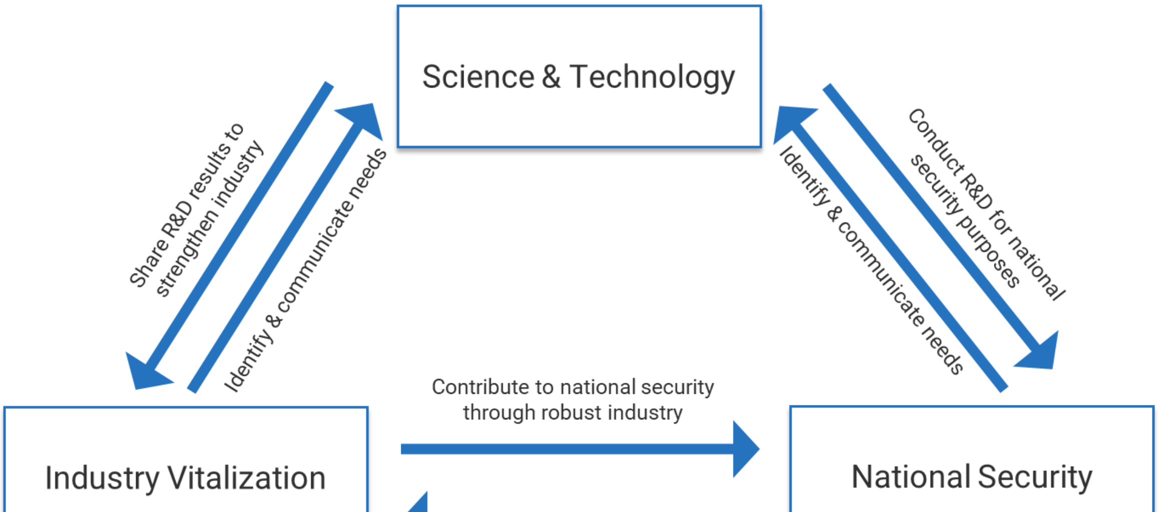

Figure 15: The organic cycle between national security, industry vitalization and science & technology (source: authors’ visualisation)

[218] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 9.
[219] Ibid. pp. 9-10.
[220] Ibid.

3.3 Tools and mechanisms to achieve objectives

3.3.1 Programmes

Space Transportation

In April 2014, the CAO released a dedicated vision document on access to space called the "Long-term Vision on Space Transportation Systems"[221]. The document identifies activities that will become common by 2040 and beyond, including deep space exploration, in-orbit satellite servicing, and deployment of space solar power systems, crewed point-to-point sub-orbital transportation, crewed sub-orbital tourism, and exploitation of Moon resources. "To prepare for this 'new normal', the government recognizes that possessing and sustaining reliable, agile and economically sound STS is critically important to continue Japan's space programs. The Vision suggests approaches to realize a world in which STS becomes a kind of infrastructure like railroads or airplanes"[222].

Consistent with this, in 2015 Basic Space Plan, the government of Japan first reiterates the resolve to prioritize the use of domestic mainstay rockets for institutional satellites (i.e. CAS, CAO, MEXT, METI, MLIT, MOE, MOD, etc.) so as to secure the autonomy of Japan's space operations.

The document then spells out four main lines of activity that will support these objectives, namely:

- the development of a New-Type Liquid-Engine Core Rocket (H3), with a view to halve the cost to enable the expansion of orders received for launch services in line with the swift start of launch services by private-sector enterprises and the schedule of the governmental satellite launch programme.
- the upgrade of the solid-fuel Epsilon Rocket, with a view to create synergies with the new H-3
- the enhancement and realignment of launch sites, "with the goal of boosting the resiliency of Japan's space-based systems"
- deliberations on rapid-response compact satellite launch systems including air-launch ways, in coordination with the studies on the operational needs and concepts for these satellites[223].

H3

The most important launch vehicle under development is the H3 launch vehicle, which is meant to be the successor of H-IIA and H-IIB and is being developed "so that Japan can maintain its autonomous access to space"[224] for spacecraft from both commercial and governmental contracts. Furthermore, the three objectives for the H3 spacecraft are "high flexibility, high reliability, and high cost performance"[225] with higher launch capabilities particularly to GTO than its predecessors.

The target cost is approximately half of the H2. The total cost of the H3 development programme, which started in 2014, have been estimated to be approximately ¥190billion (~€1.5 billion). In order to lower the manufacturing, operation and maintenance cost, MHI and JAXA have envisaged the use of a simplified

[221] Committee on National Space Policy. (2014). 宇宙輸送システム長期ビジョン (Long-term Visions on the Space Transportation System). Tokyo: CNSP. Retrieved from: https://www8.cao.go.jp/space/comittee/kettei/vision.pdf.
[222] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*.
[223] Strategic Headquarters for Space Policy. (2017). Implementation Plan of the Basic Plan on Space Policy (revised FY2017) . Tokyo: Strategic Headquarters for Space Policy.
[224] Japan Aerospace Exploration Agency. (2019). *H3 Launch Vehicle*. Retrieved from JAXA: http://global.jaxa.jp/projects/rockets/h3/.
[225] Ibid.

structure and of simplified subsystems to reduce the number of components and parts for engines, avionics, structures and propulsion systems including ground facilities. The development follows a design-for-cost approach, with MHI acting as development prime contractor (responsible for system design and manufacturing and launch service) and JAXA retaining responsibility for the overall H3 development and ground facilities as well as for critical component development (liquid engines, solid boosters, RCS, inertia measurement systems and guidance control software).

H3 is designed as a two-stage fully liquid propellant launcher, making use of evolved technology from the H-IIA/B and maximising commonalities with the Epsilon rocket. To lower cost, an expander bleed cycle engine (LE-9) will be adopted for both stages, based on the LE-5B engine of H2[226]. The first stage will use 2 or 3 LE-9 engines (150 t thrust), the single upper stage engine has a designed thrust of 14 t. As for the solid strap-on boosters, these are essentially the same as the Epsilon first stage. Overall, H3 has a length of approximately 63 m, a core stage diameter of 5.2 m and a booster diameter of 2.5m. Two fairing types have been designed, a short and a long version (see Table 17 for more specifications).

<table>
<tr><th colspan="2"></th><th>H3-22S</th><th>H3-22L</th><th>H3-24S</th><th>H3-24L</th><th>H3-30S</th><th>H3-30L</th></tr>
<tr><td rowspan="3">Stages</td><td>0. stage</td><td colspan="2">2 SRB-3 boosters (solid)</td><td colspan="2">4 SRB-3 boosters (solid)</td><td colspan="2">-</td></tr>
<tr><td>1. stage</td><td colspan="4">2 LE-9 engines (LOX/LH2)</td><td colspan="2">3 LE-9 engines (LOX/LH2)</td></tr>
<tr><td>2. stage</td><td colspan="6">1LE-5B-3 engine (LOX/LH2)</td></tr>
<tr><td rowspan="2">Performance [kg]</td><td>GTO (1,500 m/s)</td><td colspan="6">6,500+ (dV1500m/s)</td></tr>
<tr><td>SSO (500 km)</td><td colspan="6">4000+ (500 km)</td></tr>
<tr><td colspan="2">Launch site</td><td colspan="6">Tanegashima (Kagoshima Prefecture)</td></tr>
</table>

Table 17: H3 launch vehicle (source: ESPI Database)

[226] The development of LE-9 engine started in 2015, with the first engine manufactured in March 2017. On 30 April 2020, JAXA successfully carried out hot fire test for the first stage LE-9 booster. Messier, D. (3 May 2020). "Japan Test Fires Engine for New H3 Launch Vehicle" Parabolic Arc. Retrieved from: http://www.parabolicarc.com/2020/05/03/japan-test-fires-engine-new-h3-launch-vehicle/.

The H3's first launch is set for JFY 2020[227]. Following the 2020 maiden launch into SSO, a second launch to SSO is scheduled for 2021. Thereafter, the targeted launch rate will be of 5 to 6 launches per year, of which 2 to 3 will be institutional launches and 3 to 4 commercial launches. It is expected that the main transition from H-IIA to H3 should be carried out in the 2021-22 timeframe.

Epsilon Upgrades

With regards to the Epsilon launch vehicle, the 2015 Basic Space Plan and 2017 Implementation Plan clarify the target of completing the upgrading work for enhancing Epsilon's launch capabilities and its satellite coverage areas. The two documents also announce additional measures to achieving a synergistic effect with the solid rocket boosters of the H3 launch vehicle[228].

A first enhanced version of Epsilon (also referred to as Enhanced Epsilon) was launched as early as December 2016 and should be kept operational at least until 2024. Compared to Epsilon, the propellant loading of the 2nd stage was increased (14.4t vs. 10.8t) and the motor diameter expanded. Furthermore, the useable volume under the fairing was increased, resulting in an overall increase of launch vehicle length by 1.6 m. The upgrades were made to obtain a 31% increase in SSO payload capacity but also to harmonise the design with that of the future H3 strap-on booster.

Eventually, development plans foresee the introduction of Epsilon S (also referred to as Future Epsilon), which has a target performance of over 750 kg into a 500 km SSO orbit. Epsilon S will make use of further upgraded stages with increased propellant loading and will have an increased autonomy. Furthermore, the performance to LEO should be gradually improved from 1.2 t to 1.4 t. The developments should also enable a cost reduction. More specifically, Epsilon S development plan foresees:

- 1st stage propellant cost reduction, propellant loading increase from 66 to 67 t;
- 2nd stage inert mass reduction,
- 3rd stage inert mass reduction, propellant loading increase from 2.5 t to 5 t;
- 4th stage replacement by a stage using non-toxic storable propellant (See Table 18).

		Enhanced Epsilon	Future Epsilon (Epsilon S)
Stages	1. stage	SRB-A3 or (SRB-3) (BP-207 solid propellant)	
	2. stage	M-35 (14.4 t BP-205 solid propellant)	solid propellant
	3. stage	KM-V2c (HTPB)	solid propellant
	4. stage	Optional post-boost Stage (Hydrazine)	storable propellant
Performance [kg]	LEO	1,400	1400+ (500km)
	SSO	800	600+ (350-700km)-

[227] Japan Aerospace Exploration Agency. (2019). *H3 Launch Vehicle*. Retrieved from JAXA: http://global.jaxa.jp/projects/rockets/h3/.
[228] Strategic Headquarters for Space Policy. (2017). Implementation Plan of the Basic Plan on Space Policy (revised FY2017). Tokyo: Strategic Headquarters for Space Policy.

Launch sites		Uchinoura (Kagoshima Prefecture)	
Launches	Maiden flight	2016	Not flown
	Total launches	3	-
	Total failures	0	-

Table 18: Epsilon Upgrades (source: ESPI Database)

According to the Implementation Plan, in 2017 "JAXA defined the concept design based on the plan for development in synergy with the H3 launch vehicle and implemented the design concerning the addition of the thrust vector control (TVC) function to the first stage motor". They also conducted "an initial study on the use of common parts between the gas jet equipment for attitude control of the H3 and the small liquid propulsion system (PBS: post-boost stage) that corresponds to the uppermost stage of the Epsilon Launch Vehicle and on the use of common avionics parts". In 2018, JAXA also started the basic design of the second- and third-stage motors, the body structure, avionics and the small liquid propulsion system[229].

Launch sites

With respect to launch sites, in November 2017 the Japanese government "formulated the technical standards, guidelines and application manuals in consideration of the various types of operations of business operators, including rocket ventures aiming for commercial launch services"[230]. It also investigated matters necessary for the establishment of a launch range, such as the trends concerning rocket ventures (target launch markets, launch ranges, etc.) and launch needs.

Based on this, the construction of a launch pad for the H3 launch vehicle at the Tanegashima Space Centre is underway, with the aim to allow for two launches within a month, hence bringing the annual launch rate of H3 up to 10. As for Epsilon, it will still be launched from Uchinoura, although initial plans also envisaged the possibility of launching from Tanegashima.

Operationally responsive launch systems and other developments

The Japanese government began deliberations on the development rapid-response compact satellite launch systems including air-launch ways. These deliberations are being carried out in coordination with the studies on the operational needs and concepts for small, operationally responsive satellites, tailored to security needs. Towards this, in 2017 the Cabinet Office, in coordination with relevant ministries and agencies (including JAXA), began to review operational needs and concepts for these satellites[231].

Besides small launch systems, JAXA has been carrying out a reusable sounding rocket technology demonstration project in cooperation with MHI since 2010. Building on this, in 2016, JAXA and MHI reached an agreement for the joint development of a reusable experimental vehicle aimed at technology maturation. Lift-off and landing tests were conducted in 2017, while a flight test with turnover manoeuvre

[229] Cabinet Office. (2019). 宇宙基本計画工程表 (Implementation Plan of the Basic Plan on Space Policy) Tokyo: CAO.
[230] Ibid.
[231] Strategic Headquarters for Space Policy. (2017). Implementation Plan of the Basic Plan on Space Policy (revised FY2017). Tokyo: Strategic Headquarters for Space Policy.

was carried out in 2018 using a small experimental vehicle. In 2017 MHI also announced its involvement in the development of a reusable engine that could be used over 100 times. In parallel, JAXA has been conducting studies on the conditions for upper stage reusability. Importantly, the Implementation Plan highlights continuous deliberations and development with a view to establishing a future space transportation technology that will succeed the H3 rocket[232].

Space Systems

In the area of satellite systems, Japan plans to advance its EO, communications and PNT satellites.

Earth observation and Meteorology

According to the Implementation Plan of 2019, Japan plans on improving upon and expanding its fleet of Earth Observation and Meteorology satellites over the next 5-10 years and beyond (see Figure 16). Firstly, it will be starting the manufacturing of the Himawari 8/9 successor models of Geostationary Meteorological Satellites – which are projected to be operational by 2029[233]. Japan is developing the third satellite to its Greenhouse Gases Observing Satellite (GOSAT) series, the Global Observing SATellite for Greenhouse gases and Water Cycle (GOSAT-WT) to be launched in 2023, which will carry a successor model to the AMSR2 sensor carried on the GCOM-W satellite.

To tackle global and regional challenges posing a threat to the safety of Japanese citizens and people elsewhere, Japan plans on supplementing its existing fleet of optical and radar satellites by adding two additional satellites – one advanced optical satellite (ALOS-3) and one advanced radar satellite (ALOS-4) in 2020. These satellites will “contribute to space security and efforts to promote the civilian use of space”[234], ultimately setting the goal to build a satellite constellation that can robustly provide data for regional and global needs related to natural disasters, land conservation, resource and energy management as well agriculture, forestry and fishery industries[235].

Amongst the planned projects is also Japan’s cooperation with ESA on the EarthCARE spacecraft. Through providing the Cloud Profiling Radar (CPR), JAXA is contributing to the EarthCARE satellite’s ability to monitor and collect global data on aerosols, atmospheric liquid and ice, cloud distribution as well as atmospheric radiative heating and cooling[236]. The projected launch date for EarthCARE is 2022. A project which was developed by METI through JSS and NEC, the hyperspectral Earth imaging system HISUI[237], was deployed to the ISS in 2019[238]. This system aims to “contribute to enabling superior monitoring for oil and mineral exploration as well as environmental monitoring”[239].

In the future, Japan plans on moving forward with the commercialization of the ASNARO-1 system and generally plans initiatives to “capture foreign and private-sector demand for satellite data” of their EO satellites[240]. The plans for the Information Gathering Satellites – while officially a multi-purpose system – will be discussed in Section 5.3.

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[232] Ibid.
[233] Cabinet Office. (2019). 宇宙基本計画工程表 (Implementation Plan of the Basic Plan on Space Policy) Tokyo: CAO.
[234] Ibid.
[235] Ibid.
[236] European Space Agency. (n.d.). *EarthCARE*. Retrieved from ESA Earth Online: https://earth.esa.int/web/guest/missions/esa-future-missions/earthcare.
[237] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[238] Sharing Earth Observation Resources. (n.d.). *ISS Utilization: HISUI (Hyperspectral Imager Suite)*. Retrieved from eoPortal Directory: https://eoportal.org/web/eoportal/satellite-missions/content/-/article/iss-utilization-hisui-hyperspectral-imager-suite-.
[239] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p. 54.
[240] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy. p. 28.

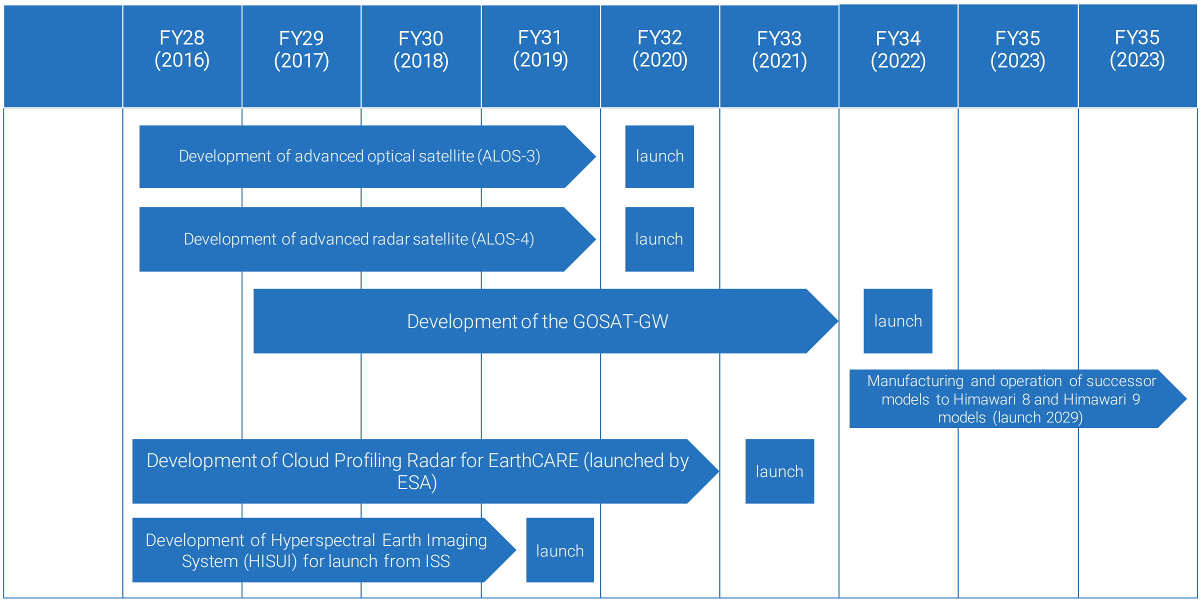

Figure 16: Timeline of EO and Meteorology Satellite Development (source: CAO) [241]

Telecommunication satellites

As detailed in Chapter 2, Japan already has at its disposal a fleet of 20 communication satellites – the majority of which are commercial communication satellites with the exception of Kirameki 2, Japan's first military communication satellite, which was launched from Tanegashima Launch Centre in 2017.

The Implementation Plan of the Basic Plan on Space Policy sets three main goals for the Japanese communication and broadcasting development. Firstly, it plans on launching the so-called Engineering Test Satellite (Kiku 9) in 2021. This new satellite bus and its development aims to enhance Japan's communication satellite competitiveness internationally and in turn aid Japan "maintain and enhance relevant areas of the space industry and the nation's science and technology infrastructure"[242].

Secondly, Japan plans on developing and launching an Optical Data Relay Satellite – the launch date of which was projected to be in 2020. This relay satellite's purpose was to aid Earth Observation satellites in relaying data to ground stations – as they oftentimes transmit large volumes of information. To this end, the development of further inter-satellite communication technology will be continued after the launch of the Optical Data Relay Satellite.

Thirdly, Japan plans to "enhance the command & control and information & communications capabilities of the Self-Defence Forces"[243] through the development and launch of further iterations of the X-Band Satellite (Kirameki-2), which was launched in 2017. More details will be provided in Chapter 5. The timeline for the civil communication satellites can be seen in Figure 17.

[241] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017)*. Tokyo: Strategic Headquarters for Space Policy.
[242] Cabinet Office. (2019). 宇宙基本計画工程表 (Implementation Plan of the Basic Plan on Space Policy). Tokyo: CAO.
[243] Ibid.

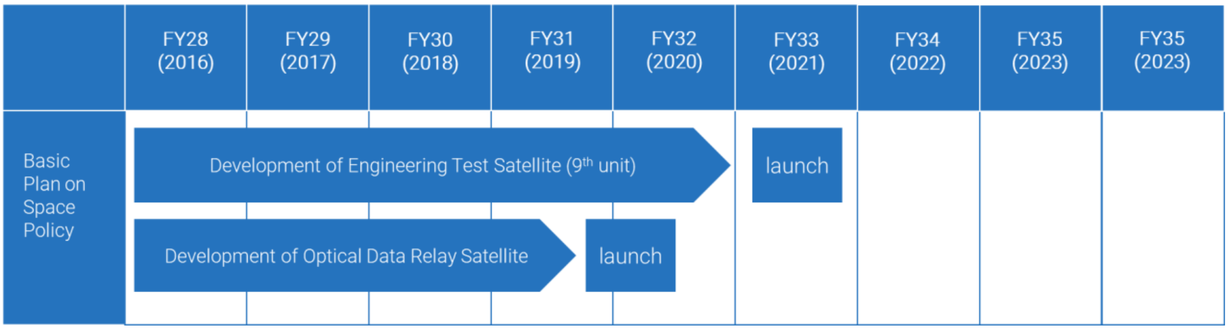

Figure 17: Timeline for Communication Satellite Development (source: CAO)[244]

Navigation satellites

The QZSS is scheduled to be increased from its current four satellites to a seven satellites constellation by 2023 to create "a constellation capable of sustaining positioning"[245] in all regions in a reliable manner[246]. Japan plans on developing a successor to its first satellite – the QZS-1– by 2021. The timeline for the QZSS can be examine in Figure 18. According to the Basic Plan on Space Policy, this system's compatibility and coordination with the GPS will be further enhanced to also foster Japan's Space Situational Awareness capabilities[247]. Furthermore, Japan is further investigating the constellation's future contribution to interoperable-GNSS.

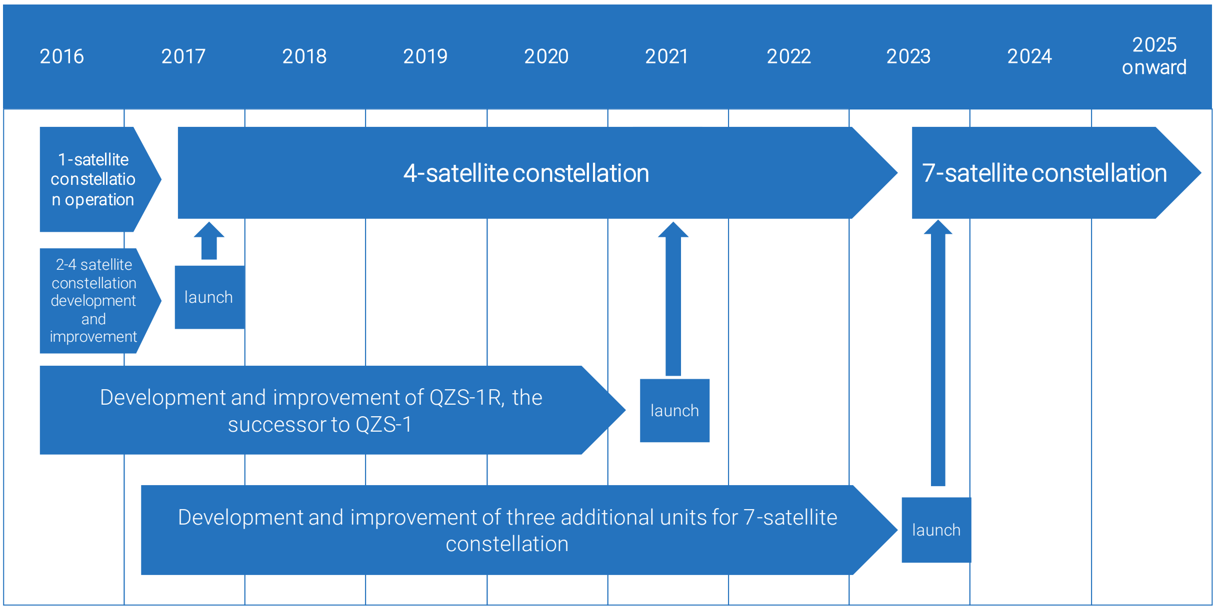

Figure 18: Timeline of QZSS development (source: CAO)[248]

Japan plans on continuously promoting the utilization of the QZSS in both Japan and internationally – in particular in the Asia-Pacific region. It further plans to provide "support for construction of an electronic control point network, the continuous development of satellite positioning technological infrastructure and reinforcement of utilization infrastructure for positioning satellites"[249]. As of 2020, Japan plans on

[244] Ibid.
[245] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[246] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf.
[247] Ibid.
[248] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[249] Ibid.

operating a "positioning augmentation service via a satellite-based augmentation system (SBAS) for aircraft" using the QZSS[250]. Japan further plans to introduce the QZSS Safety Confirmation Service (Q-ANPI) – a "satellite-based safety confirmation system" in 20 prefectures by 2021[251]. This system allows for coordinated disaster organization with the help of satellite data from QZSS on "location and opening of evacuation shelters, number of evacuees, and circumstances at evacuation shelters" received by control stations[252].

Space Science and Exploration

A roadmap for the execution of future science projects was agreed in September 2013. The roadmap categorises space projects into three classes:

- Strategic large-scale missions (L class), to be launched on H2-class or heavier launchers and aiming to attain first-class achievements for Japan in various fields, assuming international cooperation in various forms,
- competitively chosen medium-scale missions (M class), to be launched on Epsilon rockets and aiming to accrue high-frequency scientific results,
- small-scale projects (S class), aiming to maximise opportunities and generation of results through the participation in foreign-agency flagship missions as well as "small missions conducted with universities or other organizations using matching-funds and project-like schemes"[253].

An overview of the projects under development /study is provided in Table 19:

Name	Category	Launch Schedule	Mission Overview
XRISM	L-class	2020	The X-ray Imaging and Spectroscopy Mission (XRISM) is a "JAXA/NASA collaborative mission, with ESA participation. The objective of the mission is to investigate celestial X-ray objects in the Universe with high-throughput imaging and high-resolution spectroscopy. XRISM is expected to launch in early 2022 (TBR) on a JAXA H-2A rocket"[254] .
SLIM	M-class	JFY 2022	The Smart Lander for Investigating Moon (SLIM) is a small-scale demonstration lander aiming to achieve "precise navigation to a specific landing point on the moon. Through the SLIM, JAXA seeks to demonstrate the technology to reach the landing precision necessary for future lunar exploration"[255].
Destiny+	M-class	2022	DESTINY+ (Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUst Science) is a joint engineering and science mission.

[250] Ibid.
[251] Ibid.
[252] Ibid.
[253] Toukaku, Y. (May 2019). "JAXA Space Science Program and International Collaboration". ISAS/JAXA. Retrieved from: https://www.essc.esf.org/fileadmin/user_upload/essc/Toukaku_JAXA_Space_Science_Program_and_International_Collaboration.pdf.
[254] HEASARC. (2020). *X-ray Imaging and Spectroscopy Mission (XRISM) (formerly XARM)*. Goddard Space Flight Center, NASA: Retrieved from: https://heasarc.gsfc.nasa.gov/docs/xrism/.
[255] Japan Aerospace Exploration Agency. (2017). *About Research on Lunar, Planetary Science*. Retrieved from: https://global.jaxa.jp/projects/sas/planetary/.

			Engineering objectives include the development of space transportation technology using electric propulsion and acquisition of advanced flyby exploration technology. Scientific objectives include the analysis of interstellar dust and interplanetary dust particles during the cruise/flyby observations of 3200 Phaethon, a dust releasing active asteroid[256].
JUICE	S-class	2022	The ESA-led Jupiter Icy Moons Explorer (JUICE) is an ESA-led mission to explore Jupiter's icy moons. The science objectives of JUICE are to understand the emergence of habitable worlds around gas giants and to study the Jupiter system as an archetype for gas giants. ISAS/JAXA will participate to JUICE as a junior partner by providing part of the science instrument payload, including a Radio and Plasma Wave Investigation (RPWI), a Ganymede Laser Altimeter (GALA), and a Particle Environment Package/ Jovian Neutral Analyzer (PEP/ JNA)[257].
MMX	L-class	2024	The Martian Moons Exploration (MMX) mission, currently under study, aims to survey the Martian moons Phobos and Deimos and return samples from Phobos. The scientific goal of the mission is to shed light on the origin of the Martian moons and advance our understanding of planetary system formation and of primordial material transport around the boundary between the inner and outer parts of the early solar system[258].
Lite-BIRD	L-class	2027	Lite-BIRD (Light Satellite for Studies of B-mode Polarization and Inflation from Cosmic Background Radiation Detection) aims to verify inflation theory describing the expansion of the universe before the "hot big bang". The objective will be acheived through detailed analysis of primordial gravitational waves that will be performed from Sun–Earth Lagrangian point L2 to precisely observe the spiral polarization distribution (B-mode polarization) produced by the primordial gravitational waves[259].
OKEANOS	L-class	2027	The solar power sail-craft OKEANOS will maintain Japan's leadership in solar system exploration by achieving the following goals: "(1) demonstration of navigation technology by a solar power sail and transport payloads necessary for landing on an asteroid and making a round trip to the outer planetary region; (2) demonstration of exploration technology

[256] Institute of Space and Astronautical Science Japan. (2018). *Annual Report of the Institute of Space and Astronautical Science 2017.* ISAS.
[257] Ibid.
[258] Ibid.
[259] Ibid.

			by rendezvousing with a Jupiter Trojan asteroid and deploying a lander to collect samples from both the surface and subsurface to perform in-situ analysis; sample return is also considered and; (3) scientific observation using multiple deep space instruments while in both the cruising and Trojan asteroid observation environments".
SPICA	L-class	2030	SPICA (Space Infrared Telescope for Cosmology and Astrophysics) is a next generation infrared astronomical satellite currently under study by both ESA and JAXA. It intended to "to reveal the history behind star-formation in the universe and the formation and evolution processes of planetary systems".

Table 19: Space Exploration and space science projects under development/study (source: ISAS)[260]

In the execution of the above-described future projects, ISAS/JAXA attaches a key role to both international cooperation (see next section) and to private sector participation (see Chapter 4).

Human Spaceflight

Japan has agreed to extend ISS operations until 2024 and to support related operations cost in the form of supply transportation through the new HTV-X. Similar to the HTV, this new version will have a transport capacity of 5820 Kg and will consist of three modules:

- a 3.5 metres long pressurised logistics module in the bottom featuring a side access hatch to allow late loading (just before the launch),
- a 2.7 metres long Service Module in the centre that will be capable of operating independently of the other modules,
- a 3.8 metres long unpressurised cargo module that can be optionally replaced with a different mission payload[261].

The first mission of HTV-X is slated for launch in JFY 2021, with two additional flights in 2022 and 2023 respectively.

Even though financial commitment to the human spaceflight programme has continued to reduce in recent years to favour the areas of satellite navigation and satellite reconnaissance systems, JAXA is also actively involved in the definition of human missions in the post-ISS exploration context.

JAXA's plans for future human space exploration focus on the Moon and are based on a five-step approach that combines both robotic and manned missions[262]. These steps can be summarised as follows:

- Conduct water ice prospecting missions to the lunar south pole in order to assess the possibility of utilizing the water for fuel, as JAXA considers that the existence of lunar water ice can greatly affect

[260] Institute of Space and Astronautical Science Japan. (2020). "Missions". Retrieved from: http://www.isas.jaxa.jp/en/missions/spacecraft/developing/.
[261] Japan Aerospace Exploration Agency. (2017). 新型宇宙ステーション補給機(HTV-X) プロジェクト移行審査の結果について (Results of the Project Review for the new Transfer Vehicle to the Space Station (HTV-X). Retrieved from: http://www.jaxa.jp/press/2017/12/files/20171206_HTV-X.pdf.
[262] Miyake, M. (2017). "Global Partnership for Space Exploration". United Nations/United Arab Emirates - High Level Forum: Space as a Driver for Socio-Economic Sustainable Development. Retrieved from: https://www.unoosa.org/documents/pdf/hlf/HLF2017/presentations/Day2/Session_6/Presentation4.pdf.

future exploration scenarios. Therefore, measuring the existence of water ice on the surface is the top priority[263].

- Participate in US led Lunar Gateway programme with key technologies such as habitation technology and logistic resupply capacity, and send Japanese astronauts to deep space.
- Participate with key technologies in international Human Lunar Surface Exploration program starting with the preparatory mission such as the pressurized crew rover in late 2020s, and send Japanese astronauts to the lunar surface.
- Construct a fuel plant at the lunar South Pole by international collaboration using human abilities and robotic capabilities. Also develop a re-usable human lander and fuel station at the Lunar Gateway.
- Conduct a full-fledged scientific lunar exploration, resource prospecting/utilization, and moon travel.

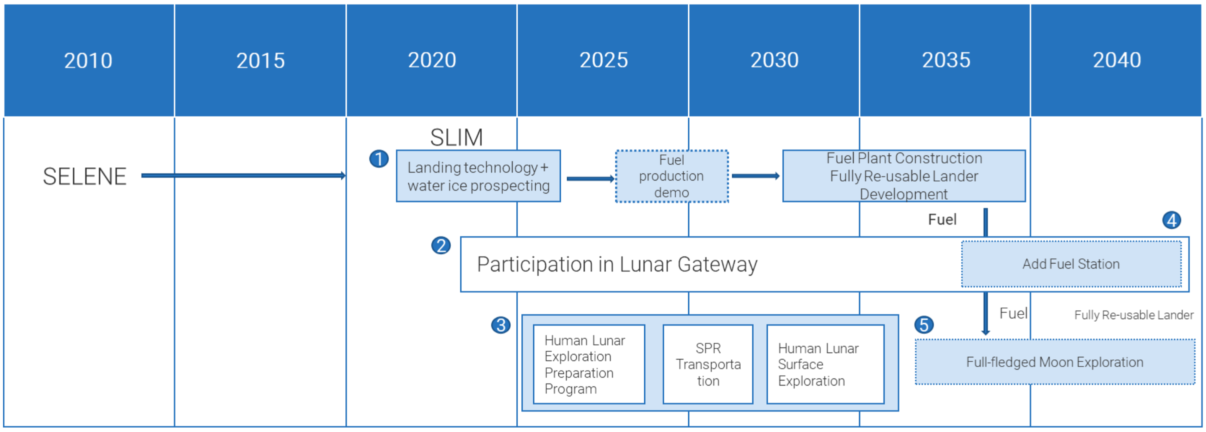

Figure 19: JAXA Plan for Future Exploration (source: adapted from: Miyake, 2017)[264]

3.3.2 Legal and Regulatory Tools

Besides the core programmatic tools, a second set of measures put in place by Japan to promote the advancement of S&T (its civil space programme´s) objectives are the legal and regulatory measures.

As already mentioned in Chapter 2, the Basic Space Law of 2008 sees the maintenance of a state-of-the-art technology and science as one of the key axes of Japan's space policy. Consistent with this, the successive Basic Space Plans have listed a series of measures the government will put in place to advance scientific results, spur technological development and foster innovation in the space sector.

Space legislations

Consistent with the provisions of Article 35 of the Basic Space Law - which requires the Government of Japan to establish a regime aimed at regulating the conduct of space activities and transposing international norms into domestic law - the Japanese government has adopted two dedicated laws in November 2016, respectively covering upstream and downstream-related activities:

- The "Act Regarding Launching and Control of Satellites" or Space Activities Act[265];

[263] Japan Aerospace Exploration Agency. (2017). **月極域探査ミッション 仮称** SELENE-R (Lunar Polar Exploration Mission – Tentative name SELENE-R). Retrieved from: https://repository.exst.jaxa.jp/dspace/bitstream/a-is/609724/1/SA6000060041.pdf.
[264] Miyake, M. (2017). "Global Partnership for Space Exploration". United Nations/United Arab Emirates - High Level Forum: Space as a Driver for Socio-Economic Sustainable Development. Retrieved from: https://www.unoosa.org/documents/pdf/hlf/HLF2017/presentations/Day2/Session_6/Presentation4.pdf.
[265] Cabinet Office, Government of Japan. (n.d). *Applying for a Permission Related to the Launching of Spacecraft, etc. and License Related to the Control of Spacecraft*. Retrieved from: https://www8.cao.go.jp/space/english/activity/application.html.

- The "Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data" or Remote Sensing Data Act[266].

The relevance of these two acts to the country´s S&T objectives is indirect, as they are primarily directed towards facilitating the investment of private actors in the space sector while ensuring legal certainty and competitiveness to Japanese companies. Hence, they will be analysed in more detail in Chapter 4. However, it is important to briefly mention here that by further invigorating the commercial space industry and stimulating private companies´ participation, the two laws are also intended to contribute to creating synergies and organic cycles between commercial space industry, national security and S&T, thereby providing support to the overall advancement of the country´s space efforts.

Data Policy

An important regulatory tool intended to foster economic growth and innovation by advancing the integration of space in Japan´s economy and society relates to the evolution of the country´s data policy. The data from JAXA's environmental satellites and past missions have been provided as open-source and free of charge data through several different web portals such as G-Portal (managed by JAXA Satellite Applications and Operation Center)[267], GCOM Data Providing Service (also managed by JAXA)[268] and the GOSAT Data Archive Service (GDAS – managed by the National Institute of Environmental Studies)[269].

With the 2020 Basic Space Plan, the Japanese government has decided that in order to promote the use of satellite data in various fields and to make it easier for satellite data users, an "Open & Free" condition should be established for current and future government satellites data with a highly public nature[270]. All such satellite data with a highly public nature will be provided free of charge in a format that is easy to process and analyse, equivalent to international standards, with the exception of sensitive data of national security concern. It is also noted that this shall not interfere with the satellite data sales activities of the private entities.

More specifically, for future government satellites, the government agencies owning the satellites should plan the satellites from the development stage to ensure the provision of highly public data with necessary processing. For government satellites already under development or in operation, the government agency owning the satellite will provide the necessary processed highly public data, to the maximum extent possible.

To ensure the stable and permanent availability of satellite data, METI in particular, will continue to enhance the government's satellite data platform "Tellus", and will work to enhance its functionality by integrating it with other platforms and expanding the variety of data and analysis tools, while making full use of the private enterprise.

The government will promote data utilization including anchor tenancy in government and public organizations through the active use of Tellus and also promote international sharing of satellite data through collaboration with overseas satellite data platforms, and will encourage private businesses to create new businesses based on satellite data.

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[266] Cabinet Office, Government of Japan. (n.d). *Applying for a License pertaining to Use of Satellite Remote Sensing Instruments and a Certification of Persons Handling Satellite Remote Sensing Data*. Retrieved from: https://www8.cao.go.jp/space/english/rs/application.html.
[267] Globe Portal System. JAXA. Accessible at: https://gportal.jaxa.jp/gpr/.
[268] Global Change Observation Mission-Climate. JAXA. Accessible at: https://suzaku.eorc.jaxa.jp/GCOM_C/data/data.html.
[269] GOSAT Project. NIES. Accessible at: https://data2.gosat.nies.go.jp/index_en.html.
[270] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.

Mechanisms to promote the use of satellite data

The free and open data policy builds on the recognition that geospatial information, including satellite remote sensing and PNT data, is the key to support the fourth industrial revolution in a wide range of fields including disaster prevention, transportation and logistics, living environment, regional development, and overseas development, and realize a "G-space society" (geospatial information advanced utilization society).

Therefore, to spearhead the use of satellites and improve the efficiency and sophistication of their use by government and local authorities some new institutional tools are also envisaged alongside the free and open data policy.

Specifically, the 2020 Basic Space Plan announces the establishment of a Task Force on Remote Sensing satellite data Utilization (tentative name), consisting of relevant ministries and agencies, to share information on the current state of satellite data use in public administration, issues and measures to be taken[271].

The relevant ministries and agencies should consider the possibility of using satellite remote sensing data for their respective operations, use the data in principle when reasonable, and clarify the requirements for satellite remote sensing data corresponding to the field of use. At the same time, the government (Cabinet Office; Ministry of Internal Affairs and Communications; Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Economy, Trade and Industry; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment; Ministry of Defense) will enhance demonstration projects to accelerate the use of satellite remote sensing data, which will lead to its implementation in society. Specifically, it will work on the establishment of demonstration themes through the collaboration of relevant ministries and agencies, strengthening collaboration with local governments, creating a model for horizontal deployment through the participation of multiple local governments, verifying the cost-effectiveness, and developing human resources at the site of use.

As for PNT data, the “QZSS Utilization Promotion Task Force”, which consists of relevant government ministries and private companies (Cabinet Office, Ministry of Internal Affairs and Communications, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Agriculture, Forestry and Fisheries, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure, Transport and Tourism, etc.), will be used to share issues and strategies for the use of positioning data in society and to further accelerate the implementation of the system by creating advanced usage models for it, including demonstration projects for agriculture, transportation, logistics, construction and other areas of daily life and economic activity, including autonomous driving.

In addition, the Task Force will strategically and continuously support the advancement of positioning technology, such as improving accuracy and reliability and enhancing resilience, while taking into account overseas technological trends and domestic and overseas needs.

Procurement Rules

An important set of measures intended to streamline the ways space activities are conducted relate to procurement mechanisms. In this respect, the Basic Space Plan of 2020 highlights that national projects, including those led by JAXA and other national institutes, should be based on procurement from the private sector to the maximum extent possible and identified in advance in the Implementation Plan. Also, the document outlines the promotion of proactive efforts by public agencies to “revise the way in which

[271] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.

they procure and contract, including the use of a new SBIR system[272], the introduction of flexible contracting arrangements such as milestone payments, and the acceleration of the release and delivery of technical and service requirements, and by increasing the amount of funding provided to venture companies and others". The document also tasks various ministries (Cabinet Office, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Economy, Trade and Industry, etc.) to expand procurement from venture companies and other private companies through the use of anchor tenancy arrangements.

The underlying goals are not only to promote the uptake of private-sector initiatives, but also to strengthen the space industry supply chain and ensure the independence of Japan's space activities. In order to achieve this latter objective, the Basic Space Plan also announces that a survey to identify important technologies required for the efficient, low-cost, short-term development and manufacturing of space systems will be started from FY2020, and dedicated research and development support and demonstration opportunities will be provided by the Ministry of Economy, Trade and Industry for these important technologies.

Comprehensive Strategy for the Development of Space Parts and Components

To maintain and reinforce space industry-related infrastructure and secure the autonomy of Japan's space operations, the availability, maturity and affordability of parts and components used for space systems need to be ensured. Towards this, in 2015 METI established a Study Group on Space Parts and Component and Working Group on Developing a Roadmap for Space Parts and Components. held meetings in October 2015 and February 2016.[59] Both the study and working group held several meetings between 2015 and 2016, collecting inputs from experts from academia, industry and government experts (including CAO, MIC, MEXT and MOD). Their efforts culminated in the results were release, in March 2016, of the Comprehensive Strategy for the Technical Development of Space Parts and Components[273], a ten-year policy document aimed at enhancing the competitiveness of parts and components produced by the Japanese space industry.

This strategy recognizes that the limited domestic demand for space-related parts and components represents a fundamental problem for Japan's space industry, as it makes industry highly dependent on importing foreign technologies, a fact that in turn causes an inadequate production capacity and level of investments. To circumvent these problems the strategy focuses on solutions to increase both domestic and export demand. The most important measures envisaged by the strategy and then incorporated in the Implementation Plan, are to:

- Secure the purchase of a minimum of two satellites per year, from both domestic and international customers, thereby enhance industry´s production capacity
- double the exports of components (from ¥160 billion to ¥320 billion)
- reduce the dependence rate on imports from 40 percent to 30 percent by advancing domestic technology
- provide timely and cost-effective on-orbit demonstration opportunities (micro-satellite released from the ISS, piggyback on H-II A/B, use of Epsilon rocket, etc.) thereby enhancing TRL.

[272] Inoue, H., Yamaguchi, E. (2017). Evaluation of the Small Business Innovation Research Programme in Japan. *SAGE Open*, 1-9. Retrieved from: https://journals.sagepub.com/doi/pdf/10.1177/2158244017690791.

[273] Ministry of Economy, Trade and Industry. (2016). 宇宙用部品・コンポーネントに関する 総合的な技術戦略 要旨 (Summary of Comprehensive Strategy on Space Parts and Components' Technical Development)- Tokyo: METI. Retrieved from: http://www.meti.go.jp/policy/mono_info_service/mono/space_industry/pdf/buhinsenryaku.pdf.

As explained by Wakimoto, through this approach Japan expects to “create a virtuous cycle: improved parts and components will drive up the space industry’s sales; expand the space industry market; and increase investments in R&D and production capacity of space parts and components”[274].

Improvement of the IPR system

An evolution of the intellectual property regime of JAXA has been also envisaged by the "Direction for IP Strategy and Support in the Space Sector"[275] formulated in FY 2019. The goal is to accompany the transfer of technologies and mature activities to the private sector as much as possible; promote an open innovation system that leads to the creation of new commercial companies by making it easier for them to build on the results of JAXA's research to grow their business, while further advancing the overall S&T objectives.

Already in the Medium and Long-term strategic plan (2018-2025) a relaxation of the rules relating to the treatment of intellectual property was explicitly recommended in order to enhance the speed with which public sector research and development results are transferred to the private sector, stimulate the creation of new companies and widen the fields of use of space technologies.

More recently, the 2020 Basic Space Plan further outlines that in order to strengthen efforts to stimulate open innovation using the results of JAXA's research and development, the government will strengthen the function of JAXA as a technology platform and promote the effective use of intellectual property and other resources with the aim to encourage the entry of new private companies into the space sector and improve the environment for intellectual property activities related to space

In addition, based on the "Direction for IP Strategy and Support in the Space Sector", the 2020 Basic Space Plan announces that the Cabinet Office and the Ministry of Economy, Trade and Industry, will support for the creation of a mechanism to collect and provide information on trends in space-related patent applications both domestically and internationally, and encourage private companies to develop IP strategies, including an open innovation strategy.

Use of Human Resources and new mode of working

Together with procurement mechanisms and IPR, the government of Japan has increasingly emphasised the need to make use of human resources as effectively and efficiently as possible in order to cope with the decrease in the working staff while maximizing space policy outcomes.

Towards this, in January 2018, the Ministry of Economy, Trade and Industry (METI) established a Study Group to hold discussions on development of specific measures to address the current situation of human resources in the space industry in Japan. Since then, the Study Group for Enhanced Human Resource Bases in the Space Industry held several meetings, the discussion results of which were compiled into a report[276].

The report highlighted that the main issues supply and demand of human resources in the space industry are: a) the severe shortage of human resources and b) the low mobility of human resources. To address these issues, the report recommended:

- to introduce new methods of work,

[274] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*.
[275] Ministry of Economy, Trade and Industry. (2020). 宇宙分野における知財対策と支援の方向性について報告書を取りまとめました (Report on the direction of Intellectual Property Measures and support in the space sector compiled). Tokyo: METI. Retrieved from: https://www.meti.go.jp/press/2019/03/20200331018/20200331018.html.
[276] Ministry of Economy, Trade and Industry. (2018). 宇宙産業分野における人的基盤強化のための検討会 報告書概要 (Summary of the Report of the Study Group for Strengthening the Human Resource Base in the Space Industry). Tokyo: METI. Retrieved from: https://www.meti.go.jp/english/press/2018/0501_002.html.

- to implement human resource development activities
- to bring in human resources and funds from different industries to further revitalize space activities.

The working methods within JAXA are progressively evolving. As regards the rules relating to personnel management, new forms of recruitment (temporary or long-term) have been introduced in order to facilitate cooperation with actors from different backgrounds. JAXA has begun to establish a cross-appointment system for recruiting certain researchers. Employed both by their home organization (company, university, research centres, etc.) and by JAXA, where they conduct their work, the researchers recruited benefit from working conditions that allow them to carry on their activities without constraint related to their professional affiliations[277].

With the goal of expanding the human resource base in the space industry, the 2020 Basic Space Plan announces the implementation of human resource development activities linked to school education. In particular, the document outlines that MEXT "will strengthen the development of the next generation of human resources through practical activities related to space technology for university students and the establishment of research centers through industry-academia collaboration, and enhance small-scale (small group, short-term) space projects in which young human resources can participate in a centralized manner in order to develop human resources who will lead future space development and utilization"[278].

In addition to specialized knowledge in the field of space, MEXT "will promote the discovery and development of human resources with advanced knowledge in the humanities and social sciences that will serve as a bridge to other fields, formulate international rules, collaborate with overseas organizations and expand markets, analyze social and economic ripple effects, and create new industries"[279].

Along the same lines, the 2020 Basic Space Plan tasks various ministries (Cabinet Office, Ministry of Internal Affairs and Communications, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Economy, Trade and Industry) to promote research and development in collaboration with researchers and engineers at universities and private companies, not only in the space sector, but also with non-space companies and universities[280]. Through these efforts, Japan aims to cope with the shortage of human resources strengthen human resource base while proactively contributing to the promotion of the space industry (see Chapter 4).

3.3.3 Diplomacy and Cooperation Frameworks

To advance its S&T interests, Japan has been increasingly making use of various diplomacy and cooperation tools. International cooperation is primarily used to fulfil several programmatic objectives such as strengthen progress in frontier areas where Japan lacks autonomy (e.g. human spaceflight) and address global challenges, but also to support Japan´s broader foreign policy agenda, including the resolve to foster the country's prestige on the world stage.

International space cooperation is mainly led by JAXA which, in close cooperation with the MOFA, has been activating a variety of cooperation avenues with both established and emerging space nations in several fields.

In term of bilateral partnerships, there is wide consensus that the United States represents one of the most dependable partners for Japan. In this regard, the 2020 Basic Plan stresses the intention of the two

[277] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[278] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.
[279] Ibid.
[280] Ibid.

sides to work together to strengthen the U.S.-Japan alliance through comprehensive collaboration in all space domains, including security, civil space applications, and space science and exploration[281].

In addition, the document outlines that a multilayered cooperative relationship should be established with like-minded countries that share strategic interests. In the civil domain, this cooperation should encompass joint development of advanced technologies, sharing of mission equipment, mutual certification of technologies, international standardization, and joint use of satellite data with a view to efficiently promote the development of technologies necessary for advancing Japan's space programme and maximize the utility of space applications in different economic sectors. In particular, in order to contribute to the achievement of the SDGs and the solution of global issues such as energy, climate change, environment, food, public health, and large-scale natural disasters while also maximizing the integration of space in Japan´s economy and society, Japan intends to promote strategic cooperation with Europe and other advanced space nations in the fields of earth observation, and satellite PNT, including in the respective applications.

Towards this, the government of Japan intends to implement international space cooperation by utilizing its satellite development and demonstration platform to the largest extent.

Together with these programmatic objectives, Japan aims further strengthen its leadership and diplomatic power by actively utilizing multilateral cooperation frameworks such as the inter-governmental Group on Earth Observations (GEO) and the Asia-Pacific Regional Space Agency Forum (APRSAF).

While Japan aims to pursue civil space cooperation in most domains, according to ESPI analyses, the most indicative areas of Japan´s international cooperation in civil space activities are represented by Earth Observation systems and applications, space science and space exploration, both robotic and human.

Earth Observation Systems and Applications

Cooperation in the field of remote sensing is pursued for both programmatic and diplomatic reasons and through multiple channels, including:

- Inter-agency agreements
- Inter-governmental initiatives
- Capacity-building programmes

In terms of inter-agency collaboration, JAXA has been engaging in several international partnership agreements and MoUs with respect to both the development of EO systems as well as the provision of EO data/applications. In terms of ongoing systems development efforts, a relevant cooperative arrangement in offered by the joint ESA-JAXA Earth Clouds, Aerosols and Radiation satellite (EarthCARE), for which JAXA will provide the world's first cloud radar (the Cloud Profiling Radar - CPR), with a target delivery date at the end of 2020. Beyond the instrumentation, JAXA will be co-responsible for the science data processing and distribution to scientists worldwide. More broadly, a strong JAXA-ESA cooperation on data exchanges between the two agencies has been established to contribute to the effective implementation of the Paris Agreement, deliver a better understanding of climate change and tackle common challenges on a global scale. ESA, for instance, is distributing data on greenhouse gases in the atmosphere from JAXA's GOSAT-1 and -2 satellites across Europe. Similarly, ESA, JAXA and the National Institute for Environmental Studies (NIES) have also signed an agreement regarding cooperation in the remote sensing of greenhouse gases (GHG) and related missions[282]. The agreement aims "to improve

[281] Ibid.
[282] This agreement was signed in the context of the One Planet Summit of December 2017, pursuant the Paris Agreement of 2015. At this Summit, participants adopted the Paris Declaration to set up a Space Climate Observatory (SOC). Japan Aerospace

the reliability and to assure consistency of the GHG data observed by multiple satellites through validation and calibration of data from Japan's GOSAT-1 and -2 and Europe's Sentinel-5P and FLEX). The underlying objective is to validate the greenhouse gases inventory required by the guidelines of the Intergovernmental Panel on Climate Change (IPCC) and hence support the effective implementation of the Paris Agreement. In 2019, JAXA and ESA have also started discussions to further cooperate on coordinated observation/acquisitions in the context of future C- and L-band SAR missions (specifically between Europe's Sentinel-1 C-band data and JAXA's ALOS-2 L-band data).

With regard to inter-governmental initiatives, a particular emphasis is given to cooperation with Asian countries and APRSAF framework. An important EO-related initiative within APRSAF is Sentinel Asia, an international collaboration among space and disaster management agencies aimed at developing a disaster management support system in the Asia-Pacific region. Like for other APRSAF-initiatives, Japan has been at the inception of this response system that make use of remote sensing data and Web-GIS technologies to improve safety in society, improve the speed and accuracy of disaster preparedness and early warning, and minimize the number of victims and social/economic losses [283]. The main activities include: emergency observations by EO satellites in case of a major disaster; acceptance of observation requests; working group activities focusing on specific disasters such as wildfire, flood, and tsunami; capacity building and human resources development for effective disaster management. Recently, the focus has been also put on support for mitigation/preparedness; response and recovery activities through utilization of EO, communications, and navigation satellites; further joint operations and human networking through capacity building and outreach.

Another important EO-related initiative within the APRSAF framework includes SAFE (Space Applications for Environment), which is a voluntary initiative to encourage environmental monitoring through the use of remote sensing technology, understand environmental changes, and contribute to risk reduction and adaptation programmes associated with disasters and environmental risks[284].

Besides APRSAF, Japan has been taking part in various international frameworks using remote sensing technology to combat climate changes and support the achievement of other UN sustainable Development Goals (SDGs). In January 2020, for instance, JAXA signed a MoU with the Food and Agriculture Organization of the United Nations (FAO) on EO data utilization to monitor forests and mangroves around the world through the use of JAXA's L-band SAR satellites. Specifically, the observation data of global forests that JAXA has been accumulating for over 25 years will be provided to the System for Earth Observation Data Access, Processing and Analysis for Land Monitoring (SEPAL) that is FAO's toolkit for monitoring forest and land-use. Additionally, this cooperation supports JAXA to improve the accuracy of its satellite data"[285].

More broadly, Japan is an active supporter of the use of EO data in the various climate change initiatives coordinated by the World Meteorological Organisation (WMO), UNESCO, the United Nations Environment Programme (UNEP), the Committee on Earth Observation Satellites (CEOS), and the International Council for Science (ICSU)[286].

Exploration Agency. (2018). *JAXA-ESA Joint Statement concerning the bilateral cooperation*. Retrieved from: https://global.jaxa.jp/press/2018/03/20180303_esa.html.

[283] Asia Pacific Regional Space Agency Forum. (2019). "Sentinel Asia". Retrieved from: https://www.aprsaf.org/initiatives/sentinel_asia/.

[284] Asia-pacific Regional Space Agency Forum. (2018). *SAFE: Space Applications for Environment*. Retrieved from: https://www.aprsaf.org/initiatives/safe/.

[285] Japan Aerospace Exploration Agency. (2020). *Agreement on Data Utilization of Earth Observation Satellite with FAO*. Retrieved from: https://global.jaxa.jp/press/2020/01/20200123-1_e.html.

[286] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.

Finally, in terms of capacity building programmes, Japan has been supporting a variety of development projects mainly in the form of Official Development Assistance (ODA) funded by the Ministry of Foreign Affairs (MOFA) and managed by the Japan International Cooperation Agency (JICA)[287]. JICA has been coordinating different types of aid programs, including numerous development projects using EO data in South East Asia, Africa, and East Europe. A relevant example in this context is offered by the "JICA-JAXA Forest Early Warning System in the Tropics" (JJ-FAST) service, which was launched in 2016 by JICA and JAXA with the aim to monitor deforestation and forest changes for tropical regions using data from JAXA's ALOS-2[288]. JJ-FAST, which is part of the "Initiative for Improvement of Forest Governance" launched by Japan at the 21st session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC), eventually aims to provide free and open monitoring data of approximately 60 countries that have tropical forests[289].

Space Science and Exploration

Given the globalisation of the international scientific community and the resource limitations of the national science and exploration programme, international cooperation plays a key role in the execution of the future science and exploration missions described in the previous section. More specifically, ISAS/JAXA attaches the highest importance to international cooperation in order to: a) realize highest outcome of the space science missions in efficient manners, b) maximize the opportunities to conduct/participate in missions, c) promote proactive communications among international space science community[290].

In the context of the planned mission, three different configurations of international cooperation come to the fore, as graphically captured in Figure 20.

Participation of foreign partners in JAXA-led missions

- XRISM with NASA, ESA
- MMX with NASA, ESA, CNES, DLR, ASI
- Destiny+ with DLR

Participation of JAXA in foreign agencies-led missions

- JUICE by ESA
- Dragonfly, WFIRST by US (under study)

Joint missions between JAXA and foreign agencies

- Bepi-Colombo: Joint ESA/JAXA
- SPICA: Joint ESA/JAXA (candidate mission)

Figure 20: Configurations of international cooperative frameworks in space science (source: adapted from Toukaku, 2019)[291]

[287] Ibid.
[288] https://global.jaxa.jp/press/2016/11/20161114_jjfast.html.
[289] Ibid.
[290] Toukaku, Y. (May 2019). "JAXA Space Science Program and International Collaboration. ISAS/JAXA. Retrieved from: https://www.essc.esf.org/fileadmin/user_upload/essc/Toukaku_JAXA_Space_Science_Program_and_International_Collaboration.pdf.
[291] Ibid.

As emerges from Figure 20, the United States and Europe represent Japan´s major partners for its future science and exploration programme. Collaboration with Europe is expected to take place at both national and pan-European level[292].

For instance, in the regards of the MMX mission (sample-return from Phobos), JAXA aims to simultaneously pursue cooperation with several European space agencies and ESA. Towards this, it has already signed implementing arrangements with both CNES and DLR and a proposal is under discussion with ESA regarding its possible participation[293]. Similarly, a feasibility study has started concerning a possible European contribution to JAXA's LiteBIRD Cosmic Background Radiation polarisation mission and an agreement was negotiated with ESA for cooperation on the X-Ray Imaging and Spectroscopy Mission (XRISM), Japan´s X-ray astronomy mission investigating energetic phenomena of the Universe. The agreement also covers cooperation with the Netherlands Institute for Space Research (SRON) [294].

Human spaceflight

For Japan, human spaceflight represents the most important area of civil space collaboration. Given the lack of autonomous human spaceflight programme, and the high international visibility of crewed endeavours, cooperation in this area allows to reach both programmatic and political objectives associated to its civil programme.

The most notable initiatives in this domain encompass the continuation of KIBO Cube and KIBO ABC projects and the participation in international Lunar Human Space Exploration programme.

Japan´s participation in the Gateway programme has been secured in 2019 through a series of consultations and high-level meetings throughout 2019. JAXA has first started to engage in detailed technical deliberations of possible contributions within the ISS Multilateral Coordination Board (MCB), the body overseeing the management of the ISS. Already in March 2019 MCB issued a joint statement in which it "endorsed plans to continue the Gateway development"[295] Then, during a joint press conference with President Abe during President Trump's visit to Tokyo in May, the heads of state expressed their intention to "accelerate discussions on cooperation regarding lunar exploration and affirmed their joint commitment for NASA and JAXA to collaborate in lunar exploration with a view toward Mars"[296].

This release was followed, on 24 September 2019, by a Joint Statement on Cooperation in Lunar Exploration by JAXA President Hiroshi Yamakawa and NASA Administrator in which "both agencies' leaders expressed their desire to expand the scientific and technological cooperation between NASA and JAXA to advance human lunar surface activities, leading to eventual human exploration of Mars"[297].

Eventually, on 18 October 2019, Strategic Headquarters for National Space Policy officially endorsed its participation in the Lunar Gateway and Artemis mission by issuing the "Policy of Japan on the Participation in International Space Exploration under the Proposal of the United States"[298]. This stance was further confirmed by the 2020 Basic Space Plan, which reaffirms the government´s intention to make the best use of the opportunity to participate in the international space exploration programme proposed

[292] Tsuneta, S. (7 March 2018). Europe-Japan Space Science collaboration. ISAS-JAXA. Retrieved from: http://www.isas.jaxa.jp/about/director_general/files/20180307.pdf.
[293] Japan Aerospace Exploration Agency. (27 June 2019). JAXA and CNES Sign Implementing Arrangement on Martian Moons eXploration (MMX) and Hayabusa 2. Retrieved from JAXA: https://global.jaxa.jp/projects/activity/int/topics.html#topics14890.
[294] Japan Aerospace Exploration Agency. (5 October 2018). JAXA and SRON Release Joint Statement to Confirm their Intention to Collaborate in Space Science and Exploration. Retrieved from JAXA: https://global.jaxa.jp/press/2018/10/20181005_sron.html.
[295] Japan Aerospace Exploration Agency. (12 March 2019). Multilateral Coordination Board Joint Statement toward the development of the Gateway. Retrieved from JAXA: https://global.jaxa.jp/press/2019/03/20190312b.html.
[296] Japan Aerospace Exploration Agency. (24 September 2019). Joint Statement on Cooperation in Lunar Exploration. Retrieved from JAXA: https://global.jaxa.jp/press/2019/09/20190924a.html.
[297] Ibid.
[298] Strategic Headquarters on National Space Policy. (18 October 2019). *Policy of Japan on the Participation in International Space Exploration under the Proposal of the United States*. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/english/decision/policy191018.pdf.

by the U.S., and secure the opportunity for Japanese astronauts to take part in the program, while making full use of Japan's presence as a space advanced country[299].

Specifically, the document states that Japan will take advantage of the country's experience in the ISS programme to work on the construction, operation, and utilization of the Gateway, as well as technology demonstrations for the utilization of the Gateway to acquire the capabilities necessary for deep space exploration. The envisaged Japanese contributions include "cooperation on Gateway, including habitation functions and logistics missions, utilizing the Japanese HTV-X spacecraft and H3 launch vehicle"[300]. In more concrete terms, JAXA plans to participate with ESA in the International Habitation Module, contributing through the development of the "ECLSS [Environmental Control and Life Support] system, Thermal control system, power system component"[301]. Moreover, JAXA plans to cooperate with NASA on Logistics Resupply[302], which entails contributing to "transport utilization on the Gateway", "transport [of] small probe and equipment on lunar orbit" as well as "share-ride of mission equipment"[303].

Further plans for lunar exploration include the development of a pressurized crew rover, the study of which is in collaboration with Toyota. This rover would contribute through "long range excursion capability for human lunar surface exploration as well as autonomous or remote operate excursion capability during unmanned period"[304].

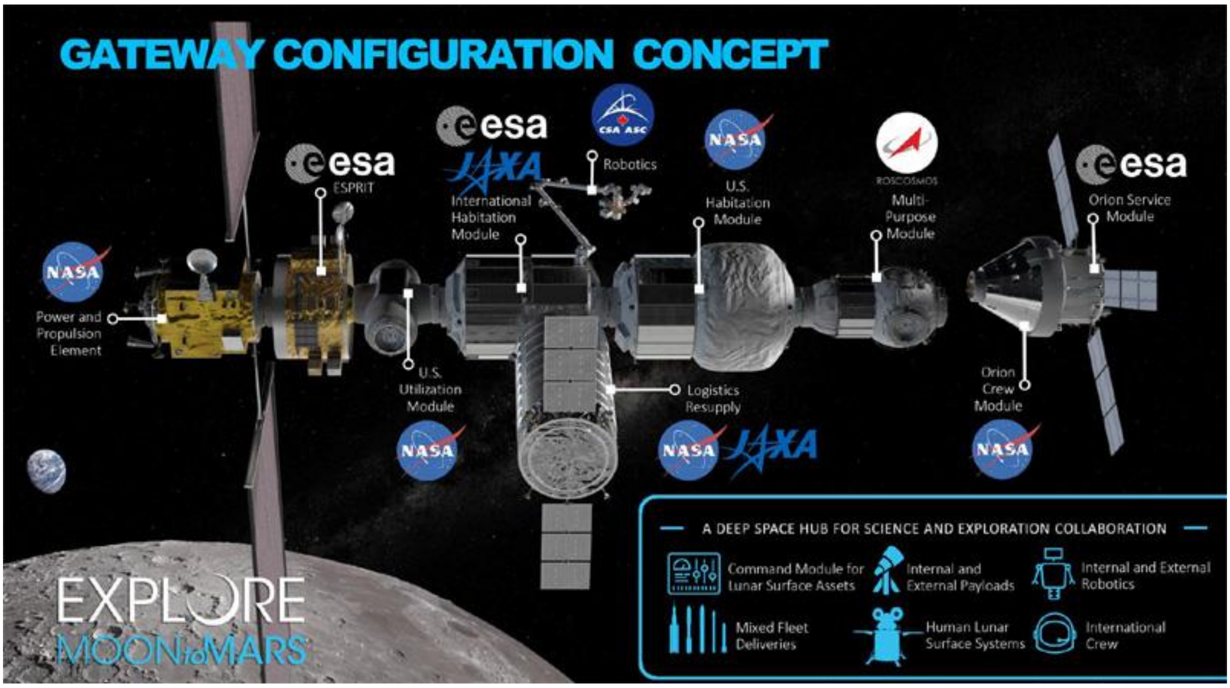

Figure 21: JAXA contribution to the Gateway (credit: JAXA, 2019)[305]

Building on the recognition that the Moon is an important place for acquisition and demonstration of technologies required for future solar system exploration, such as landing and return technologies for gravitational objects and robot technologies for exploring planetary surfaces, the 2020 Basic Space Plan

[299] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf
[300] Japan Aerospace Exploration Agency. (2019). International Space Exploration - Program. Retrieved from JAXA: http://www.exploration.jaxa.jp/e/program/index.html.
[301] Sasaki, H. (2019). JAXA's Lunar Exploration Activities. Vienna: JAXA.
[302] Japan Aerospace Exploration Agency. (2019). Multilateral Coordination Board Joint Statement toward the development of the Gateway. Retrieved from JAXA: https://global.jaxa.jp/press/2019/03/20190312b.html.
[303] Sasaki, H. (2019). JAXA's Lunar Exploration Activities. Vienna: JAXA.
[304] Ibid.
[305] Japan Aerospace Exploration Agency. (2019). "International Space Exploration – Program". Retrieved from JAXA: http://www.exploration.jaxa.jp/e/program/index.html.

also highlights that Japan will examine the approach to space science and exploration with a view to the next 20 years, including the use of the Gateway, and promote it with the participation of a wide range of scientific fields. Candidate themes for the study include lunar positioning, communication, remote sensing, multi-point exploration by a small spacecraft, 3D exploration, sample return, data science, and astronomical observation. Also, with the participation of civil society, including non-space industry, to work on building systems essential to lunar activities, including gateways and transportation on the moon, and to phase in the demonstration of elemental technologies and other world-leading results. (Cabinet Office, Ministry of Education, Culture, Sports, Science and Technology, etc.)

4 INVIGORATING THE SPACE INDUSTRY

Strengthening the competitiveness of the national space industry and Japan´s role in the global space economy is the second pillar of Japan's grand strategy for space. As in Chapter 3, this chapter will explore the evolution and drivers of Japan's space industrial efforts space programme, the objectives of its industrial space policy and the tools to implement these objectives.

4.1 Japan's Space Industry: Evolution and Drivers

With more than five decades of experience in the development of highly "sophisticated launchers, satellites, and robotic devices equal to the world's best"[306]. Japan's space industry is today internationally acknowledged for its state-of-the-art scientific and technological prowess. However, when compared to other major space actors, Japan's space industry has been historically lagging in terms of size and revenues on the commercial markets. According to data from the Society of Japanese Aerospace Companies (SJAC), the turn-over is still well below that of the US and Europe as a whole or even individual EU member States[307].

According to most analyses, the development of the Japanese space industry has been historically thwarted by three main factors:

- An exclusive dependence on public civil demand;
- a lack of private investment in R&D;
- a lack of competitiveness in the international arena[308].

Particular the first limitation presents itself in a unique way in Japan due to two historic developments. The first is the adoption of a restrictive interpretation of the notion "peaceful uses of outer space" spelled out in the Outer Space Treaty (OST), which de facto prohibited any military application of space assets[309]. This self-imposed ban on the use of space technology for military purposes is in stark contrast with the programmes of other major powers, which strongly relied on the military as a driver for the development of the national space industry. In Japan, however, there has been no demand from the military and, consequently, this ecosystem did not develop[310].

On the surface, one such situation is not dissimilar to that faced by the European space industry. However, unlike Europe, Japan could not count on commercial markets either. This is the inevitable by-product of the second major development: the 1990 US-Japan Satellite Procurement Agreement, which ended Japanese protection of its still developing satellite market from international tendering[311].

The agreement finds its root in the mounting trade frictions between Japan and the United States during the 1980s. Because the US saw a possible threat coming from the nascent Japanese satellite market, it activated the so-called Super 301 as part of their trade talks over semiconductors in the mid-1980s. As reported by Dunphy, "Super 301 is a section of the Trade Act that enables the Trade Representative to single out a country as an unfair trader, begin trade negotiations with that country and, if the negotiations do not conclude to America's satisfaction, impose sanctions. Japan was named an unfair trading nation in 1989, and negotiations began on forest products, supercomputers, and telecommunications

[306] Moltz, J.C. (2012). *Asia´s Space Race. National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press.
[307] The Society of Japanese Aerospace Companies. (2018). *Directory of Japanese Space Products & Services 2018-2019.* SJAC.
[308] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[309] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[310] Lele, A. (2013). *Asian Space Race: Rhetoric or Reality?* New Delhi: Springer.
[311] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.

satellites"[312]. Unlike other economic sectors, at the time the Japanese government did not deem space as a strategically vital sector, and eventually surrendered to the American claims, agreeing on the signature of the Japan Satellite Procurement Agreement in 1990[313].

The Procurement Agreement required Japan to open the procurement of its commercial satellites, particularly telecommunications satellites, to foreign satellite manufacturers through tendering. The only exclusion to this provision was "R&D satellites, defined as satellites designed and used entirely, or almost entirely, for the purpose of in-space development and/or validation of technologies new to either country, and/or non-commercial scientific research"[314].

According to Setsuko Aoki, "that provision was tantamount to a death sentence to the embryonic Japanese satellite industry"[315], as it ultimately rendered Japanese technology – which at that time was characterised by high cost due to small government orders – non-competitive vis-à-vis US- manufactured satellites. US satellite manufacturers, which already had economies of scale to offer lower cost satellites, entered into the Japanese market[316]. Still today, the vast majority of communication satellites owned by Japanese telecommunication companies are US-made.

All in all, these two historical factors constraining Japanese space industry development (i.e. the restrictive interpretation of the notion of peaceful uses of outer space and the 1990 Procurement agreement) created an environment in which companies lacked avenues for development, long-term funding, as well as competitiveness internationally – thus leading to a strong dependence on limited public sector demand[317]. Indeed, without the possibility to rely on the military demand nor on the commercial markets, the Japanese space industry had no other options than to base its development on the exclusive demand on the civil public sector (see Figure 22 below to see the difference in the revenue sources between the space industry of Japan and that of the EU's, which clearly demonstrates the significant dependence of the Japanese aerospace companies on government contracts.)

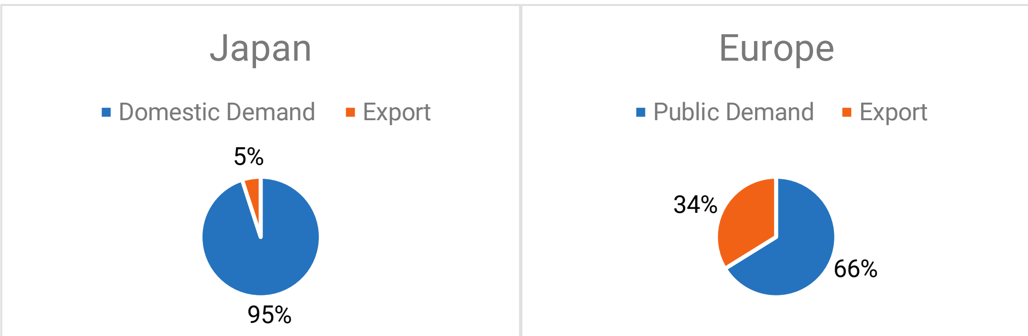

Figure 22: Space industry in Japan and Europe: Domestic demand vs. Export (source: SJAC and Eurospace) [318]

[312] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p.30.
[313] Zeng, K. (2004). *Trade Threats, Trade Wars: Bargaining, Retaliation, and American Coercive Diplomacy.* Ann Arbor: University of Michigan Press.
[314] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation. p.30.
[315] Aoki, S. (2009). Current Status and Recent Developments in Japan's National Space Law and its Relevance to Pacific Rim Space Law and Activities. Journal of Space Law, 363-438.
[316] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[317] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[318] Source: *Directory of the Society of Japanese Aerospace Companies (for Japan) and ASD Eurospace (for Europe).*

While the scope of space applications was broadened with the 2008 Basic Space Law, the structural hindrances to space industry development have caused a lack of opportunities in the past and a stagnation of the industry to recent years[319 320].

As a clear indication of Japan's space industry over-dependence on civil government contracts is the correlation between the amount of the Japanese space budget and the space industry turnover, both currently fluctuating around ¥ 300 billion. This excessive dependence on public demand prevented companies from leveraging scale to reduce costs and make their investments pay out[321]. Importantly, it also explains why after the budgetary shrinkage imposed after the "the lost decade", the space industry entered a period of profound confusion, with a drastic reduction in its revenues. Indeed, a simple look at the evolution of the turnover of the Japanese space industry over the last two decades inevitably shows a marked decline from the end of the 1990s and stagnation from the mid-2000s. Indeed, between 1999 and 2004, the turnover of the sector dropped from ¥ 379 billion (about €3 billion) to ¥ 219 billion (about €1.7 billion) in 2004 (see Figure 23)[322].

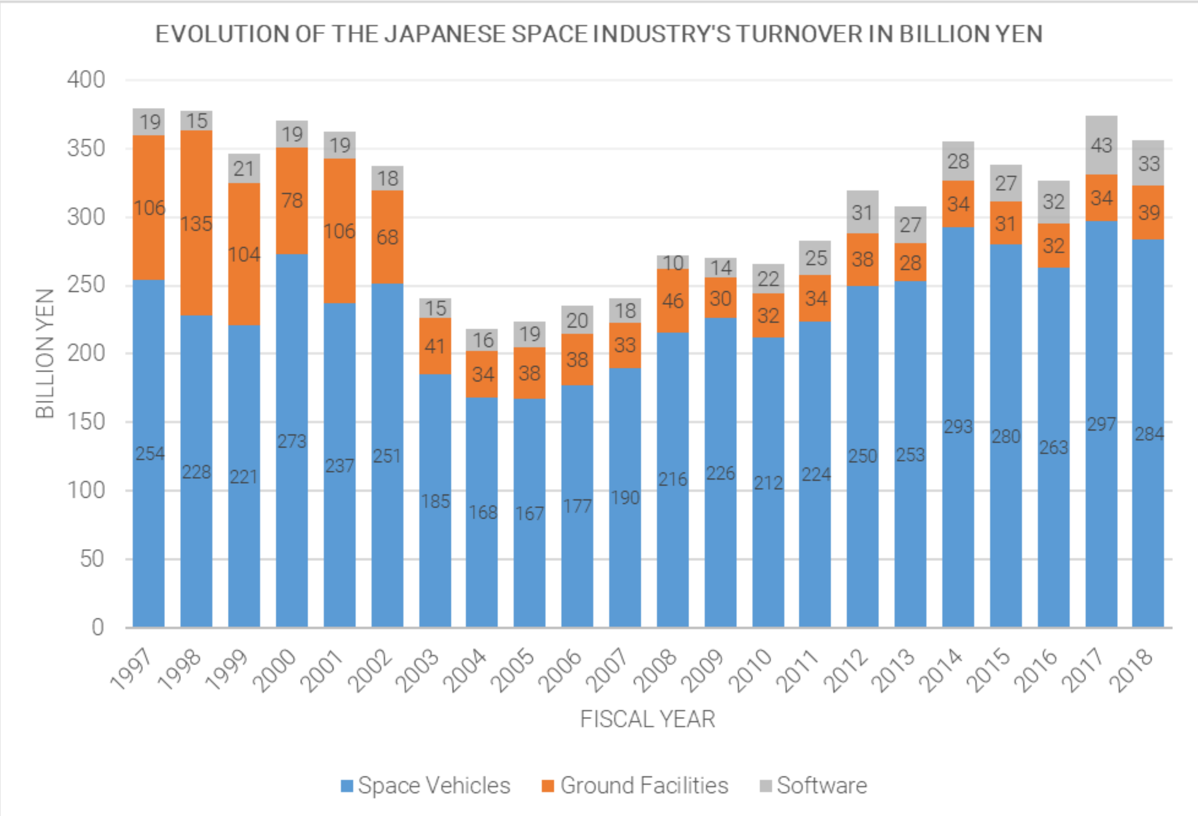

Figure 23: Evolution of the Japanese Space Industry's Turnover - in Billion Yen (source: SJAC)[323]

[319] La Regina, V. (2015). *The Space Sector: EU-Japan business and technological cooperation potential.* Tokyo: EU-Japan Centre for Industrial Cooperation.

[320] As explained by Dunphy, the industry's focus on governmental science missions caused the spacecraft design to be somewhat too specific and to lack versatile commercial applications, limiting the companies from exploring opportunities in the private sector. In turn, the limited opportunities prevented them to building up their portfolio and thus, they could not build up their share in the global market.

[321] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.

[322] The Society of Japanese Aerospace Companies. (2018). *Directory of Japanese Space Products & Services 2018-2019*. SJAC.

[323] Ibid.

In addition, as explained by Kazuto Suzuki, due to the budget decrease of the late 1990s, the traditional contract arrangements through JAXA — a rotating prime contractor system and equal distribution of subcontracts — became no longer affordable or effective. Thus, many space companies in Japan had to shrink the size of operations and several of them exited the market (e.g. Toshiba). This is also reflected in sharp reduction of the number of employees in the Japanese space industry, which almost halved in the span of a decade, passing from almost 9000 in 1997 to 5100 in 2008 (see Figure 24)[324].

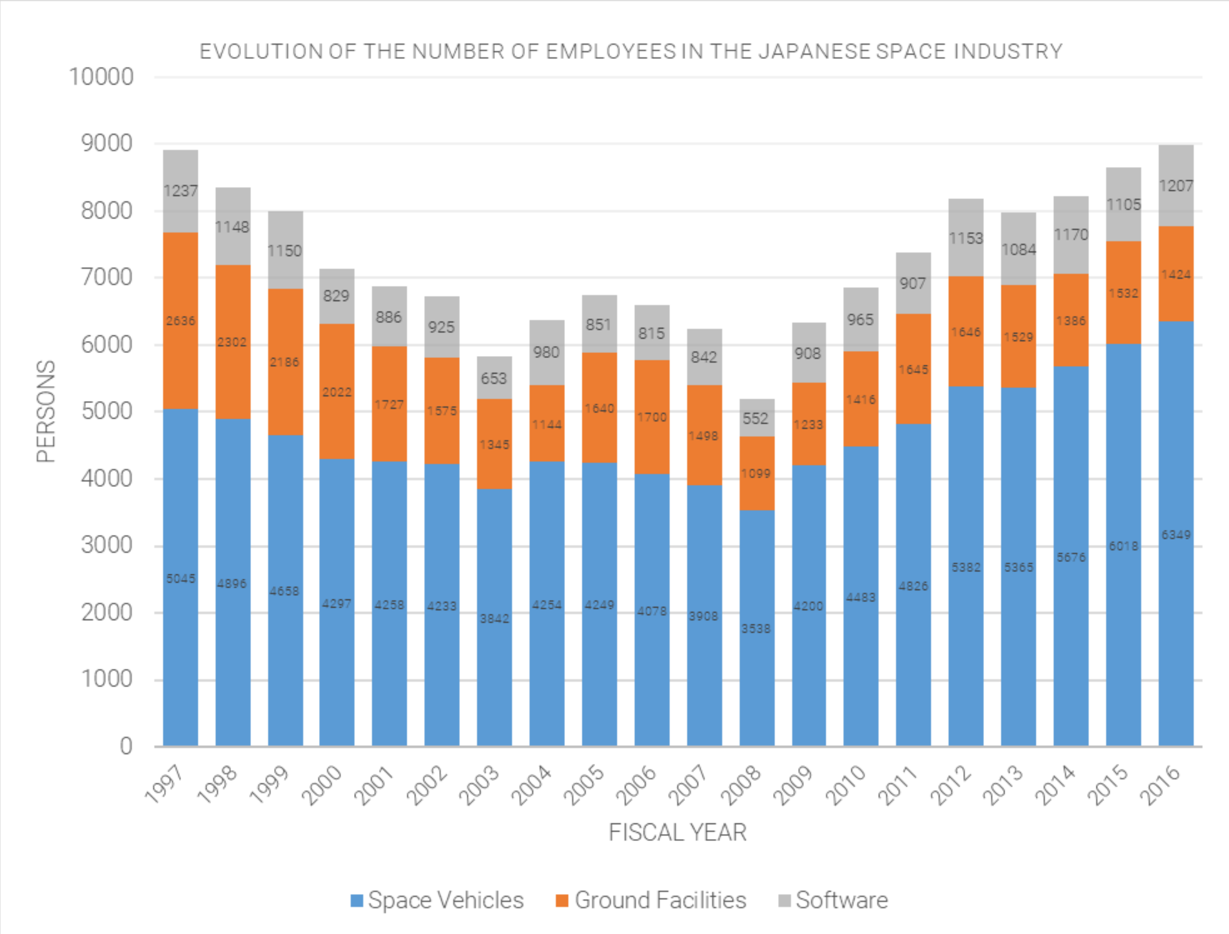

Figure 24: Evolution of the Number of Employees in the Japanese Space Industry (source: SJAC)[325]

The situation started to progressively recover by the mid-2000s thanks to the special efforts taken both by the government and private industry to support the commercialization of Japanese space technologies. Besides the efforts to introduce a pro-commercial space legislation, which culminated with enactment of the Basic Space Law in 2008, a notable move was taken in April 2007, when the exploitation of H-IIA rockets were transferred from JAXA to Mitsubishi Heavy Industries (MHI) to facilitate sales. One year later, in August 2008, MHI indeed successfully conducted its first commercial launch of a private communications satellite - Superbird-7 - for the JSAT Corporation. Importantly, Superbird-7 was also the first Japanese commercial satellite manufactured by a Japanese company, Mitsubishi Electronics. Since then, Japanese space companies started to succeed winning some bids on the international markets of launch services as well as telecommunication satellites (see Figure 25Figure 25).

[324] The Society of Japanese Aerospace Companies. (2018). *Directory of Japanese Space Products & Services 2018-2019*. SJAC.
[325] The Society of Japanese Aerospace Companies. (2018). *Japanese Aerospace Industry 2018-2019*. Tokyo: SJAC.

2008	Telecom satellite contract by Singapore Telecommunications Ltd., and Chunghwa Telecom Company of Taiwan for MELCO
2009	Launch contract for KOMPSAT-3 of South Korea for MHI
2011	two telecom satellites contract for Turksat of Turkey for MELCO
2013	Launch contract for Telesat of Canada for their Telstar 12V satellite for MHI
2014	Telecom satellite contract for Eshail Sat of Qatar for MELCO
2015	Launch contract for the UAE's EO satellite, Khalifa Sat for MHI

Figure 25: Successful bids of Japanese companies on international market (source: ESPI Database)

Despite these encouraging developments and progressive recovery of the market for space after 2010 (see Figure 25), there was a general recognition that the prospects for the Japanese space industry remained limited. Three the main reasons:

- the too modest level of the public demand to fuel the growth of a large industry
- the limited amount private investment in the space sector
- the lack of competitiveness of Japanese space products and services in the international arena

A radical rethink of Japan's approach to the space industry development was hence deemed necessary. It is in this context, that the new strategy of Japan emerges. Before disentangling its key tenets, it is useful to identify the endogenous and exogenous drivers behind the strategy.

4.1.1 Endogenous Drivers:

The vitalization objective of Japan's industry primarily rests on the recognition of the country's reliance on space-based assets for its critical national infrastructure, national security and economic development and the resulting need for a "stable and vigorous industrial infrastructure underpinning space development and utilization"[326].

Japan's space industry is primarily financed through demand from governmental institutions and requires large sums of money and a long-term financial security. However, Japan's budget allocation based on one fiscal year is hindering the space industry in its endeavour to become more stable and sustainable and is also stifling the emergence of newcomers to the industry[327].

Equally important, as highlighted by the Space Industry Vision 2030, the space industry is a strong driving force for promoting the 4th industrial revolution and encouraging the development of a "5.0 society", thereby fulfilling the mission of the broader "Japan Revitalisation Strategy". In addition to promoting productivity in other sectors, it is a frontier field for the creation of new growth, among other things due to space sector's innovation being based on big data, Artificial Intelligence (AI) and Internet of Things (IoT).

However, in its policies documents, the government also identifies shortcomings that are hindering industrial development. The high technological sophistication required in the space hardware industry is at odds with the low demand for satellites in Japan, particularly from Japan's governmental institutions

[326] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 6.
[327] Ibid. pp. 6-7.

– thus creating a system in which it is "difficult to secure profits while maintaining the necessary manufacturing and tech infrastructure over the long term"[328]. The instability of the industry also creates a Japanese industrial reliance on foreign components of satellites and other space technology. This reliance needs to be addressed in order to increase Japanese industrial autonomy[329].

New downstream industries need to be created through domestic public-private cooperation. Furthermore, the Basic Plan on Space Policy proposes to tap into new markets overseas to supplement domestic demand. More generally, the report says that "Japan must also contribute to the maintenance and advancement of its own industrial infrastructure by working to promote space equipment orders from abroad through international cooperation and diplomatic efforts"[330].

The perceived shift in global power balance in space and the increased accessibility of space have caused new countries to emerge as space actors, who "operate in space but lack domestic space industry infrastructure"[331], which Japan perceives an opportunity for its own space industry.

Furthermore, Japan must use its needs in the area of national security as a driver for "cutting-edge R&D" which can "contribute to the vitalization of the space industry and the advancement and increased efficiency of related industries"[332].

4.1.1 Exogenous Drivers

Alongside the above-discussed internal drivers, what has been driving a radical change in the strategic posture of Japan was the need to adapt to the emergence of the so-called New Space dynamic (see Figure *26*), which has further highlighted the fragility of the Japanese space industry.

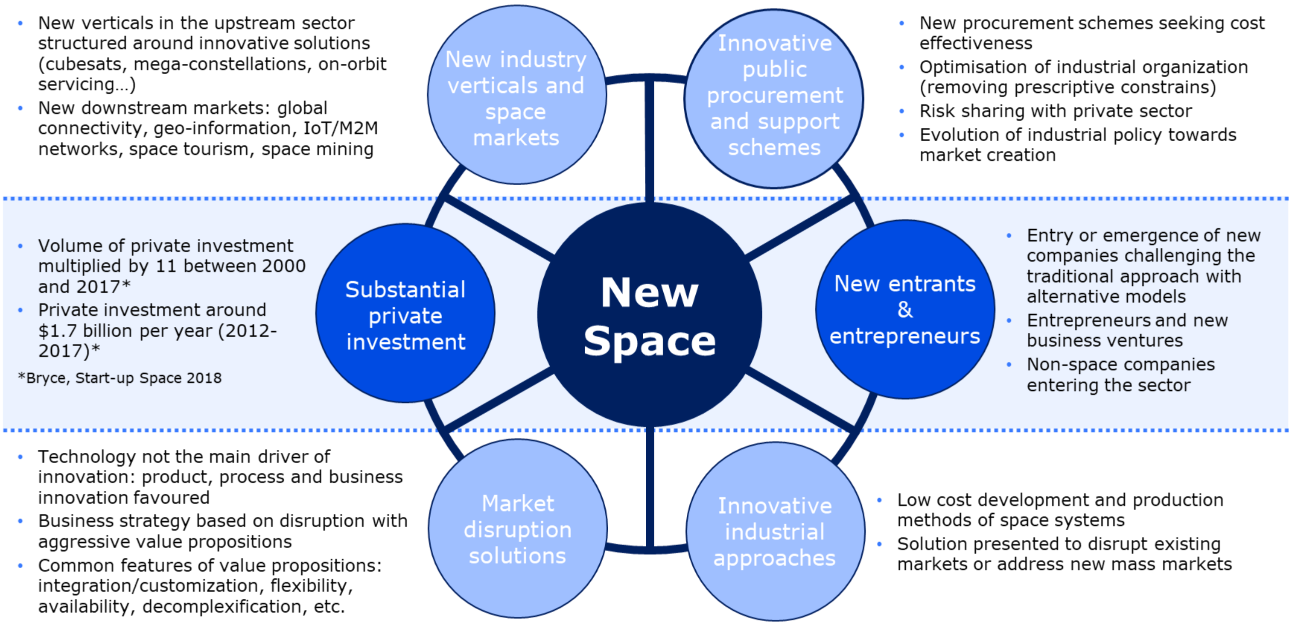

Figure 26: New *Space* dynamic (source*:* ©ESPI)[333]

This unfolding sectorial dynamic is boosted by a number of factors, including: new technologies and processes (such as automation, Artificial Intelligence, miniaturisation…); the internationalisation of the

[328] Ibid.
[329] Ibid.
[330] Ibid.
[331] Ibid.
[332] Ibid.
[333] European Space Policy Institute. (2019). *Space Venture Europe 2018: Entrepreneurship and Private Investment in the European Space Sector.* Vienna: ESPI.

Global Value Chains (GVCs); the entrance of new commercial actors from the Internet economy disturbing the incumbents; and innovative uses of satellite links and data detached from traditional space sector, with needs to adapt to new requirements (e.g. real-time imaging)[334].

As shown in previous European Space Policy Institute (ESPI) studies, the emergence of New Space "offers an interesting opportunity for governments to consider more ambitious partnerships with private businesses, contributing to the growth of the sector and to the amplification of the socio-economic impacts of space activities"[335]. Fully cognisant of this opportunity, Japan deems it essential to foster the emergence of a more business-oriented leadership in the space sector and take advantage of new possibilities offered by this new dynamic for space programmes.

At the same time, the emergence of New Space has been accompanied by a paradigm shift starkly highlighting the fragilities of the Japanese space sector. According to Lacaze, three major aspects come to the fore:

- First, the transition from state-led to private-driven space endeavours is a development that sharply contrasts with the current Japanese situation, still dominated by government initiatives. In this respect, the heavy dependence of the Japanese space industry on public procurement and the chronic weakness of investment, both public and private, prove to be heavy limitations[336].
- Second, New Space is accompanied by an extension of the scope of space technologies contributing to the emergence of new uses of space centred, in particular, on data. The data economy represents a new market on which Japanese companies are struggling to make their mark, as the Cabinet Office described in a note published in July 2018[337], stating that exploitation of space-based data requires technical expertise that is lacking for a large number of Japanese players who are interested in this new market.
- Third, technological progress (miniaturization, 3D printing, digital revolution, robotics, etc.) has reduced the costs of access to space, favouring the entry of new players into a traditionally closed market. While taking off in the United States and Europe, this dynamic struggle to settle in Japan where the privatization of space activities is still far from becoming a reality. Several reasons explain this delay[338].
    - The first reason is that there is no connection between the R&D activities conducted in the context of institutional space programs and the needs of end-users. As suggested by the *Keidanren* in a report of 2016[339], Japanese space-related R&D has been historically oriented towards the promotion of science and technology rather than the development of practical applications, and this has been hindering the transition to a more user-driven industry.
    - A second reason is related to the difficulties that Japan is facing in the market of small satellites and launchers. As also highlighted in a METI report[340], this situation more specifically stems from Japan's inability, in the face of American and European competition, to respond to price

[334] European Space Policy Institute. (2017). *Outcome Report of ESPI's 11th Autumn Conference on 'Innovation in the New Space Economy*. Vienna: ESPI.
[335] European Space Policy Institute. (2019). *Space Venture Europe 2018: Entrepreneurship and Private Investment in the European Space Sector.* Vienna: ESPI.
[336] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[337] Cabinet Office. (2018). 「スペース・ニューエコノミー創造ネットワーク（Sエス-・NET ネット）」の新たな取組のご紹介～「S-NET 相談窓口」の増設、「宇宙ビジネス創出推進自治体」の公募など～ (New initiatives of the Space New Economy Creation Network (S-NET) - Expansion of the S-NET consultation window, public applications for "space business creation promotion municipalities," etc.). Retrieved from: https://www8.cao.go.jp/space/s-net/pressr2.pdf.
[338] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[339] Keidanren. (2016). 宇宙産業ビジョンの策定に向けた提言 (Proposal of a Vision for the Development of the Space Industry). Retrieved from: http://www.keidanren.or.jp/policy/2016/105_honbun.pdf.
[340] Ministry of Economy, Trade and Industry. (2018). コンステレーションビジネス時代の到来を見据えた小型衛星・小型ロケットの技術戦略に関する研究会報告書 (Report of the Study Group on Technology Strategy for Small Satellites and Launch Vehicles for the Constellation Business Era) Retrieved from: https://www.meti.go.jp/press/2018/06/20180601005/20180601005-2.pdf.

pressures by devising a system of low-cost mass production. Further factors add difficulties, such the costs generated by the dispersion on Japanese territory of the test facilities and the limited opportunities for in-orbit demonstration (despite a dedicated JAXA programme for Innovative Satellite Technology Demonstration and the availability of Japanese experimental module KIBO on the International Space Station).

To address the structural weaknesses of the Japanese space industry, and to cope with a paradigm change marked by the US and Europe's transition towards private solutions, the Japanese government has devised a new ambitious strategy.

4.2 Disentangling the Strategy

Japan's strategy for the space industry is encapsulated in policy documents such as the 2008 Basic Space Law, the 2013 and 2015 Basic Space Plans, the Implementation Plans as well the Space Industry Vision 2030. This latter document, in particular, summarises the Japanese government's strategy to expand the space market, improve competitiveness of the industry and stimulate the space economy. The Vision was released by the CNSP in May 2017 building on the directions and strategic orientations emerged in the Japan Revitalization Strategy of 2016, which spells out the broader industrial strategy of Japan.

A combined reading of these policy documents allows to distil the core objectives of Japan's strategy for the space industry. The declared target of Japan's space industry strategy is to double the size of Japan's space economy, passing from ¥ 1,200 billion (about € 9 billion) today to ¥ 2,400 billion (about € 18 billion) by 2030. To achieve this overarching purpose, the strategy rests on four main axes, namely:

- Promotion of the space utilization industry (Downstream)
  - Improving access to satellite data
  - Encourage the use and application of satellite data
- Promotion of the space equipment industry (Upstream)
  - Ensuring global competitiveness edge
  - Support new entrants in the market
- Overseas expansion
- Improvement of the business environment

4.2.1 Promotion of the space utilisation industry

The resolve to promote the downstream space industry builds on the recognition that satellite data will be an indispensable part of the big data infrastructure, and hence a driving force of the Fourth Industrial Revolution, which will in turn contribute to strengthening the competitiveness of many industries.

At the same time, there is a recognition that in Japan the continuity of satellite data is still lacking, that channels for acquisition are confusing and that there is a shortage of service providers for value-added business solutions. Therefore, the introduction of solutions that use satellite data is limited, concurrently limiting the growth on the demand side.

The Space Industry Vision 2030 stresses that the issue of ensuring the continuity of satellite data, of increasing the frequency of observation data, and the issue of accessibility to data must be addressed, if

Japan is to stimulate the development and growth of an end-user market and the update of businesses using satellite data[341].

Tacking stock of these issues, the first axis of Japan's space strategy aims, on the one hand, to improve access to satellite data including sectors not directly related to space and, on the other hand, to promote their use and application among all private actors. To this end, the strategy advocates several measures such as the creation of catalogues on satellite data and of new models of data use based on AI technologies as well as the enactment of a free and open data policy for governmental satellites.

4.2.2 Promotion of the space equipment industry (Upstream)

The second axis of Japan's industry vitalization strategy is the promotion of the upstream space sector. As spelled out already by the Basic Space Plan of 2015, the target is to scale-up Japan's spacecraft industry to a total of ¥5 trillion in ten years. Reaching this target requires fulfilling two sub-objectives, namely:

- strengthening the international competitiveness of Japanese space industry by reducing costs for rockets and spacecraft manufacturing and by placing greater emphasis on the domestic development of cost-competitive key parts and components;
- Providing support for new entrants in the space market by ensuring the provision of in-orbit demonstration opportunities and paying particular attention to the small launch sector.

With regard to the first objective, the Space Industry Vision stresses the importance of reducing the costs for satellite manufacturing by serializing production while carrying out continuous R&D and demonstration aligned to both commercial and institutional needs. It also highlights the aim of halving the launchers' costs and shrinking their manufacturing period by steadily introducing and commercializing new rockets (namely H3 and reusable space transportation systems) as well as supporting the development of low-cost small launchers. Finally – in line with the roadmap formulated in the "Parts and Component Technology Strategy" of March 2016 – the vision document highlights the resolve to enhance the competitiveness of domestic parts and components used for space systems, an approach that is "expected to create a virtuous cycle: improved parts and components will drive up the space industry's sales; expand the space industry market; and increase investments in R&D and production capacity of space parts and components"[342].

With regard to the second objective, the strategy expresses the importance of adapting the procurement system (by inter alia considering the introduction of fixed contracts) and promoting various support measures to facilitate the creation of new space-related businesses and secure the investment potential for technological development. It also identifies the need of providing in-orbit demonstration opportunities and creating a "one-stop service" for related support measures. Finally, it recommends devising support measures for the small launcher sector (e.g. creating guidelines and survey market trends, facilitating funding and financial incentives as well as adapting launch sites to their needs).

4.2.3 Overseas expansion

While Japan's space market is stable, the space strategy recognises that in order for Japan's space industry to expand in scale, it is essential to capture the growth of overseas markets which are mainly expanding in emerging countries. Indeed, the increasing accessibility of space has allowed many new

[341] Cabinet Office. (2017). 宇宙産業ビジョン 2030 (Space Industry Vision 2030). Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/vision/mbrlistsitu.pdf.
[342] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*, 29-30.

countries that still lack a domestic space industry infrastructure to invest in space – a development that Japan sees as an opportunity for its own space industry[343].

Ensuring access to these growing overseas markets is the third axis of Japan's industrial strategy. This axis is based on three main objectives. The first one is to pay greater efforts towards identifying the potential needs of the partner countries in terms of equipment, services and human resources to then propose appropriate solutions. To this end, Japan established a "Task Force on Space System Overseas Development" composed of actors from the government and the private sector involved in the space sector. This Task Force's role is to "examine specific overseas expansion measures from a strategic perspective, taking into account Japan's strengths, the circumstances and needs in counterpart countries, and comprehensive infrastructure packages, and will seek to develop commercial space markets that bring the public and private sectors together"[344].

The second objective is to promote the use of Japanese remote sensing services and high-precision positioning services using QZSS in Asia and Oceania, while coordinating with the European Galileo system.

The third objective is to reinforce international cooperation with the main national space agencies worldwide (in particular NASA, CNES and DLR) while promoting a stronger linkages and concrete space cooperation in the Asia-Pacific region through collaboration with APRSAF, the East Asia-ASEAN Economic Research Center (ERIA), and others and the Asia Development Bank (ADB).

4.2.4 Improving the Business environment

The fourth axis of Japan's strategy to invigorate the growth of its space industry is the enhancement of the country's space business environment to facilitate new entrants in the market.

The Japanese strategy envisages in this respect three objectives. The first is to encourage the emergence of new activities and ideas by facilitating access to finance risk by venture companies and setting up competitions to support the commercialization of innovative projects.

The second objective focuses on strengthening human resources, particularly in the field of information technology, to address the requirements of the Fourth Industrial Revolution[345]. In this context, Japan aims to implement measures "to cultivate and secure human resources with expertise and specialized knowledge of the space field including technologies like positioning, communication and broadcasting, and earth observation satellites and rockets, as well as of space-related international relations and relevant policies, including consideration of acceptance of overseas human resources and dispatch of domestic human resources overseas so as to reinforce interpersonal interaction and networking, and other aspects of career paths. [...] Steps will also be taken to enhance space science and engineering research programs at universities"[346]. In addition, Japan also aims to encourage inter-organizational human resources exchange (e.g. between MEXT and METI) and joint mobilization of human resources in widely varying fields (including between space and non-space industries).

[343] Cabinet Office. (2017). 宇宙産業ビジョン 2030 (Space Industry Vision 2030). Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/vision/mbrlistsitu.pdf.
[344] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[345] The strategy acknowledges that human resources in Japan's space industry are limited, and new businesses are unlikely to start, so the scale of the industry does not expand, resulting in a vicious circle of influx of human resources to the space industry. In addition, talented people are needed to match needs and seeds. In order to solve these issues, we should enhance the mobility of human resources by strengthening networking.
[346] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf. p. 21.

Finally, the third objective focuses on the creation of an institutional and legal framework favourable to the uptake of the New Space businesses. Two areas of activity are in particular targeted, namely the development of in-orbit services and activities related to the exploitation of space resources.

4.3 Tools and Mechanisms to Achieve Objectives

In order to achieve the above outlined objectives, a number of tools have been deployed over the past few years. As in Chapter 3, these have been categorized in three types of tools: programmatic measures, legal and regulatory measures and diplomacy and cooperation tools.

4.3.1 Programmes & Tools

In line with the Basic Law on Space Policy on commercialisation of space, over the past few years JAXA (and other governmental bodies) have launched numerous initiatives to expand the Japanese space industry and promote greater use of space technologies. From a programmatic perspective, it is possible to distinguish among three broad types of tools, namely:

- Initiatives to encourage the entrance of private actors into the space market.
- Mechanisms to promote the use of space data and technologies
- Mechanisms to connect actors in the space economy

An overview of the different mechanisms is provided in Figure 27.

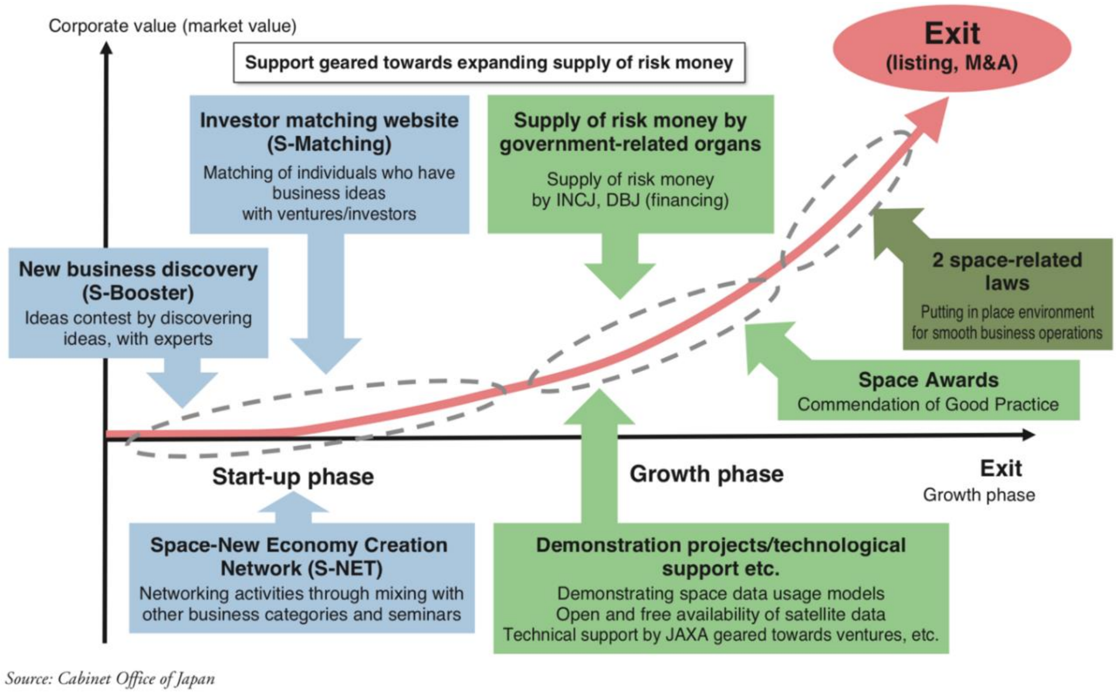

Figure 27: Mechanisms to expand space industry and promote greater use of space technologies (source: Takakura, 2019) [347]

[347] Takakura, H. (2018, July/August). Recent Trends in Japan's Space Policy -- Centered on promoting the Space Industry. *Japan Spotlight*, 24-28.

Initiatives to encourage engagement of private actors in the space sector

These types of initiatives include both institutional tools and financial mechanisms. These are summarised below:

- Creation of the New Enterprise Promotion Department
- Creation of the Space Exploration Innovation Hub (Tansa-X)
- KIBO experimental module and commercial exploitation of Low Earth Orbit
- Launch of J-SPARC: (JAXA-Space Innovation through PARtnership and Co-creation)
- Investment programmes to ease access to finance

Creation of the New Enterprise Promotion Department

One of the most important initiatives launched by JAXA to promote and support the development of the Japanese space industry lies in the creation of the New Enterprise Promotion Department. This department was created pursuant the institutional reform of April 2015, which changed of status of JAXA and centralized R&D functions within the new "Directorate for Research and Development".

With a predominant focus on spin-off technologies, the New Enterprise Promotion Department has launched a series of initiatives to encourage businesses, especially small and medium-sized enterprises (SMEs), to use JAXA’s technologies, patents and intellectual property to develop their own products. These activities are summarized in Figure 28.

Figure 28: Activities of the New Enterprise Promotion Department (source: authors´visualisation)

Creation of the Space Exploration Innovation Hub (Tansa-X)

Building on the recognition of the active role of private actors in the future Moon and Mars exploration, JAXA-ISAS created the Space Exploration Innovation Hub in 2015 with the aim to spur innovation from the union of space and terrestrial technologies cooperation between private companies and research institutes to bring together cutting-edge technologies for creating innovations both in Space exploration and on Earth[348].

Known as Tansa X (Tansa meaning exploration in Japanese), the Hub more specifically aims to encourage mutually beneficial Public-Private Partnership (PPP) projects that can simultaneously drive: a) technology development to support JAXA's future space exploration, and b) technology development to benefit the industries on the ground (see Figure 29)[349].

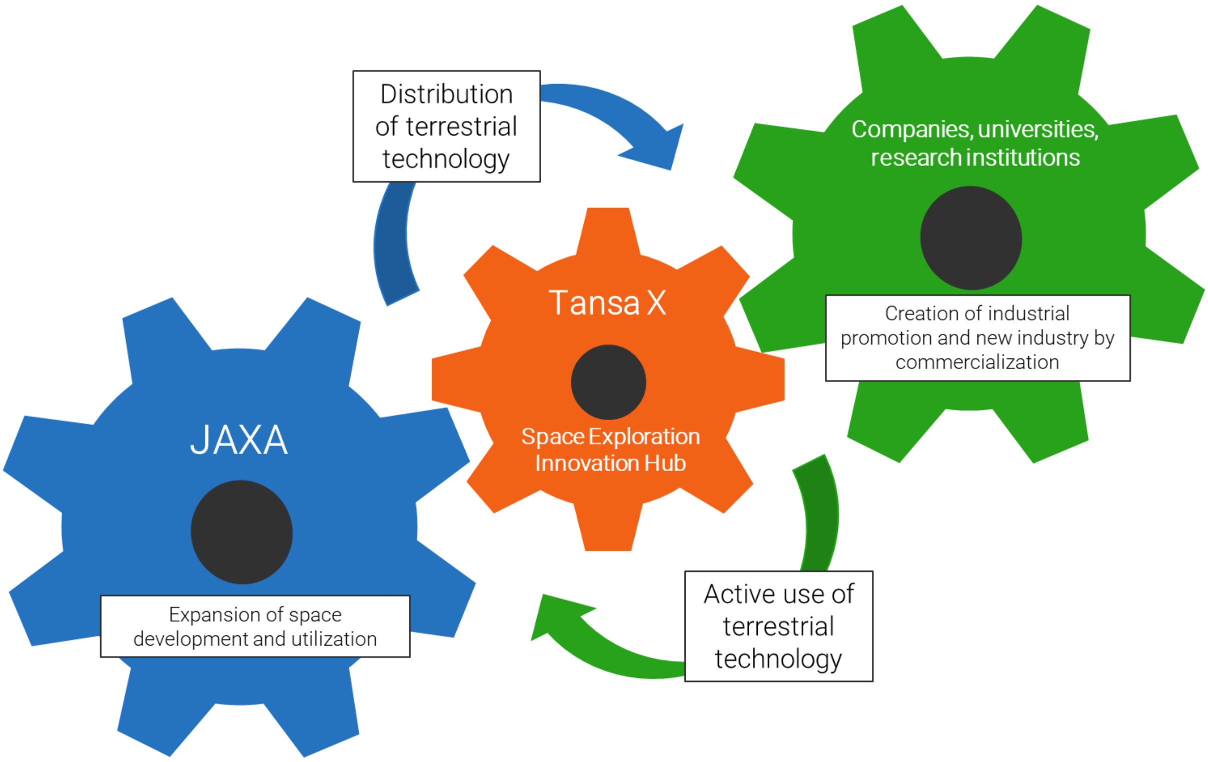

Figure 29: Current Efforts of the Space Exploration Innovation Hub (source: authors' visualisation adapted from JAXA)[350]

In order to carry out these activities, Tansa X launched the programme "Open Innovation Hub for Expanding Human Domain and Domain of Activity through Solar System Frontier Development" with the logistical and financial support of the Japan Science and Technology Agency (JST) in June 2015. The programme operates on the basis of regular calls for projects open to a wide range of participants. As reported by Dunphy, "the programme publishes a list of key research areas needed to further JAXA's space exploration efforts, and invites companies to participate on the collaborative project with JAXA. The idea is to establish a win-win scenario for both parties, where JAXA benefits from delegating key

[348] Japan Aerospace Exploration Agency. (2019). Space Exploration – Innovation Hub Center. Retrieved from JAXA: http://www.ihub-tansa.jaxa.jp/english/.
[349] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
[350] Japan Aerospace Exploration Agency. (2014). *About "Open Innovation Hub for Expanding Humanosphere and Domain of Human Activity through Solar System Frontier Development".* Tokyo: JAXA.

technology development activities, and companies and institutions benefit from using JAXA's expertise, intellectual property, and facilities to develop new products for terrestrial use as a spin-off"[351].

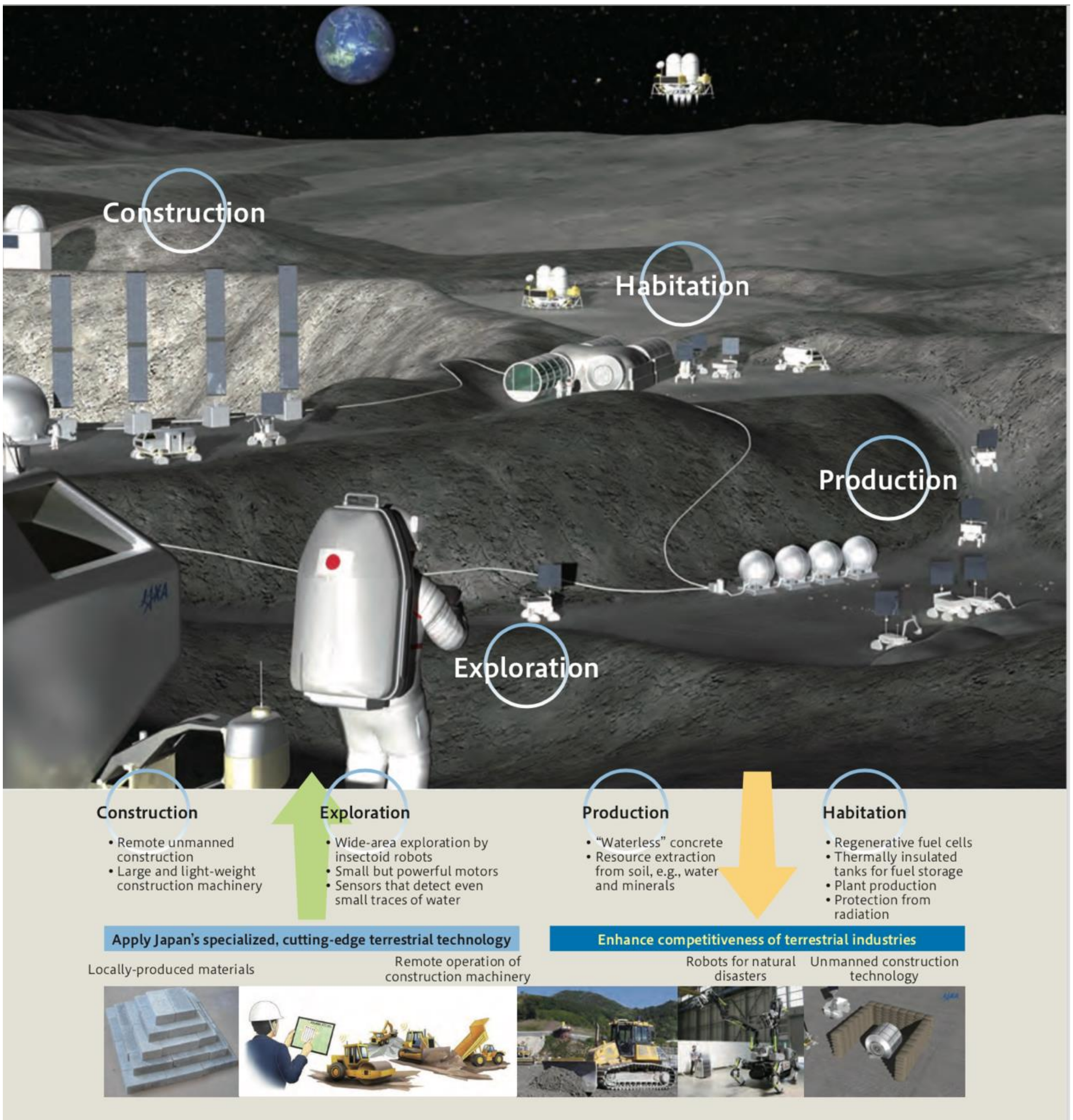

Figure 30: "Innovations from the union of space and terrestrial technologies" (source: JAXA, 2014)[352]

The projects selected are divided into two categories:

- the "Solution Creating Research" category, which includes projects with a clear technological target receiving financial support ranging from ¥ 100 to 300 million yen (€ 700,000 to 2 million) over a period of 3 to 5 years;
- the "Ideas Incubating Research" category, which includes projects implemented to discover new technologies and ideas. These projects receive financial support ranging between ¥1 and 5 million (€7000 to 37 000) over a period of one year[353].

351 Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
352 Japan Aerospace Exploration Agency. (2014). *About "Open Innovation Hub for Expanding Humanosphere and Domain of Human Activity through Solar System Frontier Development".* Tokyo: JAXA.
353 Ibid.

Since its inception, more than 100 projects in collaboration with more than 150 different partners have been launched. Importantly, several of these partnerships have been formed with companies whose core business is not directly related to space, such as Mitsubishi Materials Corporation (materials), Takenaka Corporation (architecture and construction), Misawa Home (housing construction), Hitachi Zosen Corporation (large industrial projects), and Takara Tomy (video games).

Arguably, the most prominent example of engagement with companies not directly related to space is given by the collaboration signed in May 2018 between Toyota and JAXA to jointly pursue a conceptual study on a pressurized crew rover for Moon Exploration (see Figure 31).

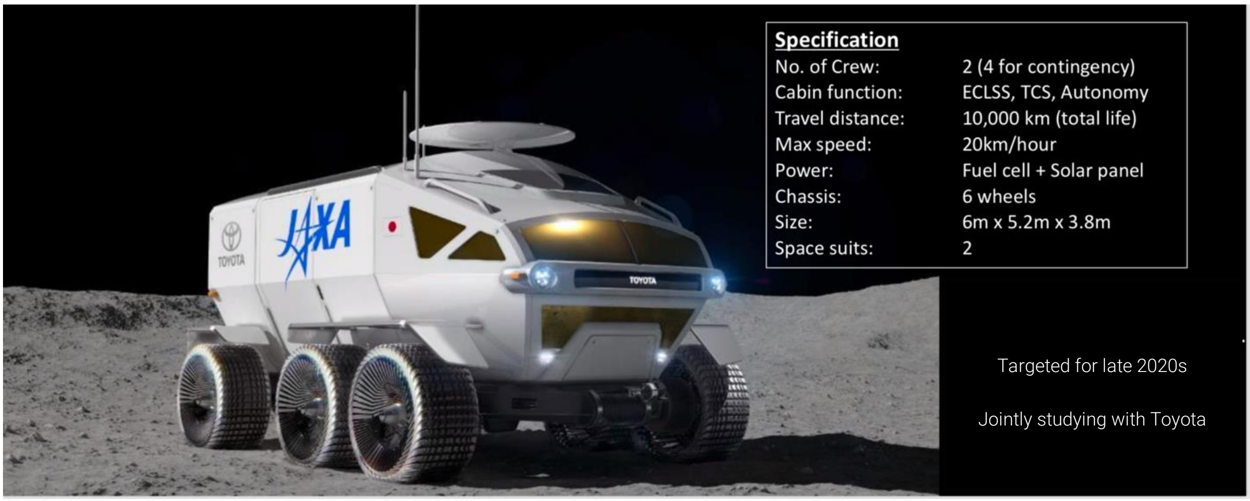

Figure 31: Human Pressurized Rover. (source: ©Toyota)[354]

Utilization of KIBO experimental module

Another important initiative devised by JAXA to stimulate engagement of private actors is the KIBO utilisation programme. As mentioned in Chapter 2 and consistent with the "Kibo Utilization Strategy" outlined by JAXA in 2017, this Japanese experimental module KIBO has been opened to academia and private actors. Through the payment of some fees, Japanese companies have the possibility to use four dedicated experimental platforms:

- the drug-design supporting platform;
- the aging research supporting platform;
- the Exposed Facility port utilization platform;
- the small satellite deployment platform.

This latter platform is also a cornerstone of JAXA's long-term strategy to promote the commercial use of LEOs in the post-ISS period. Kibo is the only module that has both an airlock and a robotic arm on the ISS from which cubesats can be deployed without EVA. Furthermore, since JAXA anticipates a sharp increase in the use of its platform, the commercialization small satellite deployment business is seen by JAXA as the first step in this strategy. Consequently, in May 2018, the agency awarded two private operators, SPACE BD Inc and MITSUI & CO., the satellite deployment service from Kibo. The two operators are now responsible for pricing, contract management, and review of applications, while JAXA will continue to provide safety reviews and transportation services to Kibo. In the long-term, other activities carried out from Kibo are also intended to be marketed once they have reached a sufficient technological maturity.

[354] Sasaki, H. (2019). JAXA's Lunar Exploration Activities. Vienna: JAXA Space Exploration Center.

From 2024, the end date of the ISS program, JAXA wants to launch a public-private commercial platform from Kibo dedicated to microgravity experiments[355].

Launch of J-SPARC: (JAXA-Space Innovation through PARtnership and Co-creation)

Launched in May 2018, J-SPARC (JAXA-Space Innovation through Partnerships and Co-creation) is a new R&D programme targeting the private sector. It is designed to stimulate the development of the space sector and create new technological innovations that can find commercial applications through a partnership that leverages JAXA's technical expertise and private sector know-how and that adopts a new way of working, i.e. a joint development approach.

J-SPARC targets a wide range of partners, from startups to large industries, by promoting an open innovation approach that brings together technologies, funds and professionals from different sectors. It is also open to universities and research institutes. The programme covers three main themes:

- "Extend the scope of human activities" (activities related to lunar exploration and other planets, relevant technologies for stays in space or in-orbit services);
- "Space and Entertainment" (space travel, virtual reality applications and augmented reality etc.);
- "Responding to the challenges of the planet" (remote sensing, positioning, telecommunications, big data, artificial intelligence, internet of things, space transportation).

The first call for proposals was launched on 8 June 2018 and four projects have already led to the launch of a partnership, namely:

- the suborbital shuttle project planned by Space Walker together with IHI Corporation[356];
- the project "Avatar X", jointly developed with the airline All Nippon Airways (ANA) and designed to develop avatars, i.e. robots controlled remotely by a human being allowing the latter to see, hear, feel and interact in real time within the environment in which the robot is located. The objective of this technology is to facilitate future space exploration missions by allowing remote bases to be built on the surface of the Moon or Mars and to ensure the maintenance of future space stations from the Earth. This program also aims to expand entertainment and space tourism activities[357];
- the project "Bosai Space Food Project", developed with the company One Table, aimed at designing foods with the dual objective of being able to be consumed in space and to meet needs in the event of a natural disasters[358];
- the educational project proposed by the Japanese companies SPACE BD and Z kai whose objective is to develop new educational methods from astronaut training methods.

Access to Finance/Financial mechanisms

Regarding financial mechanisms, dedicated investment programmes to support the growth of the space economy have been put in place by the Cabinet Office, the Development Bank of Japan (DBJ) and Innovation Network Corporation of Japan (INCJ).

Starting with the governmental initiatives, in March 2018, Japanese Prime Minister Abe Shinzo announced a new "package of support measures" to bolster the development of space ventures. Out of the 10

[355] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[356] Japan Aerospace Exploration Agency. (2019). "Space Walker". Retrieved from: https://aerospacebiz.jaxa.jp/en/spacecompany/spacewalker/.
[357] Japan Aerospace Exploration Agency. (2018). "ANA HOLDINGS and JAXA Partner to Create a New Space Industry Centered Around Real-World Avatars". Retrieved from: https://global.jaxa.jp/press/2018/09/20180906_avatarx.html.
[358] Japan Aerospace Exploration Agency. (2018). "防災分野における J-SPARC 事業コンセプト共創に関する覚書の締結について～ワンテーブル・JAXA 共同で「BOSAI SPACE FOOD PROJECT」を始動！ (Memorandum of Understanding on the Joint Creation of J-SPARC Project Concepts in the Field of Disaster Prevention - One Table and JAXA Jointly Launch "BOSAI SPACE FOOD PROJECT"!) Retrieved from: http://www.jaxa.jp/press/2018/08/20180830_jsparc_j.html.

measures included in the package, two were dedicated to providing financial support to space businesses[359].

The first measure is the creation of a fund of ¥100 billion (about €750 million) to provide private companies, especially startups, the necessary financial resources to initiate space business. Spread over five years, this amount is to be financed through public and private investors, including the DBJ and the INCJ[360].

The second measure of the package is the creation of a space-business-matching platform, the **S-Matching**. Operational since May 2018, this platform aims to cope with the absence of structured relationships between individuals with business ideas and venture companies or between investors and industrial companies by facilitating networking between economic actors in the space sector. The platform is operated by the New Energy and Industrial Technology Development Organization (NEDO), a public agency dedicated to research and development, with technical support offered by JAXA. Thanks to the creation of a dedicated website, S-Matching enables project owners to present their ideas to investors registered on the platform. The latter can get in touch directly with the entrepreneurs who have generated their interest in order to discuss in more detail how projects are implemented and financed[361]. As reported by Lacaze, "the platform already has more than 200 entrepreneurs and about fifty investors that include major Japanese groups such as Softbank Corp., Itochu Corp, Japan Airlines or Mizuho Bank"[362].

Besides the government funds, an additional source of finance tools has been made available by the DBJ. On the basis of its 4th Medium-Term Management Plan (2017-2019), which identified the aerospace sector as one of the bank's new priority areas of action, the DBJ set up a support programme in April 2017 to finance companies in the aerospace sector[363]. This Plan more specifically envisages a large-scale investment programme in the aerospace industry, spread over the period 2017-2019. In order to run this programme, a dedicated office, the Aerospace Office, was created in April 2017 and a cooperation agreement was signed with JAXA on 17 May 2017, allowing the DBJ to build on JAXA's skills to evaluate the projects to be financed. As of 2019, the DBJ has been involved in the financing of three main projects:

- the acquisition of a stake in GPAS (Global Positioning Augmentation Service Corporation);
- the acquisition of a stake in Space One;
- participation in the fundraising campaign carried out by Ispace in December 2017, which totals ¥ 10 billion (approximately € 75 million)[364].

Besides the Development Bank of Japan (DBJ), financial support is also provided by **INCJ**, an investment fund created in 2009 under the auspices of METI. Starting in 2016, the INCJ opened its investment portfolio to several companies in the space sector. In February 2016, INCJ made the decision to invest US$30 million in Astroscale and "completed two investments of US$15 million each in March 2016 and June 2017. In addition to investing the funds necessary for their business, INCJ has provided management support including the dispatch of an external director"[365]. Then, in October 2018, INCJ announced a follow-on investment, through third-party share allocation, of US$35 million. Through this funding, INCJ aims to "support technological development, demonstrations, and the structuring of

[359] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[360] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[361] Takakura, H. (2018, July/August). Recent Trends in Japan's Space Policy -- Centered on promoting the Space Industry. *Japan Spotlight*, 24-28.
[362] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[363] Development Bank of Japan (2017). "Fourth Medium-Term Management Plan" Retrieved from: https://www.dbj.jp/en/pdf/ir/about/plan/plan4.pdf.
[364] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[365] INCJ. (2018). "INCJ to make follow-on investment in Astroscale Pte. Ltd. Aiming to commercialize space debris removal" Retrieved from: https://www.incj.co.jp/english/newsroom/upload/docs/92b9f17f7f32666574d312f8943531b0798c7e49.pdf.

Astroscale's business model while contributing to the resolution of the issue of space debris, a major obstacle to the development of the space industry. Moreover, by supporting the expansion of the space industry by private companies, INCJ aims to contribute to the development of Japan's space-related R&D"[366].

In addition to Astroscale, INCJ also invested ¥ 850 million (about 6.5 million €) in the iQPS startup in November 2017; ¥ 3.5 billion (approximately € 25 million) as part of the fundraising campaign carried out in December 2017 by ispace; and ¥ 800 million (about € 6 million) in the Umitron startup.

Mechanisms to promote the use of space data and technologies

The most important mechanisms to promote the use of space data and technologies include:

- Tellus
- S-Booster
- Space Development and Utilization Grand Prize

Tellus Satellite Data Sharing Platform

Building on the recognition that "promoting the use and application of satellite data rests primarily upon improving access to satellite data" and consistent with the goal of stimulating a vibrant downstream in Japan, the Space Industry Vision enacted by the Japanese Government in the spring of 2017 states the importance of promoting the free and open data policy for governmental EO satellites.

To this end, in July 2017 JAXA released "a remote sensing catalogue that bundles together basic information related to the various types of remote sensing data that exist in Japan and overseas"[367] [368]. At the same time, METI funded the creation of a satellite data sharing platform called Tellus.

Primarily aimed at creating a new business marketplace using governmental satellite data, Tellus "is designed to facilitate easy use of satellite data — which, traditionally, has been largely inaccessible to most — by private-sector companies, universities, research institutions and other organizations, and even individuals. Tellus supports the creation of a wide variety of different business types in multiple fields that make use of more free and open space-based data"[369].

In addition to offering open and free access to governmental satellite data[370], the platform offers a range of services to boost the creation of new businesses, including: an easy-to-use interface, making use artificial intelligence technologies and analytical tools to facilitate access and exploitation of data; a cloud-based online storage service; as well as tools, free and paid, for data processing.

The development of the platform was entrusted to the Japanese company Sakura Internet under a contract concluded on in May 2018 and it is expected that the platform will generate up to ¥ 340 billion (about € 2.6 billion) by 2030.

To further stimulate the use of the platform, a data analysis contest was launched. Named Tellus Satellite Challenge, this contest is "designed to achieve understandable visual representations of satellite data usage examples, discover exceptional human resources in the area of analysis, promote greater awareness and understanding regarding satellite data types and formats, and achieve other such ends

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[366] Ibid.
[367] Takakura, H. (2018, July/August). Recent Trends in Japan's Space Policy -- Centered on promoting the Space Industry. *Japan Spotlight*, 24-28.
[368] As noted by Takakura, the idea of the catalogue is that the different businesses that have never dealt with satellite data before should be empowered to start thinking about how to use and apply satellite data.
[369] SIGNATE. (2018). "The 2nd Tellus Satellite Challenge". Retrieved from: https://signate.jp/competitions/153.
[370] Takakura, H. (2018, July/August). Recent Trends in Japan's Space Policy -- Centered on promoting the Space Industry. *Japan Spotlight*, 24-28.

with the goal of promoting widespread utilization of the Tellus platform"[371]. The theme of the first contest, held in December 2018, was the detection of landslides using synthetic-aperture radar (SAR) data. The contest saw 3400 submissions from 544 participants and assigned the winner ¥1 million.

S-BOOSTER

Launched by the Cabinet Office in 2017, S-Booster is the first project competition to promote New Space in Japan, and more specifically, to encourage the commercialization of innovative ideas developed using space technologies on the Japanese market. This yearly contest solicits the submission of business ideas from various entities, including individuals aiming to start their own business. The ideas passing the initial screening receive mentoring from space business experts on how to commercialize and capitalize them, before presenting them directly to investors and business companies who are keen to support the projects[372]. Winners of the contest receive a prize of ¥10 million.

During the first edition of the S-Booster competition, held in October 2017, over 300 projects were submitted and the first prize was awarded to a business idea that used three-dimensional wind speed data obtained from satellites to calculate the optimal flight path and altitude for airlines[373]. While the first two editions of the competition were aimed only at Japanese candidates, the 2019 edition has been opened to Asia-Pacific countries and organized around three themes:

- Business ideas utilizing Japanese Space Asset;
- Business ideas in collaboration with Japanese companies;
- Business ideas using the QZSS[374].

Space Development and Utilization Grand Prize

Launched in 2013, the Space Development and Utilization Grand Prize is a biennial competition aiming to encourage the development and commercialization of innovative space technologies[375]. The competition foresees ten different prizes, each awarded by a specific ministry/ government department.

In line with the objectives set forth by Space Industry Vision 2030, the third edition of the contest put a particular emphasis on the development of downstream technologies, in particular EO. Towards this, in addition to the existing 10 prize categories, a new award (the "Ministry of Agriculture, Forestry and Fisheries Award") was created with the aim to foster the development and use of space technologies in the domains of agriculture, forestry and fisheries. The awards of the 2017 edition are summarized below:

1. The Prime Minister's Award was conferred to University of Tokyo for the Hodoyoshi project of EO microsatellites.
2. The Cabinet Office's Award went to the Yamap Co. start-up, which developed an app allowing mountaineers and trekkers to use GPS on their smartphones rather than a separate GPS receiver.
3. The Minister of Internal Affairs and Communications Award went to National Institute of Information and Communications Technology (NICT).
4. The Foreign Minister's Award went to Kyushu Institute of Technology (Kyutech).

[371] SIGNATE. (2018). "The 2nd Tellus Satellite Challenge". Retrieved from: https://signate.jp/competitions/153.
[372] Cabinet Office. (2018). "Space Business Idea Contest ´S-Booster´". Retrieved from: https://www8.cao.go.jp/space/english/s-net/s-booster/index.html.
[373] Takakura, H. (2018, July/August). Recent Trends in Japan's Space Policy -- Centered on promoting the Space Industry. *Japan Spotlight*, 24-28.
[374] Cabinet Office. (2018). "Space Business Idea Contest ´S-Booster´". Retrieved from: https://www8.cao.go.jp/space/english/s-net/s-booster/index.html.
[375] Japan Space Forum. (2019). 第４回宇宙開発利用大賞 (4th Space Development Utilization Grand Prize). Retrieved from: http://www.uchuriyo.space/taishou/.

5. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) Award was conferred to Tokushima University for its work on astrobiology and space nutrition, as well as the study of muscle atrophy caused by weightlessness.
6. The Ministry of Agriculture, Forestry and Fisheries Award went to Aomori Prefecture for using remote sensing and satellite imagery to aid in the production of high-quality rice.
7. The Minister of Economy, Trade and Industry (METI) Award went to Axelspace for its Axelglobe project constellation of 50 EO microsatellites.
8. The Ministry of Land, Infrastructure, Transport and Tourism Award went to the company Magellan Systems Japan for its multi-GNSS receiver compatible with QZSS positioning system and offering a precision of the order of a centimetre.
9. The Ministry of the Environment Award was conferred to Sanyo Techno Marine (STM), Remote Sensing Technology Center of Japan (Restec)
10. The JAXA award went to the Tohoku University for its deorbiting mechanism applied to microsatellites[376].

Mechanisms to connect the actors in the space economy.

A third set of programmatic tools comprises mechanisms to connect the actors in the space economy.

- S-NET (Space - New Economy Creation Network)
- S-Expert Platform
- SPACETIDE

S-NET (Space - New Economy Creation Network)

Created in March 2016 by the CAO with support from METI, the S-NET (Space - New Economy Creation Network) project is a networking framework in which “companies, individuals, associations and other entities that are interested in creation of new industries and services involving space (a keyword concept of the framework), are able to participate”[377]. Under this framework, CAO and METI have been “holding regional business matching events between the space industry and other industries, aiming to facilitate the creation of new industries and services taking advantage of business involving space”[378].

Importantly, S-NET has been opened also to actors not directly related to the space sector. Indeed, approximately the 60% of the 520 members are companies not related to the space sector; 25% are companies related to the space sector; 9% individuals; 4% academic institutions; and about 4% public organizations[379].

Besides business matching events, the CAO and METI have launched several additional initiatives since 2018 to make S-NET’s more sustainable and practical. These include the creation of consultation counters in Tokyo, Osaka, Fukuoka and Sendai dedicated to providing companies with technical and commercial support; the organization of hackathons; the setting up of intensive training sessions and technical conferences targeting the exploitation of satellite data in the various prefectures of the country in cooperation with the Japan Space Systems (JSS) and the Remote Sensing Technology Center of Japan (RESTEC); the organization of annual events on space-related business in major cities across Japan; etc. Through these enhancements, the CAO and METI aim “to broaden the base on which the space industry

[376] Ibid.
[377] Ministry of Economy, Trade and Industry. (2018). “METI to Enhance the “Space New Economy Creation Network (S-NET)” Program to be More Sustainable, Autonomous, Practical”. Retrieved from: https://www.meti.go.jp/english/press/2018/0713_002.html.
[378] Ibid.
[379] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.

will develop more businesses and to support the industry in creating new business taking advantage of satellite data"[380].

S-Expert Platform

The S-Expert platform is another initiative launched by METI to support start-ups in terms of human resources. The platform is designed to connect space experts with new space companies looking for skilled labour. The initiative primarily targets active or retired experts from JAXA, the private sector or academia to meet the most diverse needs of new space companies, ranging from simple advice to full employment (part time, secondment, career change, etc.). Human resources with high expertise in other industries are also included in this framework, and human resources from other industries to the space industry can be matched by aiming to match not only venture companies but also large companies such as the equipment industry[381].

SPACETIDE

SPACETIDE is a private foundation created in 2015 and dedicated to promoting the emergence of New Space in Japan. With the support of the CAO, METI, MEXT, MIAC and JAXA, SPACETIDE organizes a conference each year, bringing together key space stakeholders on the Japanese New Space scene, including start-ups, corporations, government agencies and related organizations, investors, engineers, designers and researchers, and emerging players[382].The objectives of these conferences are to connect the actors of the new space economy, contribute to creating an ecosystem favourable to the development of the space industry in Japan and accelerate awareness of public and private decision-makers regarding the new economic opportunities related to space activities.

In 2018, the conference gathered around 600 key stakeholders discussing the ever-growing cooperation requirements between the space and non-space industry, while the 2019 edition focused on the frontier of emerging space technologies and services and gathered industry leaders not only from Japan, the US and Europe, but also from other Asian countries, to provide new angles to discussions[383].

4.3.2 Legal and regulatory measures

A second set of measures put in place by Japan to promote the uptake of private initiatives comprise the legal and regulatory measures. As in many other spacefaring countries, there has been a realisation in Japan that the development of a strong space economy requires the adoption of a sound legal framework to regulate and facilitate the conduct of commercial space activities.

As already mentioned in Chapter 2, the Basic Space Law of 2008 sees the "advancement of industry" as one of the key axes of Japan's space policy and lists a series of measures the government must put in place to spur the development of commercial space activities. More specifically, Article 16 inter alia recommends to make greater use of private operators for the supply of goods and services; enhance the speed with which public sector research and development results are transferred to the private sector; encourage private actors to use the results of public research for commercial purposes; facilitate the investment of private actors in the space sector by adopting more favourable tax provisions[384]. To enable this, Article 35 of the Basic Space Law requires the Government of Japan to establish a regime aimed at

[380] Ministry of Economy, Trade and Industry. (2018). "METI to Enhance the "Space New Economy Creation Network (S-NET)" Program to be More Sustainable, Autonomous, Practical". Retrieved from: https://www.meti.go.jp/english/press/2018/0713_002.html.
[381] Ministry of Economy, Trade and Industry. (2018). 宇宙産業分野における人的基盤強化 のための検討会 報告書 (Report of the study group on Strengthening the Human Resource Base in the Space Industry).Tokyo: METI. Retrieved from: https://www.meti.go.jp/press/2018/05/20180501001/20180501001-2.pdf.
[382] SPACETIDE. (2019). "Who we are". Retrieved from: https://spacetide.jp/en/whoweare.
[383] SPACETIDE. (2019). "What we do". Retrieved from: https://spacetide.jp/en/whatwedo.
[384] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.

ensuring legal certainty and competitiveness to Japanese companies by regulating the conduct of space activities and transposing international norms into domestic law.

Consistent with this provision, the Japanese government adopted two dedicated laws on 16 November 2016, respectively covering upstream and downstream-related activities:

- The "Act Regarding Launching and Control of Satellites" or Space Activities Act
- The "Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data" or Remote Sensing Data Act

Space Activity Act

The overarching objective of the Space Activities Act (Act No. 76 of 2016)[385] is to create a framework for "authorization" and continuous supervision for non-governmental entities to make it easier for them to launch satellites and participate in various space activities. The act is primarily concerned with the launch approval and management of satellites. It comprises three major parts:

- Permission related to the launching of spacecraft (articles 4-19)
- License related to the control of spacecraft (articles 20 to 30)
- Third party liability and compensation in the case of a launch failure or de-orbiting of a satellite (articles 35-54)

Regarding the first point, Chapter II of the law stipulates that non-governmental entities wishing to launch spacecraft need an authorization from the Government of Japan. The Cabinet Office will conduct pre-launch examinations to verify whether the entity meets a series of criteria, including: compliance with safety standards for rockets and launch facilities; the implementation of appropriate measures to ensure the safety of operations and public safety, in particular with regards to flight paths and launching areas; the ability of the operator to conducts the launch, the objectives of the satellites intended to be launched, etc.[386]. The law also defines special provisions on the application procedures for JAXA and the National Research and Development Agency (Article 19).

Concerning the satellite authorization, Chapter III of the law introduces a licensing regime for the exploitation of satellites. Also in this regard, the act stipulates that non-governmental entities need an authorization from the government, which conducts a screening on whether the objectives of the mission and measures of utilization of satellites are appropriate, the structures of the satellite ensure no risk of contamination or harmful interference, and on the existence of sound procedures for collision avoidance and end of mission disposal[387].

Finally, Chapter IV and V establish a regime compensation regarding third-party liability. The framework more specifically envisages the application of strict liability for third-party damage resulting from satellite launches and defines the "requirements of launch operators to take measures to ensure they can conduct compensation properly, including third-party liability insurance". At the same time, the law sets up a framework of financial guarantee by the state to cover an excess of compensations for third party within a certain amount.

With this provision, the Japanese government aims to alleviate financial concerns of private companies and hence make it easier for them to launch and conduct space activities[388]. Indeed, the financial

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[385] Cabinet Office of Japan. (2016). *Act on Launching of Spacecraft, etc. and Control of Spacecraft (Act No. 76 of 2016).* Tokyo: Cabinet Office of Japan.
[386] Hara, K. (2017). "Current Status of Japan Space Policy and Development of Legal Framework". Presentation at the 56th Legal Subcommittee of UNCOPUOS. Vienna: UNOOSA.
[387] Ibid.
[388] Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.

guarantee is "ultimately an asset for their international competitiveness since it positions them to offer their customers a launch service with a controlled financial risk"[389]. At the same time, it has to be noted, that this framework does not cover damage that occurs during activities in orbit. Since the liability issue for in-orbit activities may become a serious obstacle for commercial space activities, the opportunity to create a system for providing some level of public financial indemnification for damages resulting from accidental collisions is currently being discussed by the Cabinet Office[390].

Remote-Sensing Act

The adoption of the Remote Sensing Data Act (Act No. 77 of 16 November 2016)[391] builds on the recognition that the size of the global remote sensing data market is expected to grow enormously in the coming years thanks to such developments as the improvement of resolution (spatial and temporal), miniaturization of satellites and advent of mega-constellations, as well as the emergence of innovative business ideas (e.g. motion picture)[392]. As acknowledged by the MOFA, this evolution made it necessary to "establish rules to prevent misuse of RS systems and data" as well as "clarify criteria and standards to be complied with by private companies so as to enhance foreseeability and to reduce the business risks"[393].

The objective of the Act is twofold: on the one hand, it intends to stimulate the development of the Japanese data industry by providing a legal framework for regulating the activities of operators of space-based Earth observation data and, on the other hand, to supervise these activities for reasons of national security[394].

The Act deals with the commercial use of sub-meter satellite images and is comprised of three main parts:

- License to Use of Satellite Remote Sensing Instruments (Article 4 - Article 17)
- Regulations on Handling of Satellite Remote Sensing Data (Article 18 - Article 20)
- Certification of Persons Handling Satellite Remote Sensing Data (Article 21 - Article 26)

Concerning the first point, Chapter II of the law establishes a license regime to ensure the adequate use of remote sensing systems and instruments. Towards this, the use of instruments equipping remote sensing satellites must be subject to prior authorization from the government.

With regard to the second point, Chapter III of the law establishes a license regime to ensure the adequate handling of the data obtained by remote sensing systems. In order to acquire and process the data from these satellites, users need to obtain certification from the Cabinet Office.

Finally, the law enables authorities to take necessary measures to prohibit the distribution of remote sensing data to foreign entities or groups with malicious intent. More specifically, in order to ensure the secure use of remote sensing data, the law allows the Japanese authorities to restrict the distribution of such data in the event of a violation of established laws and rules or where there is sufficient ground to believe that the use of the satellite data is likely to cause adverse effect on ensuring peace and security of the International Community. Under those circumstances, "the Prime Minister may issue an order to a Satellite Remote Sensing Data Holder (excluding a natural person who has neither domicile nor residence in Japan or a corporation or any other organization which does not have a principal office in Japan that

[389] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.
[390] Ibid.
[391] Cabinet Office of Japan. (2016). *Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (Act No. 77 of 2016).* Tokyo: Cabinet Office.
[392] Hara, K. (2017). "Current Status of Japan Space Policy and Development of Legal Framework". Presentation at the 56th Legal Subcommittee of UNCOPUOS. Vienna: UNOOSA.
[393] Ibid.
[394] Lacaze, A. (2018). *Le Japon et le New Space.* Tokyo: Centre National D'Études Spatiales, Ambassade de France au Japan.

handles Satellite Remote Sensing Data in a foreign country (hereinafter referred to as a "Foreign Handler") to prohibit provision of the Satellite Remote Sensing Data designating the scope and time period" (article 19)[395].

4.3.3 Diplomacy and Cooperation

In recent years, Japan has activated its diplomatic channels to advance its industrial interests. Diplomacy and cooperation tools are in particular used to fulfil the third objective of Japan's industrial strategy, i.e. overseas expansion. As mentioned in Chapter 4.2, the limited size and saturation of the Japanese market make this move more and more pressing. A variety of measures can be identified. The most important are detailed hereafter.

Reinforcement and Promotion of Packages Sales

The first and most notable measure for promoting overseas development lies in the promotion of package sales (which comprise launch service, satellite systems, personnel training, etc.) especially in emerging countries.

This practice has thus far achieved mixed results, but Japan is currently strengthening this measure by tailoring the package according to the needs of the partner countries. Towards this, Japan is holding direct dialogues with user agencies in the partner countries to compensate the possible lack of sufficient understanding of the actual needs of the partner country.

Based on this need assessment, Japan intends to devise additional support tools, including the development of a service business using the traded satellite systems; the development of human resources, including the acceptance of students of the partner countries; support to the space policy development in the partner countries; technical cooperation between JAXA and Japanese universities; the comprehensive utilization of various government support measures, including government development funds, Official Development Assistance (ODA), and other government funds (OGF); the establishment of a local subsidiary dedicated to aftercare services such as maintenance as part of the package[396].

Consistent with these measures, Japan already implemented cooperation in human resource development with Vietnam, the United Arab Emirates (UAE) and Turkey, and has held consultations with the UAE, Thailand, Indonesia, Myanmar and Australia for formulating strategic projects[397]. Japan also started deliberations on cross-regional cooperative schemes, including contributions to global challenges with space technologies, contributions to the management of marine and fishery resources, human resource development and the establishment of human networks. Finally, Japan is strengthening its overseas development promotion system by setting up a project manager who will play a central role in promoting the project with the respective partner country, while also focusing on the coordination with relevant ministries and agencies in Japan through the establishment of a permanent support organization.

Promotion of Downstream Services

A second measure for promoting overseas development concerns the strengthening of industrial cooperation to improve and accelerate downstream applications & services development, particularly in the field of PNT and remote sensing. The cornerstone of such cooperation services is the Asia-Pacific region, where Japan is promoting the use of its QZSS to contribute to PNT information service, disaster

[395] Cabinet Office of Japan. (2016). *Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (Act No. 77 of 2016).* Tokyo: Cabinet Office.
[396] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[397] Ibid.

prevention, and the efficiency improvement of agriculture, forestry and fisheries industries. Consistent with the development status of the PNT infrastructure in the partner country, "high precision positioning is realized by the combination of the electronic reference point, integrated data center and positioning satellites, and efficiency improvement of infrastructure development and automatic operation"[398].

In this regard, Japan has already started to launch pilot projects to promote the utilization of Quasi-Zenith Satellites among ASEAN countries. For instance, Japan started the demonstration of a navigation system to avoid traffic congestion in Thailand, a survey on the needs related to the field of traffic in Vietnam, as well as a pilot project for maritime transportation in Indonesia. Moreover, in cooperation with the Task Force on Space System Overseas Development, Japan has started promoting cooperation for establishing networks of electronic reference stations in the Asia-Pacific region[399].

Besides this cooperation in the Asia-Pacific region, Japan has also been expanding industrial cooperation with Europe in the field of the GNSS market. Collaboration between Europe' GNSS (Galileo) and Japan's system (QZSS) is considered "vital to stimulate the world's GNSS market and to incubate new business which can bring a variety of benefits to end user in the world"[400]. Towards facilitating this collaboration, a Cooperation Arrangement was signed on 8 March 2017 between the Government of Japan and the European Commission, to ensure that "Japan benefits from European GNSS know-how and that European businesses can benefit from the GNSS developments happening in Japan"[401].

The stated goal of the Cooperation Agreement is "to enhance EU-Japan policy cooperation in order to prioritize industrial sectors for utilizing satellite positioning and creating new business services". Consistent with this, the two sides now share information on trends in the industries in use in Japan and Europe, targeting auto-driving, ITS, ships, railways, aviation, agriculture, construction, surveying, mobile terminals, disaster reporting, and crisis management[402].

The Cabinet Office and the European Commission have also been holding regular "EU-Japan Satellite Positioning Public-Private Roundtables", the last edition of which took place in Tokyo in March 2019. These events are intended to provide companies (including SMEs and start-ups) from the EU and Japan with an opportunity to explore potential business cooperation in the application of GNSS technologies[403].

B2B Partnerships Promotion

Another key measure devised by Japan lies in mechanisms to support the creation of partnerships between industrial players in Japan and third countries. The development of business partnerships is seen as an instrumental move to help the promotion of Japanese technologies around the world, thus opening more opportunities for Japanese businesses outside the national market.

Among these mechanisms particularly interesting is "S. Booster in Asia". Building on the success of the S-Booster initiative and on the recognition that space business in the Asian region is rapidly growing, in 2019 the Cabinet Office of Japan launched a space business contest 'S-Booster' in the regions of Asia and Oceania. The contest invites space-based business ideas from entrepreneurs and individuals in the

[398] Cabinet Office. (2017). 宇宙産業ビジョン 2030 (Space Industry Vision 2030). Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/vision/mbrlistsitu.pdf.
[399] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[400] Tsuruda, M. (2017). "Japanese Space Industry Policy Overview". Retrieved from: https://www.eu-japan.eu/sites/default/files/imce/1._meti_tsuruda_1.pdf.
[401] European Global Navigation Satellite System Agency. (2019). "Japan Joins the GNSS table with QZSS". Retrieved from: https://www.gsa.europa.eu/newsroom/news/japan-joins-gnss-table-qzss.
[402] European Global Navigation Satellite System Agency. (2019). "4th EU-Japan Satellite Positioning Roundtable set for 14 March". Retrieved from: https://www.gsa.europa.eu/newsroom/news/4th-eu-japan-satellite-positioning-roundtable-set-14-march.
[403] Ibid.

region to promote mutually beneficial business activity and collaboration with the space community in Japan. Applications for new space business ideas are based on three categories:

- Business idea based on the utilization of Japanese space assets
- Business idea seeking collaboration with Japanese companies
- Business idea based on the utilization of QZSS

Winners of the contest receive financial support, free business coaching from Japanese accelerators and have opportunities to meet with Japanese companies and investors[404].

[404] Cabinet Office. (2018). "Space Business Idea Contest ´S-Booster´". Retrieved from: https://www8.cao.go.jp/space/english/s-net/s-booster/index.html.

5 Strengthening Japan's Security through and in space

5.1 Japan's space security policy: evolution and drivers

Japanese space law and policy have undergone a fundamental change since the country became a space-faring nation – an evolution heavily influenced by historical factors facilitating and constraining its development. After World War 2, Japan enshrined its commitment to becoming a pacifist country in Article 9 of its constitution of 1947, which is considered to be "the primary formal restraint on Japanese remilitarization" after the War[405].

Specifically, Article 9 on the "Renunciation of War" states that:

> *Aspiring sincerely to an international peace based on justice and order, the Japanese people forever renounce war as a sovereign right of the nation and the threat or use of force as means of settling international disputes. In order to accomplish the aim of the preceding paragraph, land, sea, and air forces, as well as other war potential, will never be maintained. The right of belligerency of the state will not be recognized.*

This article falls in line with the so-called Yoshida Doctrine, named after the first post-war Prime Minister Yoshida Shigeru who was elected in 1946. This doctrine encompassed three core elements: firstly, an anti-militaristic stance reflected in Article 9 of the Constitution; secondly, a reliance on the alliance with and extended deterrence provided by the United States for Japan's national security; and lastly, an emphasis on economic growth and technological innovation as a foreign policy instrument as well as a means to national security[406].

This Doctrine and specifically Article 9 of the constitution in turn had an impact on the way space policy has progressed and put constraints on security related space policy. Perhaps the most apparent example is the "Peaceful Purposes Resolution" (PPR) of 1969, which, as discussed in Chapter 3, clarified that Japan´s space activities had to be "limited to peaceful purposes" (*heiwa no mokuteki ni kagiri*), with peaceful meaning both "non-aggressive" and "non-military".

A first deviation from this policy occurred in 1985 when the government decided that the Japanese Self-Defence Forces (SDF) would "be allowed to use space-based communications, observation and meteorological data that were already commercially available"[407] – according to the "Principle of common use" (*ippanka gensoku*). Subsequently, in response to a North Korean missile flight over Japan in 1998 (the so-called "Taepodong shock"), the government initiated the development of the Information Gathering Satellite (IGS) program, which enabled monitoring of military activities in the region "under the guise of a 'multipurpose' satellite program"[408]. In this way, Japan continued to formally comply to the PPR resolution.

As mentioned in Chapter 2, the most profound change to Japanese space policy occurred with the adoption of the Basic Space Law in 2008. This law was introduced with the purpose of stating the "basic principles and basic matters for the realization of the basic principles"[409] – in other words providing the foundation to and cornerstones of Japanese space policy.

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405 Samuels, R. J. (2007). *Securing Japan: Toyko's Grand Strategy And The Future of East Asia.* New York: Cornell University Press.
406 Ibid.
407 Kallender, P. (2016). Japan's New Dual-Use Space Policy. The Long Road to the 21st Century. *Asie.Visions 88*, 16.
408 Suzuki K. (2015) Space Security in Japan. In: Schrogl KU., Hays P., Robinson J., Moura D., Giannopapa C. (eds). *Handbook of Space Security*. New York: Springer.
409 Cabinet Office. (2008). *Basic Space Law.* Tokyo: Cabinet Office. Retrieved from: http://stage.tksc.jaxa.jp/spacelaw/country/japan/27A-1.E.pdf.

The Basic Space Law changed the future of Japanese space policy in a fundamental way by changing Japan's interpretation of *peaceful purposes* from "non-military" to "non-aggressive"—thus stepping in line with other space-faring nations and international space law and opening the door for heretofore prohibited military applications[410]. The articles of the law emphasized the utilization of space to positively contribute to international cooperation, security, diplomacy, industrial growth, the environment, the citizens of Japan and humanity as a whole[411]. Since then, many more developments have transpired in Japan's space policy which more strongly emphasize the connection between space and security – as can be seen in Figure 32.

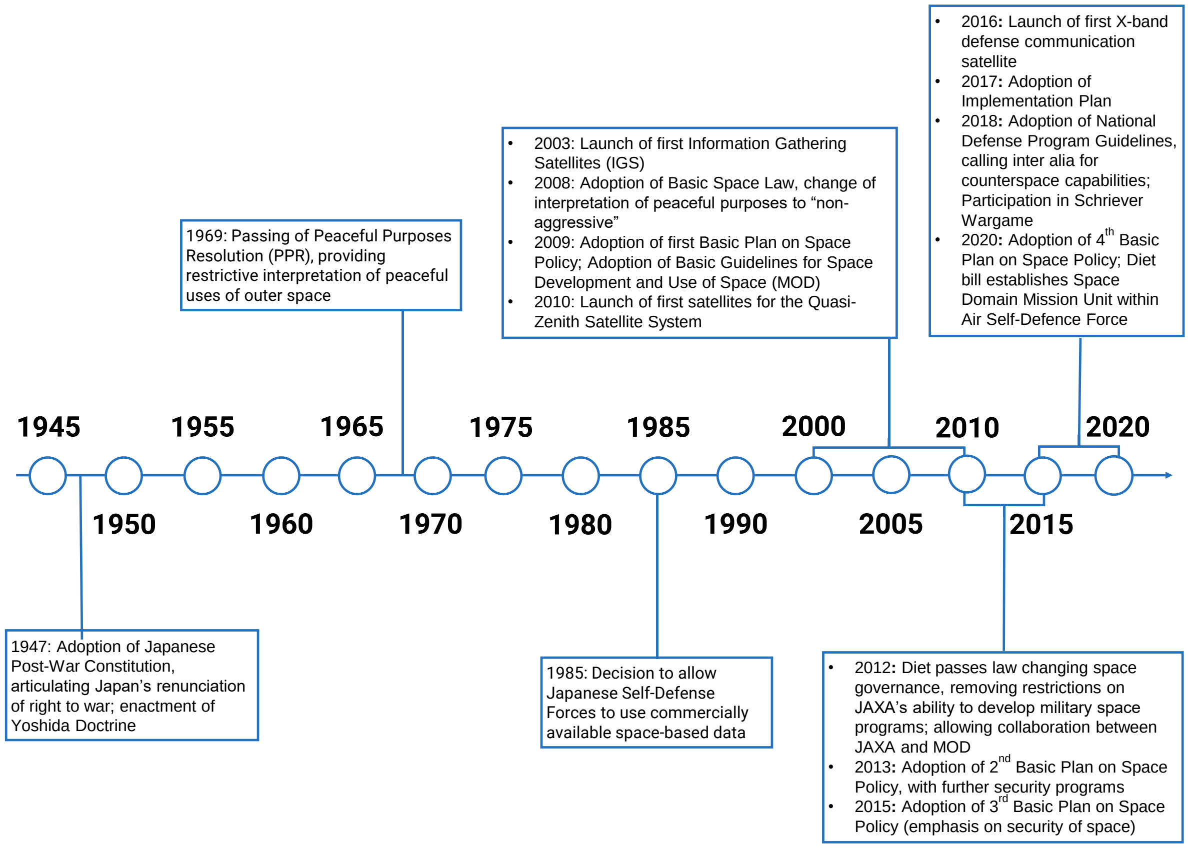

Figure 32: Timeline of security-related events in Japanese space policy (source: authors´ visualisation)

There is substantial debate on the evolution of Japanese space security policy, on the adoption of the Basic Space Law and subsequent developments detailed above. According to Peoples (2013), while there is consensus on the significance of the adoption of the Basic Space Law, there are "different explanatory accounts of the rationales and motivations behind the Basic Law"[412] and the departure from the Peaceful Purposes Resolution it signified.

Peoples (2013) identifies a variety of explanatory narratives, the first of which shows "an emphasis on exogenous 'shocks' and the external strategic environment"[413]. While some scholars reject the idea of a rush to militarization after the "Taepodong" incident of 1998, it is almost universally referred to as a

[410] Pace, S. (2015). U.S.- Japan Space Security Cooperation. In: Schrogl K-U., Hays P., Robinson J., Moura D., Giannopapa C. (eds). *Handbook of Space Security*. New York: Springer.
[411] Cabinet Office. (2008). *Basic Space Law.* Tokyo: Cabinet Office. Retrieved from: http://stage.tksc.jaxa.jp/spacelaw/country/japan/27A-1.E.pdf.
[412] Peoples, C. (2013). A normal space power? Understanding 'security' in Japan's space policy discourse. *Space Policy 29(2)*, 135-143.
[413] Ibid.

contributing factor to the evolution of Japanese space policy. Secondly, the "market-to-military" thesis most prominently promoted by Pekkanen and Kallender-Umezu emphasizes that exogenous events facilitated the industry's strategy to push the government to clear the way to an expansion of space activities beyond the commercial restriction. Another narrative emphasizing domestic politics points toward the role of various ministries and bodies as well as political parties and individual politician's role in the evolution of the space policy[414]. Other scholars, such as Christopher Hughes, consider the variety of factors leading to the Basic Law to rather be cumulative and representing a decades-long "erosion" of the dominant policy and trajectory created by the 1969 Peaceful Purposes Resolution[415].

Rather than expanding on the "why" question of the evolution of Japan's space security policy – frequently leading to a dichotomy of a 'militarized vs not militarized' Japan, Peoples (2013) finds use in exploring the "how", i.e. how Japan conceptualizes security now. He finds that Japan conceptualizes security in a broad sense, akin to the theoretical frameworks of comprehensive security or human security – encompassing "a multitude of 'security' dimensions that range from human security, to environmental issues, crisis management and disaster response *as well as* potential military applications"[416].

Embedded into the larger definition of security, a multitude of documents provides information on Japan's space security policy, such as the Basic Law, the Basic Plan on Space Policy as well as the Implementation Plans of 2017 and 2019. Japan provides information on its general defense policy, the conceptualization of its changing surrounding security environment as well as self-conceptualization within this environment in multiple documents, most notably in the "Defense of Japan" white paper as well as the "National Defense Program Guidelines" published by the Ministry of Defense (MOD) in 2018. Consolidating the statements and observations made in these official documents, a picture emerges of the exogenous and endogenous drivers and challenges for Japan's (space) security policy.

5.1.1 Exogenous driver

Preceding an examination of security challenges emanating from specific actors or incidents, Japan observes general changes in the security context it is embedded in, which pose challenges to and thus influence Japan's (space) security policy.

The Ministry of Defense observes changes to the security environment surrounding Japan which are perceived to be "accelerating and becoming more complex" while "uncertainty over the existing order is increasing"[417]. These changes include "rapid technological innovation"[418], particularly related to military technologies, ongoing inter-state competitions "across the political, economic and military realms"[419] combined with methods of manipulation and subversion of state sovereignty with the potential threat of turning into "hybrid-warfare"[420]. In a similar vein, according to the draft of the Basic Plan on Space Policy of 2020, there has been a noticeable shift in the space sector brought about by a dissolution of the predominantly bilateral US-Soviet competition towards a more multipolar power structure[421]. The draft of the Basic Plan on Space Policy of 2020 further mentions the commoditization of space technology, which

[414] Ibid.
[415] Ibid.
[416] Ibid.
[417] Ministry of Defense. (2018). Japan National Defense Program Guidelines for FY 2019 and beyond (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf.
[418] Ibid.
[419] Ibid.
[420] Ibid.
[421] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.

due to advances in space technology and an increased presence of new nations and commercial actors in space also contributes to "a major game change, including from the perspective of security"[422].

The Ministry of Defense identifies specific exogenous challenges to the defense and security of Japan which it perceives to be particularly worrisome:

The nuclear and missile development of North Korea is seen as "an unprecedentedly serious and imminent threat to Japan's security"[423]. Already in 1998, the "Taepodong shock" left a lasting impression of threat emanating from North Korea, further exacerbated by North Korea announcing its withdrawal from the nuclear Non-proliferation Treaty (NPT) in 2003 and further missile tests over the Sea of Japan in 2006. The *Defense of Japan* report by the MOD however in particular refers to a multitude of nuclear and ballistic missile tests since 2016 and the country's capability to target vast areas of Japan. The MOD further calls on the "international community to remain united" regarding North Korean denuclearization[424]. In light of the US–North Korea Summit Meeting of June 2018, Japan critically monitors North Korean efforts in line with its promises of "complete, verifiable and irreversible" denuclearization[425].

The MOD further considers China a security concern due to a lack of transparency in the country's build-up of military capabilities and modernization of its military. Particularly the quantitative and qualitative armament efforts of its nuclear and missile capabilities as well as its navy and air force are perceived as a concern, especially due to "China's sea and air power […] expanding its operational areas surrounding Japan", including disputed areas West of Okinawa Island – noting multiple activities by Chinese air force fighters, submarines as well as aircraft carriers[426]. Likewise, the MOD notes that Russian military activities in the Japan's proximity, including the Northern Territories, have increased as well – as demonstrated by missile cruiser and military bomber sightings[427].

Furthermore, in addition to the traditional domains, i.e. air, land and sea, the MOD notes that new domains, such as space or cyberspace, are being added – domains in which countries aspire to achieve superiority. Specifically, Japan observes an effort from many countries to attempt to achieve military superiority in space, referring in particular to Chinese Anti-Satellite (ASAT) tests and considers the resulting space debris to pose a further threat to satellites. The 2018 MOD white paper identifies a further potential threat in the alleged development of ASAT jamming technology as well as so-called "killer satellites" able to disrupt another satellite in space directly – alleging both Russia and China are currently developing these capabilities[428].

Regarding the United States, Japan reflects on the National Space Strategy of 2018 and the statement within calling space a warfighting domain "and that the United States would seek to deter, counter and defeat threats in the space domain that are hostile to the national interests of the United States and its allies"[429]. Japan also observes Russia's reaction, which criticizes the United States in its 2015 National Security Strategy for allegedly deploying weapons to outer space and thus "undermining global and regional stability"[430].

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[422] Ibid.
[423] Ministry of Defense. (2018). Defense of Japan 2018. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2018/DOJ2018_Full_1130.pdf.
[424] Ibid.
[425] Ibid. p. 481.
[426] Ibid. p. 3.
[427] Ibid. p. 4.
[428] Ibid. p. 30.
[429] Ministry of Defense. (2018). Defense of Japan 2018. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2018/DOJ2018_Full_1130.pdf. p. 197.
[430] Ibid. p. 125.

Figure 33 provides a timeline of events outside of Japan that have driven forward the debate on space security. Japan's overall observation concludes that "the risk to the stable use of outer space has become one of the critical security challenges for countries"[431].

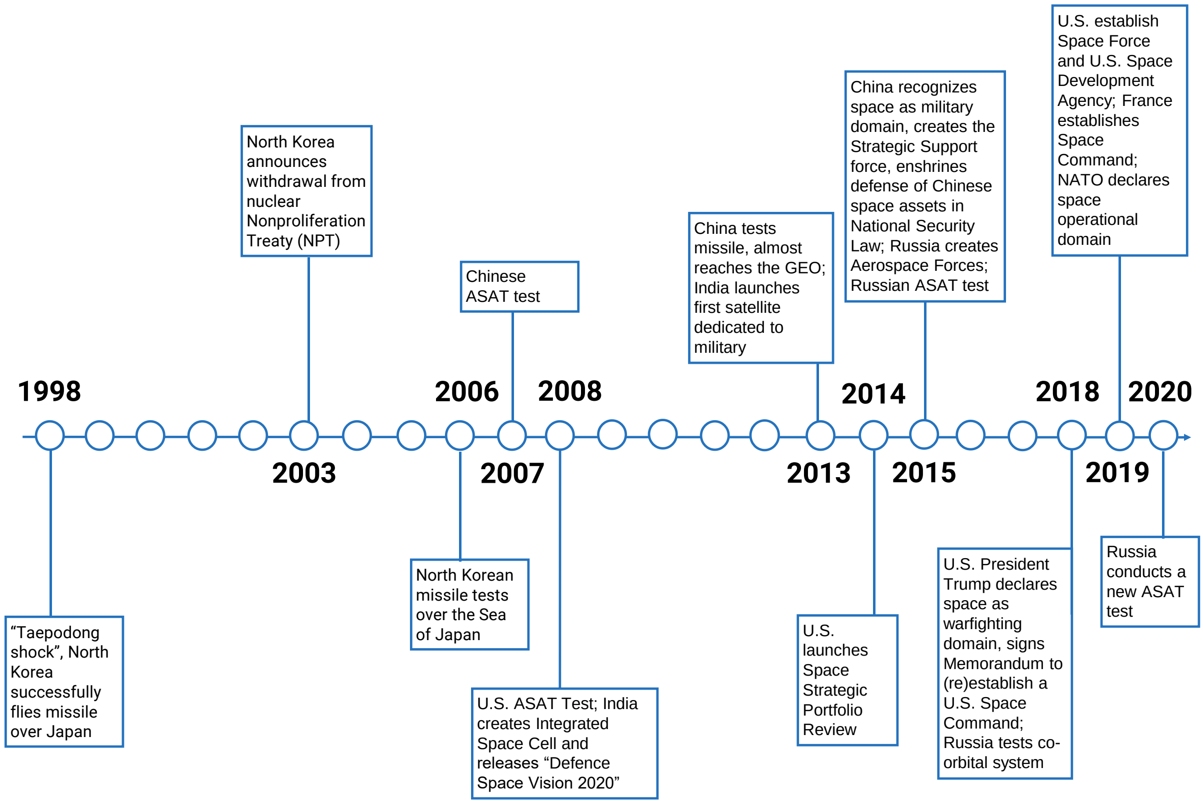

Figure 33: Events outside of Japan driving space security debate (source: authors´ visualisation)

5.1.2 Endogenous Drivers

Samuels (2007) offers a contextualization of endogenous drivers of security policy by asserting that Japan has a history of a "pervasive sense of vulnerability in world affairs [that] was always reflected in domestic politics"[432], which harkens back to "Japan's devastating defeat in the Pacific War"[433] as well as domestic political conflict due to "contested views of the cold war, expectations for the alliance with the United States, and beliefs about the legitimacy of the Japanese military"[434].

Within this historical context, the MOD states there are multiple circumstances endogenous to Japan that bring about a level of vulnerability. Firstly, the nature of its landmass as an archipelago with "numerous islands remote from the mainland" as well as large Exclusive Economic Zones and within this space the "life, person and property of its nationals, territorial land, waters and airspace, as well as various resources"[435] create a substantial environment to secure. Secondly, deriving from the first circumstance, Japan heavily depends on international trade to meet its food and energy needs and thus is dependent

[431] Ibid. p. 196.
[432] Samuels, R. J. (2007). *Securing Japan: Toyko's Grand Strategy And The Future of East Asia*. New York: Cornell University Press.
[433] Ibid.
[434] Ibid.
[435] Ministry of Defense. (2018). Defense of Japan 2018. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2018/DOJ2018_Full_1130.pdf.

on unrestricted and safe maritime and air transport[436]. Furthermore, due to Japan's location in the Pacific earthquake belt and its specific climate and topography, the country is prone to experiencing devastating natural disasters – creating yet another source of vulnerability to its "industry, population, and information infrastructure" as well as critical facilities[437].

Japan moreover perceives a vulnerability of its defence capabilities due to personnel and budgetary constraints brought about by "aging population with declining birth rate and severe fiscal situation"[438].

Regarding the intersection between security and space, Japan reiterates the ubiquitous use of space for a variety of purposes, i.e. communication, earth observation, broadcasting, positioning, etc. and the resulting need for access to space without interference or threat to space assets. Furthermore, countries are expanding the use of space for military purposes and as the concept of national borders does not exist in space, countries are increasing utilizing space for C4ISR (command, control, communication, computer, intelligence, surveillance and reconnaissance) purposes, particularly for military communication and early launch detection[439].

As the previous version, the Basic Plan on Space Policy of 2020 stresses the importance of Japan-US cooperation – in particular its dependence on US extended deterrence in the Asia-Pacific region. An interference with space-based assets caused by their degradation or actions of other actors could jeopardize the US's ability to effectively deter as well as the Japanese SDF's ability to defend, due to its dependence on US space-based systems[440].

Both exogenous and endogenous factors deliver a cumulative effect which in turn has informed Japan's current space security policy. The next section will complete the picture on Japan's space policy by adding Japan's space security policy to the commercial and civil space policy explored in previous chapters.

5.2 Japan's space security objectives

Driven by and in light of these external and domestic drivers, Japan defines its broad security objective as setting out to "maintain Japan's peace and security, to ensure its survival and to defend to the end Japanese nationals' life, person and property of its nationals and territorial land, waters and airspace"[441].

More specifically in regard to space, Japan defines three security-related objectives, namely, to:

- strengthen the utilization of space to support Japan's national security;
- promote a stable and sustainable use of outer space;
- ensure superiority in space.

These objectives – which correlate to the general topics of, outer space for security and security in space are examined in the following sections.

5.2.1 Supporting security through outer space

Due to the perceived increase of national security threats within the changing security environment detailed above, and in light of the increasing importance that space assets have for security and defence

[436] Ibid.
[437] Ibid.
[438] Ibid.
[439] Ibid.
[440] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.
[441] Ministry of Defense. (2018). Defense of Japan 2018. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2018/DOJ2018_Full_1130.pdf.

purposes, Japan has since the enactment of the Basic Space Law in 2008 recognised the use of space "to ensure international peace and security, and to increase the national security of Japan"[442] as a key objective of its national space programme.

The objective has been further confirmed and clarified in the Basic Guidelines for Space Development and Use of Space, enacted in January 2009, within the successive Basic Space Plans (in 2009, 2013, 2015 and 2020), as well as the National Security Strategy (NSS) and in the National Defence Programme Guidelines, which place national security at the forefront of Japan´s space-related activities, while maintaining the country´s exclusive defensive-oriented posture.

The Basic Guidelines in particular represents the first document providing a background for Japan´s space-based security and defense activities. It states that "due to the sophistication of military science and technology in recent years, the buildup of defense capabilities is increasingly focused on networking – the interactions of individual pieces of equipment and systems such as sensors, communication devices, command and control systems and various platforms (vehicles, vessels, aircraft, etc.) – to achieve systemization – maximizing of the equipment's performance as an ensemble. For such networking and systemization of the equipment, it is extremely beneficial to take advantage of the nature of space, being a part of no national territory and is not bound by conditions such as topography, as well as to conventional systems and hardware set on the earth's surface. For the foreseeable future, the development and use of space will be absolutely necessary for defense purposes"[443].

Consistent with this, the NSS[444] and the successive Basic Space Plans (which are closely interlocked with NSS) outline the Japanese government´s aim to "reinforce its space-based systems for positioning, communications, data collection, etc., from the vantage point of utilizing space to strengthen Japan's national security capabilities"[445]. Specifically, through a combined reading of these various policy documents, there appears to be three main target areas for advancing Japan´s space-related capabilities and promoting their utilisation in the security and defence field, namely:

- enhance Japanese military´s strategic support system, with a particular view on particular Command, Control, Communication, Computer, Intelligence, Surveillance, Reconnaissance (C4ISR) functions.
- promote disaster response and national resilience to major disasters such as earthquakes, tsunamis, volcanic eruptions, typhoons and torrential rains.
- contribute, in cooperation with the international community, to solving increasingly serious global issues such as energy, climate change, the environment, food, public health, and large-scale natural disasters, thereby supporting the achievement of the SDGs.

Regarding the first sub-objective, Japan plans on effectively enhancing and using various space-based assets and functions, including information gathering, surveillance, early warning, military communications and security-relevant navigation, positioning and timing services[446] for a variety of defense purposes. The most important include C4ISR functions to support the operations of the Self Defense Forces (SDF), Ballistic Missile Defence (BMD); and Maritime Domain Awareness, which due to the very configuration of Japan as a maritime nation with long coastlines and a vast Exclusive Economic

[442] Cabinet Office. (2008). *Basic Space Law.* Tokyo: Cabinet Office. Retrieved from: http://stage.tksc.jaxa.jp/spacelaw/country/japan/27A-1.E.pdf.
[443] Ministry of Defense. (2009). Basic Guidelines for Space Development and Use of Space. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/d_act/d_policy/pdf/space_development.pdf.
[444]Ministry of Foreign Affairs (2013). National Security Strategy (Provisional Translation). Retrieved from: http://japan.kantei.go.jp/96_abe/documents/2013/__icsFiles/afieldfile/2013/12/17/NSS.pdf.
[445] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.
[446] Ibid.

Zone (EEZ), acquires a particular importance[447]. Within the 2020 Basic Space Plan, the Japanese government specifically, recognises the important role to be played by space assets in the fulfilment of the Free and Open Indo-Pacific Strategy (see Focus Box)[448].

Focus Box: Free and Open Indo-Pacific and Space

The Free and Open Indo-Pacific Strategy, as envisioned by MOFA, is a foreign policy strategy aiming to "promote peace, stability and prosperity across the region to make the Indo-Pacific free and open as "international public goods", through ensuring rules-based international order including the rule of law, freedom of navigation and overflight, peaceful settlement of disputes, and promotion of free trade"[449].

The incentive for this strategy seems to find its origin in the region´s growing security concerns ranging from piracy, to terrorism, proliferation of WMD´s, natural disasters, and illegal fishing[450]. To fulfil the strategy, Japan´s actions are based on three pillars[451]. The first considers the promotion and establishment of themes such as the rule of law, freedom of navigation, and free trade[452]. The second, pursuit of economic prosperity, aspires to improve connectivity whether it be physical (ports, roads, …), social (education, training, …), or institutional (harmonization of rules)[453]. The third one promotes peace and stability through two channels. On the one hand, capacity-building, on issues of Maritime Law Enforcement, Maritime Domain Awareness, and Human Resource Development. On the other hand, "High Availability/Disaster Recovery", to manage anti-piracy, counterterrorism, non-proliferation, humanitarian assistance, disaster relief, and peacekeeping operations[454].

For all these activities, Japan recognizes the supporting role to be provided by space assets. More specifically, the BSP of 2020 affirms that in cooperation with the relevant ministries and agencies, the Government of Japan will study and take necessary measures to improve MDA using space technology in a comprehensive manner, including through the combination of data from satellites with aircraft, ships, and ground infrastructure, as well as cooperation with the United States.

The BSP also states that in coordination with the Ocean Basic Plan and its Implementation Plan, Japan will strengthen the efforts and improve the space systems (in terms of temporal and spatial resolution) for collecting and gathering maritime information according to the users´ requirements, specifically through the use of ALOS-2, ALOS-3, ALOS-4, the QZSS, as well as small satellites optical and SAR satellites[455].

With regard to the second sub-objective, Japan space-related policy documents highlight that "by developing a seamless network of satellites and related facilities for positioning, satellite communication

[447] The National Defense Program Guidelines state that for Japan´s peace and prosperity is fundamental to ensure the safety of maritime and air traffic by strengthening the order of "Open and Stable Oceans," an order based on fundamental norms such as rule of law and freedom of navigation". Ministry of Defense. (2018). *Japan National Defense Program Guidelines for FY 2019 and beyond* (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf.
[448] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.
[449] Ministry of Foreign Affairs of Japan. (2020), Free and Open Indo-Pacific. MOFA. Retrieved from: https://www.mofa.go.jp/files/000430632.pdf.
[450] Ministry of Foreign Affairs of Japan. (2019). To achieve a "Free and Open Indo-Pacific" in Diplomatic Bluebook 2019, Chapter 1 "International Situation and Japan´s Diplomacy in 2018". MOFA. Retrieved from: https://www.mofa.go.jp/policy/other/bluebook/2019/html/chapter1/c0102.html#sf01.
[451] Ministry of Foreign Affairs of Japan. (2019). Towards Free and open Indo-Pacific, p2. MOFA. Retrieved from: https://www.mofa.go.jp/files/000407643.pdf.
[452] Ibid.
[453] Ibid.
[454] Ibid.
[455] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.

and broadcasting, weather, environmental monitoring, land and marine observation, etc., and utilizing these space-based systems, Japan will boost its capabilities to prepare for and respond to for large-scale natural disasters such as earthquakes, tsunami, volcanic eruptions, typhoons, tornadoes, and concentrated heavy rainfall"[456]. For Japan – prone as it is to be affected by natural disaster – this is a key national security objective.

On a larger scale, Japan perceives a set of global challenges threatening the security of the international community – e.g. energy, climate change, environmental issues, food shortages, large-scale natural disasters – that can only be tackled with "global-scale solutions"[457]. Japan acknowledges that other countries, such as the US, China and EU nations are already using space-based assets to contribute to problem solving of these global issues and aspires to do the same, for both national security and prestige reasons.

Furthermore, Japan acknowledges with interest that the EU and China are in the process of "forging cooperative relationships with countries" that lack the same capabilities – "thereby strengthening their leadership positions within the international community"[458]. In a like manner, the Basic Plan on Space Policy asserts that "Japan, as well, must position its space development and utilization capabilities as a crucial tool for strategic diplomacy, contribute to the resolution of global issues using its strengths in space technology, and move to strengthen its diplomatic presence"[459] – thus also contributing to national security.

All in all, it is clear that in this country that previously adopted a strict pacifistic vision of space, a bold move towards the militarization of this domain in response to a fast-transforming environment is quickly taking shape.

5.2.2 Ensure a stable and sustainable utilisation of outer space

In light of space's status as common heritage of mankind and the increased use of space for civil and military purposes by a growing number of actors, Japan is concerned with the "growing risks to secure and stable utilization of space"[460].

The emergence of new space actors increases congestion in space and debris production and is considered a serious concern to all nations that depend on space-based assets for their critical national infrastructure and national security. Japan further is concerned with the Chinese ASAT test of 2007 and Chinese efforts to increase its ASAT capabilities for the disruption of satellites. The demise of the US-Soviet dominance in space and the shift towards a multipolar world is perceived by Japan as a significant threat to a once existing "mutual understanding" on the "secure and stable utilization of space"[461]. Furthermore, there is also a risk to space assets emanating from space weather conditions, requiring a resiliency to radiation and heat.

Particularly the threat to space assets and the "disruption of people's lives"[462] that results as a consequence are of particular concern to Japan, as space technology is used for the safety of different modes of transportation, the functioning of telecommunication as well as "radio communication used in

[456] Ibid.
[457] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf.
[458] Ibid.
[459] Ibid.
[460] Ibid.
[461] Ibid.
[462] Ibid.

disaster prevention"[463] – an aspect Japan is particularly concerned due to its vulnerability to natural disasters mentioned previously.

Therefore, in light of the perceived vulnerabilities to Japanese space assets, the 2015 Basic Plan on Space Policy already clearly states that Japan's objective is "to address these risks effectively and ensure secure and stable utilization of outer space"[464]. Within the 2020 Basic Space Plan, the objective gain even more prominence as compared to the other national interests. The document in particular outlines the country´s resolve "to ensure a sustainable and stable utilization of space by improving the ability to characterize the space environment, strengthening functional assurance, and by playing an even greater role in establishing international rules"[465].

Indeed, Japan emphasizes that ensuring safety, security and sustainability of outer space activities is a goal that can be best achieved through sustained international efforts, rather that unilateral actions. This specific posture stems not only from the particular security situation Japan has faced since the end of WWII, but also from the recognition that, the challenges to the security and sustainability of space activities are inherently global in nature, and thus response should be global.

This viewpoint is duly reflected in the stance taken by Japan within international fora such as COPUOS and the CD. For example, at the 1st Committee of the 2017 UNGA session, the Japanese ambassador to the Conference on Disarmament, Nobushige Takamizawa, stated: "Japan reaffirms the importance of enhancing the rule of law in outer space and will continue working with other nations to that end. In this connection, we reiterate the need to implement principles of responsible behavior for outer space activities, which could be an important step for international rule-making. In particular, we encourage all states to refrain from any action which brings about, directly or indirectly, damage or destruction of space objects. We thus continue to express our concerns about the development of anti-satellite weapons (ASAT) capability. With regard to the idea of preventing an arms race in outer space, which we support in principle, Japan´s outer space activities have always been peaceful in nature and this will continue"[466].

Again, at the meeting of the First Committee of the 2019 Session of UNGA, the Japanese delegation reiterated the importance of agreeing and implementing principles of responsible behavior: "The implementation of these principles can build up operational best practices of what is responsible behavior in outer space. We believe that this approach could be practical step for future multilateral rule-making in outer space, and could prove relatively durable in the face of changing circumstances"[467].

Together with these diplomacy and cooperation measures, Japan aims to attain the safety and security of its space infrastructure through a series of programmatic tools. While the specific tools and programmatic measures Japan intends to purse will be detailed in Section 5.3 generally speaking, Japan identifies a twofold path. On the one hand it aims to achieve these objectives through strengthening international cooperation as well as its partnership with the US. On the other hand, Japan wants to increase the resilience of its space infrastructure to debris, deliberate attacks, and space weather events by developing SSA and early warning systems and by fortifying the technological sophistication of hardware used in Japanese satellites. As also assessed by Nakasuka, by simultaneously "working for the resilience of [its] space systems and promoting the creation of international rules concerning the

[463] Ibid.
[464] Ibid.
[465] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.
[466] Delegation of Japan to the Conference on Disarmament. (17 October 2017). Statement by Nobushige Takamizawa Ambassador of Japan to The Conference on Disarmament at The First Committee of the 72nd Session of The General Assembly. Retrieved from: https://www.disarm.emb-japan.go.jp/files/000300878.pdf.
[467] Ministry of Foreign Affairs. (29 October 2019). Statement by the Delegation of Japan at The Meeting of The First Committee 74th Session of The United Nations General Assembly. Retrieved from: https://www.mofa.go.jp/mofaj/files/000544585.pdf.

utilization of space, Japan will prevent any abnormal change in outer space from adversely affecting Japan´s security and civilian use of outer space and secure the stable utilization of outer space"[468].

5.2.3 Gain space superiority

Whereas Japan primarily aims to ensure space security of through the promotion of norms of responsible behaviour, the recognition of their slow progression (particularly within the CD) and the deteriorating international circumstances have recently forced the country´s officials to recognise the need of furthering its military deterrence and response capabilities by attaining space superiority, i.e. the ability to use space for one´s own purposes while denying it to an adversary.

It is important to highlight that the topic of space superiority as a military objective has been traditionally absent from Japan´s policy debates, defence doctrines, and policy documents, which – consistent with the previous objective – have firmly proposed a vision of space as a peaceful domain. However, the topic has gained prominence over the past few years, precipitated by the increasing weaponization tendencies brought about by the recent evolution in the posture and military doctrine of the major space powers.

In its "National Defense Program Guidelines for [Fiscal Year] 2019 and beyond", released in December 2028, the government recognizes that Japan's security environment is becoming more testing and uncertain at a remarkably faster speed than expected when the "National Defense Program Guidelines for FY 2014 and beyond" was formulated. To prevent threats to Japan from materializing to menace life and peaceful livelihood of its nationals, it behooves Japan to take measures that are in line with these realities"[469].

Consistent with this, the document stresses that in strengthening its defense capability, it has become essential for Japan to "achieve superiority in new domains, which are space, cyberspace and electromagnetic spectrum"[470]. Indeed, to be able to deter and counter threats, Japanese officials now consider it necessary to adapt to the new modes of warfare that combine capabilities in new domains (space, cyberspace and electromagnetic spectrum) and in traditional ones (land, sea and air)[471].

Towards this, the guidelines direct Japan to build a Multi-Domain Defense Force; "a defense capability that can execute cross-domain operations, which organically fuse capabilities in all domains (including space, cyberspace and electromagnetic spectrum) to generate synergy and amplify the overall strength, so that even when inferiority exists in individual domains such inferiority will be overcome and national defense accomplished"[472].

With specific regard to the space domain, the document states that for Defence the objective is to "ensure superiority in use of space at all stages from peacetime to armed contingencies" and to "work to strengthen capabilities including mission assurance capability and capability to disrupt opponent's command, control, communications and information"[473].

This objective was further reiterated at a session of the Diet in January 2020 by Prime Minister Abe Shinzo, who outlined plans to "drastically bolster capability and systems in order to secure superiority"[474],

[468] Nakasuka S. (2015). "The Current Status and Review of Japan ´ s Space Security Policy Seen in the Basic Plan on Space Policy and Subsequent Discussions". Tokyo: National Institute for Defense Studies.
[469] Ministry of Defense. (2018). Japan National Defense Program Guidelines for FY 2019 and beyond (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf. p. 7.
[470] Ibid. p. 2.
[471] Ibid. p. 10.
[472] Ibid. p. 11.
[473] Center for Strategic and International Studies. (April 2019). *Space Threat Assessment 2019*. Retrieved from: https://csis-prod.s3.amazonaws.com/s3fs-public/publication/190404_SpaceThreatAssessment_interior.pdf.
[474] Associated Press. (20 January 2020). Abe says new unit will defend Japan from space tech threats. Retrieved from: https://apnews.com/2d88b7c34a5d004eaa59791b8587579d.

including through the creation of a Space Defense Mission Unit to monitor space debris, collect intelligence on foreign space capabilities, especially on "hunter-killer" satellites and conduct satellite-based navigation and communications[475] (see next section).

By the same token, the latest version of the Basic Space Plan 2020, officially enacted on 30 June 2020, alludes to the country´s objective to "ensure superiority in use of space at all stages from peacetime to armed contingencies". In accordance with the Guidelines, the document also outlines that to achieve this objective SDF will "work to strengthen its mission assurance capability and capability to disrupt opponent's command, control, communications and information"[476].

Whereas on the former aspect the Basic Space Plan clarifies that "the government will study and take necessary measures to ensure the comprehensive and continuous functioning of the Japanese and allied space systems" (including such measures as redundancy, hardening, responsive small satellite systems, etc.) on the latter aspect the document remains more silent, as no official indication about the development of offensive counterspace capabilities is given.

The aforementioned Guidelines, however, state that "to prevent any actions that impede its activities, SDF will conduct on a steady-state basis persistent monitoring as well as collection and analysis of relevant information. In case of such event, SDF will promptly identify incidents and take such measures as damage limitation and recovery. In case of armed attack against Japan, SDF will, on top of taking these actions, block and eliminate the attack by leveraging capabilities in space, cyber and electromagnetic domains. In addition, in light of the society's growing dependence on space and cyberspace, SDF will contribute to comprehensive, whole-of-government efforts concerning these domains under appropriate partnership and shared responsibility with relevant organizations"[477].

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5.3 Tools & mechanisms to achieve objectives

Predominantly detailed in the Implementation Plan of 2017 and in the Basic Space Plan of 2020, Japan envisions a set of measures or tools to achieve the objectives discussed above. These measures and tools entail concrete expansion of capacity-building programmes, but also legal and regulatory frameworks as well as diplomatic and cooperative frameworks. This next section will pertain to the various tools Japan currently employs and plans to employ.

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[475] The Japan Times. (May 2019). "Japan to assign 100 personnel to new satellite monitoring unit". Retrieved from: https://www.japantimes.co.jp/news/2019/05/14/national/science-health/japan-assign-100-personnel-new-satellite-monitoring-unit/#.XN5onsgzaUl.

[476] Center for Strategic and International Studies. (April 2019). *Space Threat Assessment 2019*. Retrieved from: https://csis-prod.s3.amazonaws.com/s3fs-public/publication/190404_SpaceThreatAssessment_interior.pdf.

[477] Ministry of Defense. (2018). *Japan National Defense Program Guidelines* for FY 2019 and beyond (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf. p. 12.

[478] Ministry of Defense. (2018). *Japan National Defense Program Guidelines* for FY 2019 and beyond (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf. p. 12.

5.3.1 Programmes

Space Situational Awareness

As identified by Yoshitomi, current Japanese SSA capabilities present a number of shortcomings. Firstly, not only are the Japanese radar and telescope systems over a decade old – thus presenting an aging system in need of replacement – the radar possesses limited capability and is only able to track approximately 5% of space debris in Low Earth Orbit that is available in the JSpOc catalogue. Moreover, once collected, JAXA's data analysis capability is limited[479].

Consequently, Japan greatly depends on SSA data from the Department of Defense (DoD) of the United States[480]. Strategically, Japan is however aware of the importance of SSA for national security – a stance that is reflected in the increased responsibilities of the military in SSA operations and in the country´s aspiration for greater autonomy and the pursuit of independent capabilities.

With a view to improve its SSA capabilities and establish a national operational framework for SSA, in 2018, JAXA completed the design of an upgraded SSA operational system and concluded a cooperation agreement with MOD, which has also jurisdiction over the development of the future SSA system. Specifically, Japan aims to "establish a national operational framework for SSA" by 2023[481]. The roadmap is detailed in Figure 34.

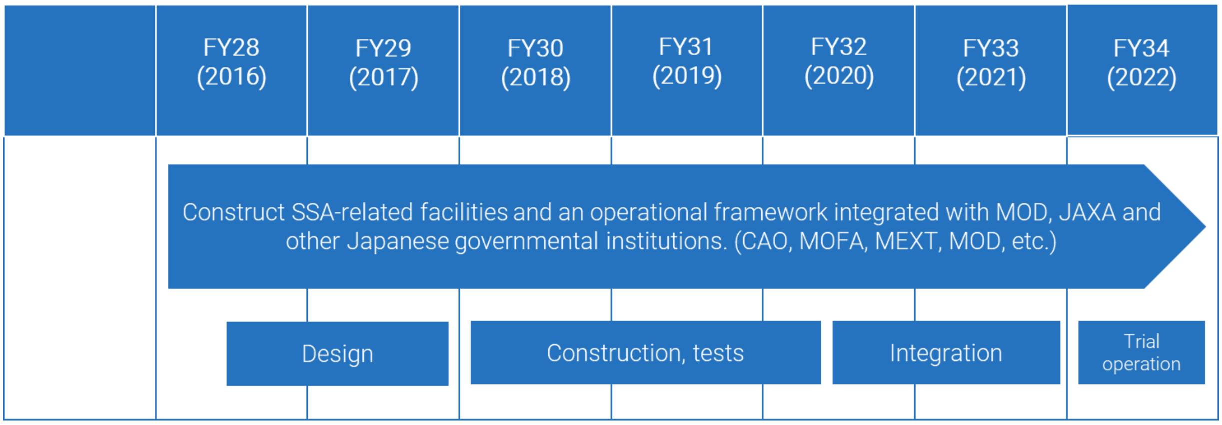

Figure 34: SSA Development Timeline (source: authors' visualisation adapted from Yoshitomi, 2019)[482]

To this end, Japan is developing a new radar at Kamisaibara Space Guard Center (KSGC), which compared to the present system capable of observing 10 objects simultaneously of the size of 1.6m, will have an observation capability of 10 cm and able to track 30 objects simultaneously[483]. While the telescope at Bisei Space Guard Center (BSGC) will maintain current capability, it will be refurbished[484]. However, Japan's SSA data analysis will be significantly enhanced by introducing a new system which is able to manage 100,000 objects instead of 30,000; observe 10,000 paths per day instead of 200 and conduct automatic observation planning instead of manual[485]. A comparison of current and planned capabilities is provided in Table 20 below.

System	Specifications	Current Capabilities	Planned Capabilities

[479] Yoshitomi, S. (2019, January 24). SSA Capabilities and Policies in Japan. Seoul, South Korea.
[480] Ibid.
[481] Cabinet Office. (2019). 宇宙基本計画工程表 (Implementation Plan of the Basic Plan on Space Policy). Tokyo: CAO
[482] Yoshitomi, S. (2019, January 24). SSA Capabilities and Policies in Japan. Seoul, South Korea.
[483] Ibid.
[484] Ibid.
[485] Ibid.

Radar	Observation capacity	1.6 m class (at an altitude of 650 km)	10 cm class
	Number of observable objects at once	Up to 10	Up to 30
Optical telescope	Detection limit grade	1 m telescope: about 18 grade	1 m telescope: about 18 grade
		50 cm telescope: about 16.5 grade	
Analysis system	Number of managed targets	Max 30,000 objects	Max 100,000 objects
	Amount of observation data (Radar)	200 paths/day	10,000 paths/day
	Compiling an observation plan etc.	Manual processing	Automatic processing

Table 20: Current and planned SSA capabilities (source: Yoshitomi, 2019)[486]

Japan's MOD is also "preparing to construct another radar capable of detecting the space debris in GEO"[487]. The MOD, which does not have its own SSA system yet, will have jurisdiction over the development of the future SSA system. As reported by the Institute for Defense Analyses, while JAXA has traditionally been in charge of SSA, trends indicate that MOD will start taking a lead on the operations side, with JAXA moving into a technical support position[488]. The future SSA network shall be composed of both ground- and space-based elements linked to the U.S. SSA network.

Indeed, while Japan is aspiring for greater autonomy and the pursuit of independent capabilities, the country wants to keep their SSA system interoperable with other systems internationally and establish "a system to quickly share mages and other data with the US"[489].Towards this, in 2019, Japan and the United States announced plans to connect their SSA data starting in 2023[490]. Japan also plans to intensify its partnership with the United States by continuing the participation in SSA table-top exercises organized by the US Strategic Command and by possibly placing U.S. SSA sensors on the next QZSS satellite to be launched in 2023[491]. Japan also further intends to explore cooperation opportunities with other states such as France. Japan and France have already "signed a technical agreement concerning information sharing related to SSA"[492].

[486] Ibid.
[487] Lal, B., Balakrishnan, A., Caldwell, B. M., Buenconsejo, R. S., & Carioscia, S. A. (2018). *Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM).* IDA Science & Technology Policy Institute.
[488] Ibid.
[489] Ibid.
[490] The Mainichi. (30 March 2019). "Japan, US to collaborate on space surveillance". Retrieved from: https://mainichi.jp/english/articles/20190330/p2a/00m/0na/002000c.
[491] Ministry of Foreign Affairs. (19 April 2019). *Joint Statement of the Security Consultative Committee*. Retrieved from: https://www.mofa.go.jp/files/000470738.pdf.
[492] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017)*. Tokyo: Strategic Headquarters for Space Policy.

Together with SS&T of space objects, Japan plans to further enhance the provision of space weather services. In this regard, the 2020 Basic Space Plan announces dedicated efforts to improve the ability "to observe and analyze the ionosphere, magnetosphere, and solar activity on a regular basis, and deliver space weather forecasts through manned operations 24 hours a day, 365 days a year"[493].

In addition, the document outlines that in order to further enhance the ability to respond to changes in the space environment, the government will encourage "collaboration between relevant organizations in Japan and abroad to further improve our observation and analysis systems for the ionosphere and solar activity, as well as research on simulation technology using observation data to improve the accuracy of our space weather forecasting system"[494].

Defence systems

Perceiving an acute need to respond to threats emanating from the proliferation of Weapons of Mass Destruction and ballistic missiles – particularly in light of advancements in the North Korean ballistic missile and nuclear weapons program – Japan is in the process of enhancing and upgrading its ballistic missile defense (BMD) capabilities[495].

In essence, Japan plans to establish a structure which integrates the various missile defense capabilities of the different Self-Defense Force services in order to respond to "multiple, complex airborne threats"[496]. Consisting of a multi-tiered defence system, Japan's BMD capabilities currently include the PAC-3 system of the Air-Self Defense Forces, surface-to-air guided missile units of the Ground Self Defense Forces (GSDF), Aegis-equipped destroyers of the Maritime Self-Defense Forces, "interconnected and coordinated by the Japan Aerospace Defense Ground Environment (JADGE)"[497].

According to the Medium-Term Defense Program (FY 2019 – FY 2023), there are a number of measures that Japan will take to enhance its BMD program to an integrated system. Firstly, the Aegis-equipped destroyers of the Maritime Self-Defense Forces will be increased from six to eight in FY2020. Moreover, "the GSDF will establish 2 squadrons of ballistic missile defense (BMD) units" and transform the ASDF surface-to-air guided missile units from six to four, maintaining 24 fire squadrons[498].

Japan will "continue to upgrade the capabilities of its existing Aegis-equipped destroyers (DDG) and surface-to-air guided missile PATRIOT system"[499] by equipping the latter with "new advanced interceptor missiles (PAC-3 MSE) that can be used both for response to cruise missiles and aircraft and for ballistic missile defense (BMD)"[500]. The introduction of the PAC-3MSE will enable Japan to extend the interception altitude to "tens of km" instead of less than 20km[501]. The SDF will furthermore "procure its interceptor missiles for BMD (SM-3 block IB and block IIA)" as well as "long-range ship-to-air missiles (SM-6) and mid-range ground-to-air guided missiles"[502].

[493] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf
[494] Ibid.
[495] Ministry of Defense. (2018). *Japan National Defense Program Guidelines for FY* 2019 and beyond (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf.
[496] Ministry of Defense. (2018). *Japan National Defense Program Guidelines for FY 2019 and beyond* (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf. p. 27.
[497]Ministry of Defense. (2019). *Defense of Japan 2019*. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2019/DOJ2019_Full.pdf.
[498] Ministry of Defense. (2018). *Medium Term Defense program (FY 2019 – FY2023).* Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/chuki_seibi31-35_e.pdf. p. 4.
[499] Ibid. p.13.
[500] Ibid. p. 11.
[501] Ministry of Defense. (2019). *Defense of Japan 2019*. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2019/DOJ2019_Full.pdf.
[502] Ministry of Defense. (2018). *Medium Term Defense program (FY 2019 – FY2023).* Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/chuki_seibi31-35_e.pdf p.13.

As a further significant upgrade to its BMD capabilities, Japan announced that it would procure a land-based Aegis system (Aegis Ashore)[503], a "missile defense system that consists of radars, a command communication system, a vertical launch system (VLS)" – to be developed in particular in response to North Korea's improved launch capabilities which exceed the sensible deployment of the Aegis-equipped destroyers[504]. However, on 15 June 2020 it was reported that the procurement of the Aegis Ashore was suspended by MOD[505].

To improve the detection and tracking capabilities and Japan's ability to respond in an effective and efficient manner incorporating the equipment available of each SDF service, several further initiatives will be introduced:

- "Upgrading its Japan Aerospace Defense Ground Environment (JADGE)";
- "Procuring its air defense command and control system (ADCCS)";
- "developing its new and fixed air defense radar";
- "Adding cooperative engagement capability (CEC) to its E-2D";
- "R&D on a network system that enables engage-on-remote launch of weapons by destroyers (DD) (FC network";
- "and research on satellite-mounted dual-wave-length infrared sensors";
- "conduct bilateral training and exercises to enhance the effectiveness of the Japan-U.S. bilateral BMD response posture"[506].

The Basic Plan on Space Policy of 2020 states that the government will deliberate on the viability of early-warning satellites, etc. and take necessary measures, taking full account of potential alternatives such as cooperation with allied nations, as well as the technological feasibility for Japan and cost-benefit analysis[507] – with the Cabinet Office and the Ministry of Defense in the deliberations.

Whereas through its BMD system Japan theoretically possesses an inherent counterspace capability that with some modifications could be used as a direct ascent ASAT system to intercept satellites in LEO, the Japanese government has never shown intention to test this capability. However, there are subtle indications the MOD has started to envisage the possibility to develop other counterspace capabilities in order to ensure space superiority.

Consistent with the abovementioned Guidelines – which direct the SDF to "build the capability to disrupt C4I of opponents in collaboration with the electromagnetic domain"[508] – priority seems to have been assigned to the development of electronic warfare (EW) capabilities, rather that direct ascent ASAT systems. In this respect, in August 2019, it was reported that the MOD plans "to develop systems to intercept from the ground foreign satellites or airborne warning and control system (AWACS) planes, using electromagnetic waves"[509].

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[503] Ibid p. 13.
[504] Ministry of Defense. (2019). *Defense of Japan 2019*. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2019/DOJ2019_Full.pdf.
[505] Yeo, M. (2020). *Japan suspends Aegis Ashore deployment, pointing to cost and technical issues*. DefenseNews. Retrieved from: https://www.defensenews.com/global/asia-pacific/2020/06/15/japan-suspends-aegis-ashore-deployment-pointing-to-cost-and-technical-issues/.
[506] Ministry of Defense. (2018). *Medium Term Defense program (FY 2019 – FY2023).* Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/chuki_seibi31-35_e.pdf. p. 13.
[507] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf
[508] Ministry of Defense. (2018). *Japan National Defense Program Guidelines for FY* 2019 *and beyond* (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf.
[509] The Japan News. (19 August 2019). "Satellite interceptor sought by mid-2020s". Retrieved from: https://the-japan-news.com/news/article/0005948349.

IGS, Small Operationally Responsive Satellites & other remote sensing satellites

As of February 2020, the Cabinet Satellite Intelligence Centre operates a fleet of eight Information Gathering Satellites in orbit – five of which are radar imaging satellites and three optical imaging satellites[510]. The IGS constellation's main purpose is to "provide early warning of impending hostile launches in Japan's neighbourhood and perform surveillance to collect information necessary for national security"[511].

Japan plans on implementing measures to "reinforce these satellites' role in the national security field"[512] as well as enhance their "readiness and rapidness of response"[513]. In concrete terms, by 2025, Japan wants to develop and launch two additional optical satellites (IGS-Optical 8, IGS-Optical 9) and two additional radar satellites (IGS-Radar 7, IGS-Radar 8), two Optical Surveillance Capability Augmentation Satellites and a Data Relay Satellite[514].

In order to enhance its maritime domain awareness (MDA) capabilities, Japan has engaged in a whole of government approach to fully establish a Maritime Situational Display System to collect, share and disseminate information on the maritime domain[515]. Furthermore, Japan has entered into a dialogue with the United States and France and explores the opportunities for cooperation. Japan plans to combine the use of satellites with the use of aircraft, ships, and terrestrial infrastructure.

Furthermore, Japan is considering the development and deployment of Operationally Responsive Small Satellites in the field of remote sensing. These satellites would be maneuverable and would aid to build a more robust constellation of satellites that can cover all observational requirements and complement IGS data[516]. To this end, different ministries and agencies will deliberate and also take into account the "results of participation in the Schriever Wargame, a US-organized table top exercise"[517] collected in 2018.

Regarding the overall "improvement of mission assurance of Space Systems"[518], the Implementation Plan contains a scheme integrating various technology at different states of the mission – corresponding to defensive activities, those strengthening the resilience and those related to recovery and restructuring of capability. Furthermore, the Implementation Plan contains a list of fundamental efforts to be made towards the improvement of mission assurance, which ranges from strengthening international cooperation to specific measures to strengthen technology and the industrial infrastructure[519].

Quasi-Zenith Satellite System (QZSS)

The QZSS is scheduled to be increased to a seven satellites constellation by 2023 to create a constellation capable of sustaining positioning[520] in all regions in a reliable manner. According to the Basic Plan on Space Policy, this system's compatibility and coordination with the GPS will be further enhanced to also foster Japan's Space Situational Awareness capabilities[521].

510 Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.
511 Dunphy, R. (2016). *Space Industry Business Opportunities in Japan: Analysis on the Market Potential for EU SMEs Involved in the Earth-Observation Products & Services.* Tokyo: EU-Japan Centre for Industrial Cooperation.
512 Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf.
513 Ibid.
514 Cabinet Office (December 2019). 「宇宙基本計画工程表」 [Implementation Plan of the Basic Plan on Space Policy] Tokyo: CAO.
515 Ibid.
516 Ibid.
517 Ibid.
518 Ibid.
519 Ibid.
520 Ibid.
521 Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.

Reflected in the Basic Plan on Space Policy 2020, it is important to “secure autonomous PNT capabilities, which are indispensable for maintaining and strengthening Japan’s security”[522]. Furthermore, Japan plans on promoting the QZSS in the Asia-Pacific region[523] by fostering “the development of networks of electronic reference stations and other positioning infrastructure, and the roll-out of services that utilize Quasi-Zenith Satellites”[524]. Japan is furthermore investigating the constellation’s future contribution to the Free and Open Indo-Pacific strategy.

X-Band Defense Satellites communication network

Japan is currently operating an X-Band satellite called Kirameki-2, which was launched in 2017 as the first link in its GEO X-Band Satellite-Based Defense Communication Network. The purpose of this system dedicated to exclusive use by the military is to “enhance the command & control and information & communication capabilities of the Self-Defense Forces”[525].

A second satellite –also called DSN-1/Kirameki-1 –was originally planned for FY2015, but was launched by an Ariane-5 series rocket in 2018. The satellite orbits in GEO and carries the DSN-1 X-band communication payload, for which the Japanese Ministry of Defense has contracted DSN Corporation (a SKY Perfect JSAT subsidiary).

The MOD commenced operation and utilization after their respective launches in 2018 and 2017 and both Kirameki-1 and Kirameki-2 have a prospective lifespan of 15 years[526]. As stated in the Basic Plan on Space Policy 2020, Japan has decided to launch the third unit of this X-band defense satellite communication network by 2022[527] and will continue R&D on space communication system technology as well as increase mission assurance[528].

5.3.2 Legal and Regulatory Measures

The most basic legal regime pertaining to the use of space and consequently also the use of space for security purposes is the Basic Space Law of 2008. Notably, the Basic Law sets out to ensure the safety of the citizens of Japan by mitigating natural disasters and other threats to their wellbeing as well as ensuring that the pursuit of space technologies and applications with specific military purposes is allowed. As iterated in previous chapters, the BSL is significant as it sets the legal foundation for military space activities in Japan.

The Ministry of Defense’s National Defense Program Guidelines of 2018 as well as the Medium Term Defense Program (FY2019 – FY2023) provide the Japanese Security policy by stating the country’s defence objectives, but also contains Japan’s vision on how space is embedded into the country’s larger security strategy. The guidelines states that the “SDF will contribute to comprehensive, whole-of-government efforts concerning these domains under appropriate partnership and shared responsibility with relevant organizations”[529].

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[522] Ibid.
[523] Ibid.
[524] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[525] Ibid. Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[526] Ibid.
[527] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf
[528] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[529] Ministry of Defense. (2018). *Japan National Defense Program Guidelines for FY* 2019 *and beyond* (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf.

Principles on Transfer of Defense Equipment and Technology

Furthermore, consistent with the National Security Strategy of Japan, the Government of Japan has established "Three Principles on Transfer of Defense Equipment and Technology"[530]. The first principle defines "cases where transfers are prohibited" which include:

- "Cases where the transfer violates obligations under treaties and other international agreements that Japan has concluded";
- "Cases where the transfer violates obligations under UN Security Council resolutions";
- And "cases where the defense equipment and technology are destined for a country party to a conflict (a country against which the UN Security Council is taking measures to maintain or restore international peace and security in the event of an armed attack"[531].

The second principle relates to cases where transfer of defence equipment and technology "may be permitted", such as cases where:

- "The transfer contributes to active promotion of peace contribution and international cooperation";
- And "the transfer contributes to Japan's security"[532].

For these cases, the government states a need for more transparency and strict examination of cases. Lastly, the third principle establishes a guiding principle for the recipient country government to gain "prior consent regarding extra-purpose use and transfer to third parties"[533]. For Japan, "an appropriate overseas transfer of defense equipment and technology" contributes to clear objectives:

- "further active promotion of the maintenance of international peace and security through timely and effective implementation of contribution to peace and international cooperation such as international peace cooperation, international disaster relief, humanitarian assistance, responses to international terrorism and piracy, and capacity building of developing countries";
- "strengthening security and defense cooperation with Japan's ally, the United States as well as other countries";
- "maintaining and enhancing Japan's defense production and technological bases, thereby contributing to Japan's enhancement of defense capability, given that international joint development and production projects have become the international mainstream in order to improve the performance of defense equipment and to deal with their rising costs"[534].

Space legislation

Legal and regulatory measures of relevance to national security also include the *Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data* in 2016 defines which responsibilities lie with the Japanese national government regarding Satellite Remote Sensing Data and "establishes a licensing system for the Use of Satellite Remote Sensing Instruments, and provides obligations of a Satellite Remote Sensing Data Holder"[535]. A license can be obtained by submitting an application to the Prime Minister of Japan providing the information specified by the Cabinet Office, e.g. "the type, structure and capability" of the instrument as well as which orbit the satellite equipped with the instrument is in[536]. Given

[530] Ministry of Foreign Affairs. (2014). "The Three Principles on Transfer of Defense Equipment and Technology". Tokyo: MOFA. Retrieved from: https://www.mofa.go.jp/files/000034953.pdf.
[531] Ibid.
[532] Ibid.
[533] Ibid.
[534] Ibid.
[535] Cabinet Office of Japan. (2016). *Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (Act No. 77 of 2016).* Tokyo: Cabinet Office.
[536] Cabinet Office of Japan. (2016). *Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (Act No. 77 of 2016).* Tokyo: Cabinet Office.

the increase in remote sensing applications and consequently the market thereof, the Ministry of Foreign Affairs asserts that the rules set by this Act will not only promote new remote sensing (RS) services and industries which will in turn contribute to the safety of citizens on the ground through their contributions to disaster prevention, etc. Moreover, the act will also "enable authorities to prohibit distribution of RS data to ensure peace and security of the international community"[537].

In a similar vein, the *Act on Launching of Spacecraft, etc. and Control of Spacecraft passed* in 2016 also contributes to Japanese security. While the conduct of space activities previously had been privy to government entities, as new private and commercial actors entered the realm of space activities there was an increasing need to ensure these activities were regulated, supervised and conducted with public safety in mind. This act is meant to regulate the authorization of launches, the control of satellites as well as provide a "framework of compensation with regard to third-party liability" should there be damages resulting from satellite launches[538].

Debris mitigation measures

Regarding the safety of spacecraft in space, Japan "implements space debris mitigation guidelines, such as the Space Debris Mitigation Guidelines of the COPUOS and voluntary guidelines proposed by the Inter-Agency Space Debris Coordination Committee (IADC) through domestic legislation and standard"[539]. Moreover, JAXA complies with the so called JAXA-Management Requirement JMR-003C, which is a national norm that puts certain requirements on space missions to mitigate space debris. This standard includes requirements regarding the end-of-life break up of satellites, their transfer to Geostationary Orbit as well as their orbital lifetime[540]. Furthermore, Japan has purposefully adjusted its JAXA-Management Requirements to be equivalent to the International Organization for Standardization (ISO) Space Debris Mitigation Requirements and generally supports "the revision of international standards for debris prevention by ISO"[541].

Reorganisation of military space

In order to "ensure superiority in use of space at all stages from peacetime to armed contingencies" and to "work to strengthen capabilities including mission assurance capability and capability to disrupt opponent's command, control, communications and information"[542].

In order to be able to deter threats, Japanese officials consider it necessary to adapt to the new modes of warfare, which combine capabilities in new domains (space, cyberspace and electromagnetic spectrum) and in traditional ones (land, sea and air)[543]. For this reason, a reorganisation of military space activities has been foreseen.

Specifically, the Medium Term Defense Program (2019-2023) specifies that in order to build a structure that is capable of realizing cross-domain operations including space, "SDF will strengthen the Joint Staff's posture designed for effective SDF operations and for new domains, thereby enabling swift exercise of SDF's capabilities. For the future framework for joint operations, SDF will take necessary measures after considering how to conduct the operation of organizations in which the functions in the new domains are

[537] Hara, K. (2017). "Current Status of Japan Space Policy and Development of Legal Framework". Presentation at the 56th Legal Subcommittee of UNCOPUOS. Vienna: UNOOSA.
[538] Ibid.
[539] Ministry of Foreign Affairs. (2019). "Agenda Item 7 – Space Debris". Retrieved from MOFA: https://www.mofa.go.jp/mofaj/files/000449922.pdf.
[540] Ibid.
[541] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[542] Center for Strategic and International Studies. (April 2019). *Space Threat Assessment 2019*. Retrieved from: https://csis-prod.s3.amazonaws.com/s3fs-public/publication/190404_SpaceThreatAssessment_interior.pdf.
[543] Ministry of Defense. (2018). *Japan National Defense Program Guidelines for FY* 2019 *and beyond* (Provisional translation). Tokyo: MOD. Retrieved from: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/20181218_e.pdf.

operated unitarily, and come to conclusions after considering how the integrated structure should be during steady-state to appropriately execute instructions from the Minister based on the posture of the strengthened Joint Staff. SDF will also work to flexibly leverage personnel of each SDF service through such efforts as building posture for force protection and damage recovery with an eye on mutual cooperation among SDF services”[544].

With specific regard to space, SDF will establish one squadron of the Japanese Air Self-Defence Forces (ASDF) in order to conduct persistent monitoring of situations in space, and to ensure superiority in use of space at all stages from peacetime to armed contingencies. The new squadron, called Space Domain Mission Unit (SDMU), will in particular monitor space debris, collect intelligence on foreign space capabilities, especially on “hunter-killer” satellites, and conduct satellite-based navigation and communications. In 2019, the Abe government announced that it would assign 100 people to the Unit, which will be created in 2022 and located on Fuchu air base (near Tokyo) managed by the Japanese Air ASDF[545].

Already from 2020, a first version of the unit is to be formed within these Forces and assigned with approximately 20 personnel. The law establishing the SDMU was eventually passed by the Japanese Diet on 17 April 2020[546]. The new squadron will to work with both U.S. Space Command and JAXA.

Indeed, among the institutional measures foreseen to achieve the security objectives is the reinforcement of the existing partnership between the Ministry of Defence and JAXA, with regard to both the utilisation of space assets for security purposes (e.g. the IGS and QZSS) and the development of the future SSA network[547]. This partnership will enable MoD to better exploit the expertise and technical capabilities JAXA has built in the civil space sector.

Similarly, there is an opening towards exploiting the assets of commercial space sector to support the MoD objectives. In this context, the Basic Space Plan states that in order to contribute to both ensuring redundancy and enhance C4ISR functions, the use of commercial satellites including nanosatellites should be promoted based on the examination of the status and operational requirements by the various ministries and agencies[548].

5.3.3 Diplomacy and Cooperation Frameworks

Diplomacy and cooperation are given high prominence in attaining Japan´s space security objectives. Space security objectives are indeed premised on international cooperation, particularly with the United States. Consistently, the most important actions Japan aims to pursue are strengthening of space security alliance with the United States and other like-minded partners (including Europe), while proactively continuing the promotion of multilateral norms and rule for responsible space behaviour.

[544] Ibid.
[545]The Japan Times. (14 May 2019). “Japan to assign 100 personnel to new satellite monitoring unit” Retrieved from: https://www.japantimes.co.jp/news/2019/05/14/national/science-health/japan-assign-100-personnel-new-satellite-monitoring-unit/#.XN5onsgzaUl.
[546]Takahashi, K. (22 April 2020). Japan passes law to form its first ´Space Operations Squadron´. Jane´s Defence Weekly. Retrieved from: https://www.janes.com/article/95619/japan-passes-law-to-form-its-first-space-operations-squadron.
[547] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.
[548] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.

Strengthening the Security Alliance with the United States

Japan's alliance with the United States has a long and at times strained history – an alliance which Ambassador Mansfield (US Ambassador to Japan) called "the most important bilateral relationship out there, bar none"[549].

Japan identifies the United States as "the world's leading space superpower"[550] and observes that while in the past, the US approach to space was characterized by independent implementation of space projects aimed at maintaining dominance in space, there has been a shift in space policy towards a more collaborative policy emphasizing resiliency and efficiency through partnership[551].

This increased importance of space in the bilateral cooperation between the US and Japan is reflected in the level of cooperation: upon holding the US-Japan Security Consultative Committee in 2012, the countries established the US-Japan Comprehensive Dialogue on Space in 2013 – which has been taking place on annual basis and elevating the topic of space on the agenda of bilateral relations[552].

In this context, Japan has been speaking of a "new era of Japan-US space cooperation" which was pronounced "during May 2014 working-level talks between Japan and the US pursuant to the Japan-US Security Consultative Committee"[553]. This cooperation is to build on shared national security concerns of both countries and address the previously mentioned vulnerabilities to the space infrastructure utilized in US deterrence in the Asia-Pacific region.

Providing more details in the 2015 Guidelines for Japan-US Defense Cooperation, the two countries aim to offset the possible risks associated with the vulnerability of their systems by focusing on space situational awareness; early-warning; command, control and communications, and by "ensuring the resiliency of relevant space systems that are critical for mission assurance"[554].

Through the Basic Space Plans of 2015 and 2020 and through the successive Japan-US Security Consultative Committees, specific actions to enhance collaboration with the U.S in these domains have been identified.

Particular attention is given to strengthening SSA cooperation. While, as stated, Japan is aspiring for greater autonomy and the pursuit of independent capabilities, the country wants to at the same time keep their SSA system interoperable with the U.S. and develop "a system to quickly share mages and other data with the US"[555].Towards this, in 2019, Japan and the United States announced plans to connect their SSA networks starting in 2023[556].

[549] Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press.
[550] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf.
[551] Ibid.
[552] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*.
[553] Strategic Headquarter for Space Policy. (2015). *Basic Plan on Space Policy.* Tokyo: Strategic Headquarter for Space Policy. Retrieved from: https://www8.cao.go.jp/space/plan/plan2/plan2.pdf.
[554] Ministry of Foreign Affairs. (2015). The Guidelines for Japan-U.S. Defence Cooperation. Tokyo: MOFA. Retrieved from: https://www.mofa.go.jp/files/000078188.pdf.
[555] Lal, B., Balakrishnan, A., Caldwell, B. M., Buenconsejo, R. S., & Carioscia, S. A. (2018). *Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM).* IDA Science & Technology Policy Institute.
[556] The Mainichi. (30 March 2019). "Japan, US to collaborate on space surveillance". Retrieved from: https://mainichi.jp/english/articles/20190330/p2a/00m/0na/002000c.

Japan also plans to intensify the SSA partnership with the United States by placing a U.S.-provided SSA sensor on the next QZSS satellite to be launched in 2023[557] and by continuing cooperation on ground data acquisition for space weather monitoring and alerts[558].

Cooperation with the United States in space defence issues will be also reinforced through the permanent presence of Japanese officers at the Combined Space Operations Center at Vandenberg Air Force Base and by continuing the participation in SSA table-top exercises organized by the US Strategic Command. Furthermore, building on the outcome of its participation in the October 2018 Schriever Wargame hosted at by the U.S Air Force Base in Alabama, Japan intends to address issues related cybersecurity of space systems in cooperation with the U.S., as a way "to better prepare the Alliance for cross-domain operations" (which include space, cyberspace and the electromagnetic spectrum). Interestingly, on the occasion of the Security Consulting Committee of April 2019, the respective ministers affirmed that "international law applies in cyberspace and that a cyber-attack could, in certain circumstances, constitute an armed attack for the purposes of Article V of the U.S.-Japan Security Treaty"[559].

By the same token, at the sixth meeting of the Comprehensive Dialogue on Space, which took place in July 2019, and in the Basic Space Plan of 2020 Japan reaffirmed its intention to explore opportunities for cooperation in enhancing the use of space systems for Maritime Domain Awareness (MDA) and early warning functions.

Strategic cooperation with like-minded partners and multilateral frameworks

Beyond the indispensable partnership with the US, Japan is pursuing cooperation with various European countries as well as countries in the Asia-Pacific region on matters related to both space security and security from space.

On the former issue, Japan has in particular pursued policy dialogues and a series of agreements with several European countries and institutions. For instance, Japan has "signed a technical agreement concerning information sharing related to SSA with France"[560] and at the Japan-U.K. summit meeting in 2017 the two countries issued the Japan-U.K. Joint Declaration on Security Cooperation, which includes space cooperation[561]. Japan has been also discussing matters related to space safety and security with ESA (in particular with regard to space weather, NEOs and space debris) as well as the European External Action Service (EEAS) in the context of the EU-Japan Space Dialogue[562]. It has also been a strong supporter of the EU-originated Code of Conduct, by actively participating in the multilateral consultations and by conducting outreach with other Asian countries.

More broadly, Japan supports a multitude of international agreements, treaties and groups that pertain to coordinating satellites' safe and effective operation vis-à-vis congestion and debris in space, and their longevity. These include Japan's participation in or adherence to standards set by the Inter Agency Debris Coordination Committee (IADC), the International Organization for Standardization (ISO), the Space Frequency Coordination Group (SFCG), the International Telecommunication Union (ITU). Through its

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557 Ministry of Foreign Affairs. (19 April 2019). *Joint Statement of the Security Consultative Committee*. Retrieved from: https://www.mofa.go.jp/files/000470738.pdf.

558 U.S. Department of State. (24 July 2019). *Joint Statement on the Sixth Meeting of the U.S.-Japan Comprehensive Dialogue on Space*. Retrieved from: https://www.state.gov/joint-statement-on-the-sixth-meeting-of-the-u-s-japan-comprehensive-dialogue-on-space/.

559 The two sided also clarified that "a decision as to when a cyber-attack would constitute an armed attack under Article V would be made on a case-by-case basis, and through close consultations between Japan and the United States, as would be the case for any other threat". Ministry of Foreign Affairs. (19 April 2019). *Joint Statement of the Security Consultative Committee*. Retrieved from: https://www.mofa.go.jp/files/000470738.pdf.

560 Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017)*. Tokyo: Strategic Headquarters for Space Policy.

561 Ibid.

562 Ministry of Foreign Affairs. (15 March 2019). The Fourth Meeting of Japan-EU Space Dialogue. Retrieved from: https://www.mofa.go.jp/press/release/press4e_002376.html.

Space Weather Forecast Center, Japan also contributes to the International Space Environment Service (ISES) by acting as a regional warning centre, delivering operational Space Weather forecast, ground-based observations, developing original space weather forecasting models. The Space Weather Forecast Centre makes up one of 16 countries collaborating on space weather research – with ESA contributing through a Collaborative Expert Center[563]. Japan also continues to collaborate internationally through the Asia-Oceania Space Weather Alliance (AOSWA), which was established in 2010 to facilitate information sharing on space weather in the region[564].

With regard to space for security, a particular emphasis seems to have been given to cooperation with the United States and other Asia-Pacific countries towards enhancing maritime safety and security within the broader Free and Open Indo-Pacific strategy. The incentive for this strategy seems find its origin in the region´s growing security concerns which range from piracy, to terrorism, proliferation of WMD´s, natural disasters, illegal fishing and attempts to change the status quo in the region [565].

Aware that the challenges to this objective may not be solved through domestic initiatives alone, Japan has been inviting any nations holding similar views to join the cause[566]. Different types of concrete cooperative measures are being executed to secure the peace and stability of the Indo-Pacific region[567]. The focus has been also put on support for mitigation/preparedness; response and recovery activities through utilization of EO, communications, and navigation satellites; further joint operations and human networking through capacity building and outreach[568].

Capacity building plays an essential role in Japan´s bilateral cooperation with several Asian countries. In this context, the Ministry of Defense references ongoing capacity building programmes with various countries to enhance "the ability of countries to handle natural disasters and maritime problems on their own" in order to contribute to global security[569]. These countries include Uzbekistan, Myanmar, Mongolia, Laos, Vietnam, Philippines, Brunei, Papua New Guinea, Timor-Leste, Indonesia, Malaysia, Sri Lanka, Cambodia, Djibouti, Thailand and Singapore.

Japan further plans to expand its international cooperation, particularly with coastal countries in the Middle East and Asia-Pacific region to address natural disasters and climate change – thereby offsetting risks associated with these challenges. To this end, Japan's Task Force on Space System Overseas Development will work along the vision of the "Basic Policy for Capacity-building Support for Developing Countries in the Space Field"[570].

More broadly, Japan is actively supporting the activities of several international frameworks that address various issues related to broader security matters such as disaster prevention, etc. These include Japan's

[563] National Institute of Information and Communications Technology (Japan). (n.d.). ISES. Accessible at: http://www.spaceweather.org/ISES/rwc/rwc_jp.html.
[564] Asia-Oceania Space Weather Alliance. (n.d.). Accessible at: https://aoswa.nict.go.jp/index.html.
[565] Ministry of Foreign Affairs of Japan. (2019). To achieve a "Free and Open Indo-Pacific" in Diplomatic Bluebook 2019, Chapter 1 "International Situation and Japan´s Diplomacy in 2018". MOFA. Retrieved from: https://www.mofa.go.jp/policy/other/bluebook/2019/html/chapter1/c0102.html#sf01.
[566] Ministry of Foreign Affairs of Japan. (2020). Japan´s effort for a free and open Indo-Pacific, p2. MOFA. Retrieved from: https://www.mofa.go.jp/files/100056243.pdf.
[567] Amongst others, it provided infrastructures and equipment to enhance post-earthquake reconstruction in Nepal and for flood control in the Philippines; delivered terrorism surveillance equipment in Kenya, Thailand, the Philippines, Bangladesh and the Maldives; organized a training program on illegal fishery control in Thailand; and put patrol vessels at the disposal of Sri Lanka, Djibouti, Malaysia, Vietnam, and the Philippines; and encouraged the establishment and sound application of legal systems in Cambodia and Laos. Ministry of Foreign Affairs of Japan (n.d.), Free and Open Indo-Pacific: Basic concept, p4, MOFA. Retrieved from: https://www.mofa.go.jp/policy/page25e_000278.html; Ministry of Foreign Affairs of Japan (2019). Towards Free and open Indo-Pacific, p15. MOFA. Retrieved from: https://www.mofa.go.jp/files/000407643.pdf.
[568] Ibid.
[569] Ministry of Defense. (2018). Defense of Japan 2018. Tokyo: MOD. Retrieved from: https://www.mod.go.jp/e/publ/w_paper/pdf/2018/DOJ2018_Full_1130.pdf.
[570] Strategic Headquarters for Space Policy. (2017). *Implementation Plan of the Basic Plan on Space Policy (revised FY2017).* Tokyo: Strategic Headquarters for Space Policy.

participation in or adherence to standards set by the ASEAN Disaster Information Network (ADInet), the Asian Association for Remote Sensing (AARS), and the international COSPAS-SARSAT system for search and rescue operations.

Multilateral cooperation for norms and rule-making

Beyond its bilateral and multilateral cooperation, Japan is increasingly emphasizing the need to engage in diplomatic efforts that help establish appropriate rules for space activities in accordance with space-related treaties.

It should be reiterated that Japan has been one of the countries that supported the Code of Conduct for Outer Space Activities originally proposed by the EU in December 2008. Likewise, Japan has been actively supporting the adoption UNCOPUOS Guidelines on Long-Term Sustainability of Outer Space Activities[571] as well as their implementation.

While Japan has been supporting the UNGA Resolution on the Prevention of an Arms Race in Outer Space (PAROS) and has participated in substantive discussions in the Conference on Disarmament (CD) as well as in the Group of Governmental Experts (GGE), it also recognizes that there are still diverging views on the issue and that more-proactive efforts are needed, starting from more pragmatic and near-term measures such as TCBMs[572].

In this context, and in line with the statement made by the Japanese delegation at the Meeting of the First Committee 74th UNGA Session in 2019, the 2020 Basic Space Plan contains a section dedicated to Japan´s efforts to increase trust and prevent mistrust, misperception or miscalculations in space activities among states. The document in particular stresses that "in order to ensure Japan's space security and sustainable and stable use of space, Japan will strategically cooperate with allied and like-minded countries and play an even greater role in creating effective rules in a comprehensive manner, including measures against space debris, while demanding each country to act responsibly in space". In addition, "to avoid the risk of misunderstanding and miscalculation, Japan will communicate the importance of strengthening communication among the countries concerned and the implementation of transparency and confidence building measures (TCBM) in outer space"[573].

[571] Wakimoto, T. (2019). A Guide to Japan's Space Policy Formulation: Structures, Roles and Strategies of Ministries and Agencies for Space. *Pacific Forum: Issues and Insights 19*.
[572] Ministry of Foreign Affairs. (29 October 2019). Statement by the Delegation of Japan at The Meeting of The First Committee 74th Session of The United Nations General Assembly. Retrieved from: https://www.mofa.go.jp/mofaj/files/000544585.pdf.
[573] Cabinet Office. (2020). 宇宙基本計画 (Basic Plan on Space Policy). Unofficial Translation by ESPI. Tokyo: CAO. Retrieved from: https://www8.cao.go.jp/space/plan/kaitei_fy02/fy02.pdf.

6 Japan´s space strategy: an appraisal

Having conducted space activities for over 60 years, Japan has emerged as one of the most experienced actors in the global space arena in Asia and worldwide, with comprehensive end-to-end capabilities and internationally renowned accomplishments.

Despite some assessments that Japan´s efforts have not been guided by "anything like a coherent national strategy"[574] for most of its space journey, the passing of the Basic Space Law of 2008, the four subsequent Basic Plans on Space Policy as well as the other sectorial policies with which the BSPs are interlocked (e.g. the National Security Strategy), make it evident that Japan has, in fact, matured a clear strategy for space. Not only: this strategy now proves to be also ambitious and multifaceted, if not full-spectrum.

Japan´s space strategy has been changing and rapidly expanding over the past decade, with a major paradigm shift since the enactment of the Basic Space Law in 2008. Japan has shifted from an almost exclusively S&T centred space programme focused on achieving technical autonomy and driving the utilization of space for scientific purposes to a more holistic approach. This approach emphasizes how interconnected S&T, a healthy and thriving space industry and national security are and it deems an effective response to challenges to those three components as the best pursuit of **"securing Japan"**.

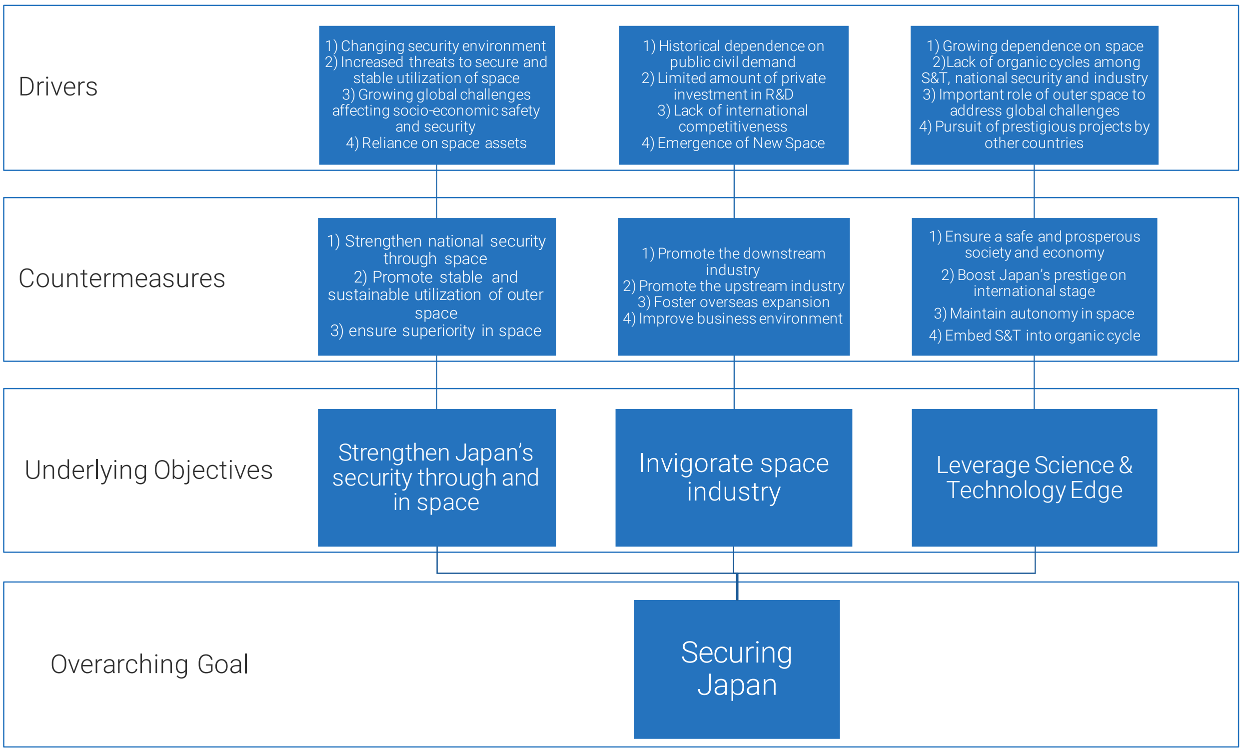

Figure 35: Japan's driver assessment and space strategy towards "Securing Japan" (source: authors' visualisation)

The tenet of "Securing Japan", which has been a central axis in Japanese domestic and foreign policy, also guides Japan's posture in space. The assessment of the environment surrounding Japan that is detailed in all relevant policy documents (e.g. the Basic Space Plan, the Defence Guidelines, etc.) has brought to the fore a variety of challenges which are driving developments in three pillars of Japanese space strategy. This assessment has allowed Japan to develop concrete countermeasures to these

[574] Pekkanen, S. M., & Kallender-Umezu, P. (2010). *In Defense of Japan.* Stanford, California: Stanford University Press. p. 11.

threats which in turn are objectives of the space policy and which all work towards the overarching goal of "securing Japan". The concrete drivers as well as countermeasures and objectives can be examined in Figure 35.

Whereas Japan's space efforts now prove to be embedded within this overarching security driver, it would be misleading to reduce the ongoing shifts in the space policy posture of Japan to a mere militarization (or normalization) of its space programme. Some specific objectives (such as the stated goal of gaining superiority) and associated actions (i.e. the establishment of the SDMU and the planned development of space control capabilities) are certainly moving into this direction. Remarkably, these transformations are also bound to have far-reaching impacts on Japan´s foreign and defence posture and to generate animated debates – if not controversy within the political environment and the public.

However, the securitization of the Japanese space policy is in fact broader. The report shows how the concept of security can be broadened to cover not only the traditional military dimension of space activities, but to encompass also the wider categories of economic, environmental, societal and human security, the threats to which can be mitigated or tackled through this space strategy. From this perspective, even the industry vitalization objective and the associated promotion of a New Space dynamic can contribute to the overarching goal of securing Japan. In addition, it shall be noted that the various objectives are seen as mutually re-enforcing and hence deliberately interlinked with each other (see Figure 36).

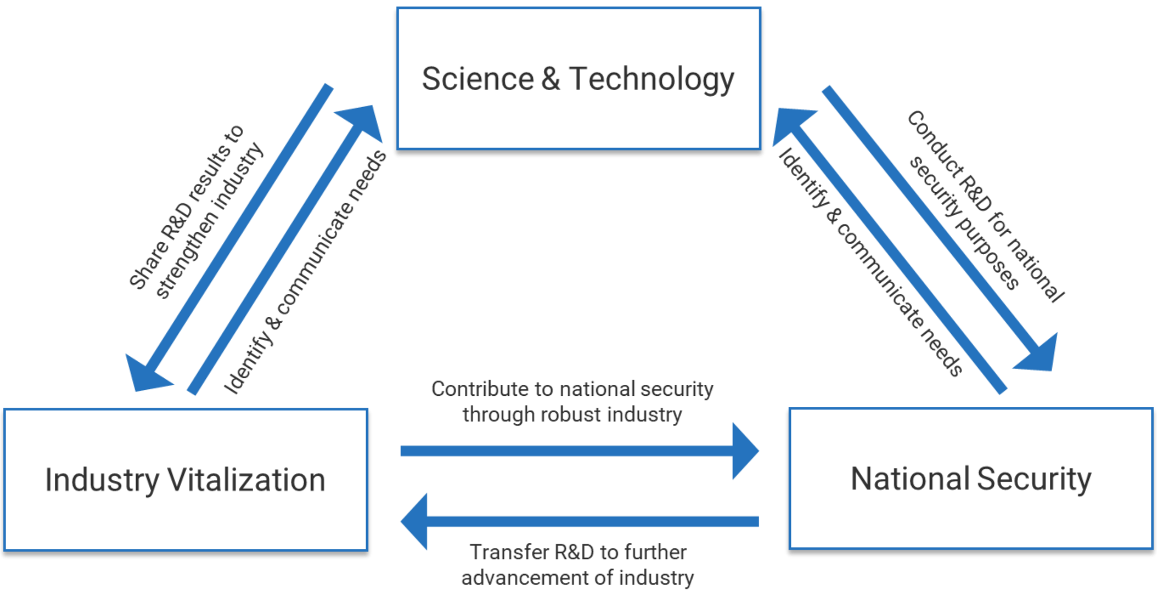

Figure 36: Synergies among the space strategy´s objectives (source: authors' visualisation)

The matrix below (see Table 21) details the framework of tools employed by Japan to reach the objectives identified as integral to Japan's space strategy. For each of the pillars of Japan's space policy – science & technology, industry, security – three fields of action exist: capacity-building programmes, legal & regulatory regimes, and diplomacy and cooperation frameworks. In each of these fields of action, Japan has devised key measures to fulfil the aforementioned objectives.

	Field of action		
Securing Japan in subdomain	Programmes *Operational capacities to achieve the objectives*	Legal and institutional tools *Reference framework to conduct space activities*	Diplomacy and cooperation *Fulfil objectives by harmonising and coordinating space efforts with foreign players*
Civil efforts *Maintain and leverage the S&T edge in economy and society*	Key measures: Development of H-3 and Epsilon; New application satellites for EO and communications; Expansion of QZSS; Implementation of M class and L class science and exploration missions (probes, landers, rovers, etc.); Continuation of R&D programmes	Key measures: Law Concerning Japan Aerospace Exploration Agency; JAXA Mid-Term Plan - FY2018 to FY2024; JAXA Fiscal Strategic Plan; JAXA Vision/JAXA 2025 project	Key measures: Participation in the US-led Lunar Space Exploration programme; Participation of foreign partners in JAXA-led missions (e.g. MMX); Joint missions with foreign partners in various fields (e.g. EarthCare, JUICE, etc.); Strengthening of capacity-building programmes (JJ-FAST, GSMAP, Sentinel Asia, KIBO Cube, KIBO ABC, etc.).
Industrial efforts *Invigorate space industry and stimulate the space economy*	Key measures: New Enterprise Promotion Department; Investment programs & access to finance; Tansa-X; J-SPARC; Tellus; S-Booster, S-NET, S-Expert Platform; Space Development and Utilization Grand Prize	Key measures: *Space Industry Vision 2030;* *Remote Sensing Data*; *Space Activity Act;* new IPR regulations and procurement approach; Strategy on Space Parts and Components; Repositioning of JAXA vis-à-vis private industry	Key measures: Promotion of package sales; Promotion of downstream services in the Asia-Pacific region; Promotion of cooperation between Galileo and QZSS for downstream services; Promotion of B2B through matching events
Space Security efforts *Ensure national security through and in space*	Key measures: Expansion of QZSS; X-Band Defence Satellites communication network; Expansion of IGS constellation; Enhancement of MDA; Operationally Responsive Small Satellites; Mission assurance of space systems; SSA system and SSA sharing; Research on NEOs and SWE; Develop BMD and EW capabilities	Key measures: MOD National Defense Program Guidelines 2018; MOD Medium Term Defense Program (FY2019 – FY2023); Enforcement of *Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data* and *Act on Launching of Spacecraft, etc. and Control of Spacecraft;* Implement COPUOS Space Debris Mitigation Guidelines and IADC voluntary guidelines	Key measures: Reinforce alliance with the U.S. by following up on US-Japan Security Consultative Committee; Strengthen security cooperation with like-minded partners (e.g. SSA); Continue capacity building programmes within the Free and Open Indo-Pacific strategy; Support multilateral initiatives and rules of the road for responsible space behaviour

Table 21: Key tools to achieve objectives of space strategy (source: authors´ visualisation)

Japan's strategy in space shows an effort to strike a balance between different fields of action as well as a recognition that an emphasis on programmes alone is not likely to yield the desired outcomes. Only with the concomitant implementation and enforcement of regulatory tools and institutional reforms and through pursuing diplomatic and cooperative efforts can Japan create the necessary synergies to harness the potential of its programme and enhance its capability to exploit them to maximize the benefits for society.

Overall, the toolbox Japan has now at its disposal can help counteract potential bottlenecks for success such as the stagnating budget for space – the allocation of which on the surface does not reflect the ambition and prioritization of the programme itself. Japan shows through initiatives such as promoting the creation of an organic cycle and new synergies among the various stakeholders, that it can make use of resources smarter and ensure outstanding results even with a plateauing budget.

Some further developments can be interpreted as a reflection of ambition and prioritization of space, such as the increased mention of space at highest political level, including by Prime Minister Abe Shinzo, and an increase in the institutional demand of launches – as reflected in a projected to amount to 39 between 2015-2024 as compared to 26 between 2005-2014, as well as its increasingly active New Space entrepreneurs.

Therefore, it would be unwise to appraise the effectiveness or level of ambition of Japan´s space activities judging only from indicators such as the expenditure level or the number of satellites put into orbits. At the same time, it is undeniable that the relative size of Japan´s space programme will increasingly matter, especially when comparing Japan´s space efforts to the ones led by continental-size actors such as US, China, and even Europe.

As these countries continue to increase the resources dedicated to space activities along with their level of ambition, Japan will find it hard to keep pace with their developments and retain its competitive edge in all domain of activities (and secure its position in the international space hierarchy).

Indeed, notwithstanding the certainly remarkable synergies the country is creating among the various facets of its programme, as long as the dedicated resource remains within the same order of magnitude, it will be hard for Japan to effectively fulfil all the objectives set forth in its space strategy. This implies that the country will be inevitably confronted with both the need to 1) prioritise different activities /objectives and 2) strike a proper balance between between multiplying the benefits of enhanced cooperation and the level of independence/autonomy it wants or can achieve.

On the first point, the dilemmas faced in setting priorities are already evident when comparing the different Basic Space Plans. To illustrate, in order to make room for the new security & defence-oriented activities, the latest Basic Plan of 2020 seem to sacrifice the emphasis on securing supply chain autonomy (components) that was put in the previous Basic Plan of 2015.

Regarding the second point, the need to balance cooperation and autonomy most starkly emerges in highly demanding areas such as human spaceflight and space security. While Japan is aspiring for greater autonomy and the pursuit of end-to-end capabilities in both domains, the country also recognises the continuous need to leverage international cooperation in order to reach the stated objectives. Indeed, the very definition of objectives and activities in these domains continue to be informed by the partnership with the United States and premised on interoperability with their programmes.

Looking into the future, it can be therefore expected that Japan´s international space cooperation will sensibly increase, particularly with the U.S. ally, but also with other like-minded partners that may provide Japan with alternative partners, which do not generate friction with Washington (e.g. European countries and institutions as well as Australia and India). Indeed, although Japan will certainly continue to reinforce space cooperation with the United States for security reasons, it is also likely is that it will consciously seek a diversification of its partnership portfolio away from Washington, to not be too reliant on the capabilities of one single partner and also to address the perennial concerns over both entrapment and abandonment. Arguably, one such diversification will be constructed on programmatic bases, for instance, by privileging cooperation with Europe in the field of space science where European and Japanese priorities are converging, or by focusing on the Asia-Pacific region with regard to the creation of business partnerships and commercial service provision where links are already strong thanks to APRSAF and other bilateral cooperation.

Whereas cooperation will continue to play an important role in Japan´s toolbox, Japan's end-to-end capabilities and its development of complex program initiatives to further its goals it should not be overlooked. An increased emphasis put on industry vitalisation has not only yielded an increasingly vibrant New Space sector, it will also stimulate competition in the provision of space-related services, which can also be expected in the coming years. The specific measures that Japan has put in place to stimulate the growth of its commercial industry are indeed wide-ranging and – together with its increasingly active economic space diplomacy – they will likely make of Japan a fierce competitor for European and American primes and SMEs. Its legacy in space science and technology and related initiatives to boost R&D have allowed amongst others, the ambitious pursuit of exploration missions, for instance its future participation to Moon exploration scheme envisaged by the U.S. Its increased funding for and procurement of the development of its space security infrastructure will enable Japan to meet its space security needs. All of the initiatives related to the three pillars detailed in the report show Japan's relentless ambition in its space pursuit.

Alongside the programmatic tools, the Japanese government has also envisaged specific regulatory measures, new policy processes and institutional reforms that enable a more effective planning, management and revision of national space efforts as well as a more efficient exploitation of space activities through enhanced coordination among the different stakeholders (including different government ministries, academia, and industries). In comparison to other major space powers, the level of integration and synergy reached by the institutional set-up is unparalleled. It enhances and underpins an ambitious space policy and thus allows Japan to harness the potential of its programme and enhance its capability to exploit them and thus to maximize the benefits for society and the country.

It is this report's assessment, that these aspect in particular make Japan well suited to face the challenges that lie ahead. Due to its legacy in space, sustained efforts and ambitious policies and programmes, Japan is bound remain among the most prominent actors in space for decades to come.

Annexes

Annex A – English-Japanese Translations

English Name	Japanese
Major stakeholders	
CAO	内閣府
JAXA	国立研究開発法人宇宙航空研究開発機構
MAFF	農林水産省
METI	経済産業省
MEXT	文部科学省
MIC	総務省
MLIT	国土交通省
MOD	防衛省
MOE	環境省
Key policy documents	
Basic Space Plan	宇宙基本計画
Implementation Plan	宇宙基本計画工程表
JAXA Mid to Long Term Plan	JAXA 中長期計画
Space Industry Vision 2030	宇宙産業ビジョン 2030

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