ESPI

European Space Policy Institute

Full Report

New Space in Asia

Experts views on space policy and business trends in Asian countries

Report:

Title: "ESPI Report 77 - New Space in Asia - Full Report"

Published: February 2021

ISSN: 2218-0931 (print) • 2076-6688 (online)

Editor and publisher:

European Space Policy Institute (ESPI)

Schwarzenbergplatz 6 • 1030 Vienna • Austria

Phone: +43 1 718 11 18 -0

E-Mail: office@espi.or.at

Website: www.espi.or.at

Design: copylot.at

Cover page picture credit: Shutterdock

Table of Content

INTRODUCTION

About New Space

The global landscape of space activities is currently undergoing profound changes. Whereas the vast majority of space activities today is still led by governments with private industries acting as suppliers for public programmes and relying massively on public funding, a disruptive, commercially-driven approach to space has emerged, marked by ambitious undertakings aiming to capture space markets with innovative schemes and business models. In this new ecosystem, private actors are playing a more prominent role, pursuing the eventual goal of conducting space business independently from governments.

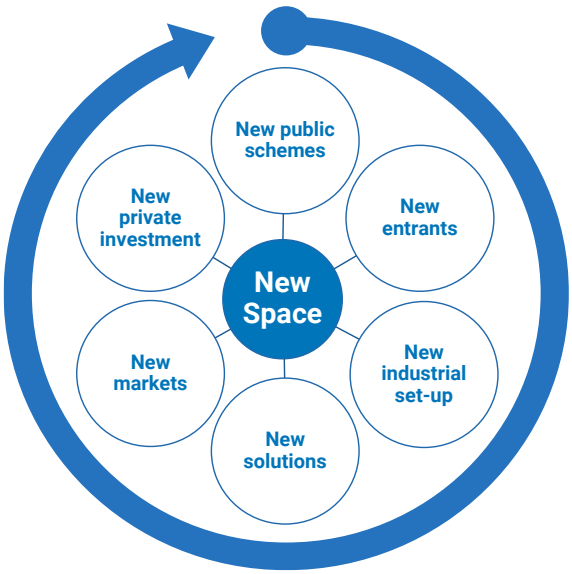


Figure 1: Overview of the New Space trends

This new dynamic, usually referred to as New Space, encompasses a wide range of diverse and interrelated trends leading the space sector towards a more business and service-oriented step:

- New public schemes for space programmes, procurement and support to innovation involving new arrangements with the private sector and the development of new public instruments.
- New entrants including emerging spacefaring nations and new business ventures from space companies and start-ups as well as from non-space companies seeking to enter the space sector.
- New solutions including new products and services but also disruptive value propositions such as integrated solutions, lower prices, reduced lead times, lower complexity, better flexibility…
- New markets under exploration or development in both the upstream and downstream segments of the space value chain (e.g. in-orbit servicing, satellite broadband, satellite imaging, micro-launchers…)
- New industrial set-ups and implementation of new industrial methods and processes for the development and production of space systems as part of innovative business models.[1]
- New private investment tools from various sources and involving various funding instruments (e.g. venture capital, private equity, loans, prizes, crowdfunding…).

[1] New techniques and methods adopted by New Space players include, for example, industrial organisation optimisation, supply chain rationalisation and vertical integration, miniaturisation, proven technologies re-use, economies of scale, production line automation and digitisation, standardised architectures, use of COTS, reusable launchers or in-orbit servicing.

The combination of these trends is leading to a deep transformation of the space sector characterised by a growing investment, an increasingly more prominent involvement of private actors and the emergence of a more business-oriented leadership.

The rise of private actors is exemplified by the number of new companies created in recent years. According to NSR, between 2010 and 2018, over 600 new space companies have been founded, a trend that has been accompanied – and also enabled – by the parallel growth of private investment.

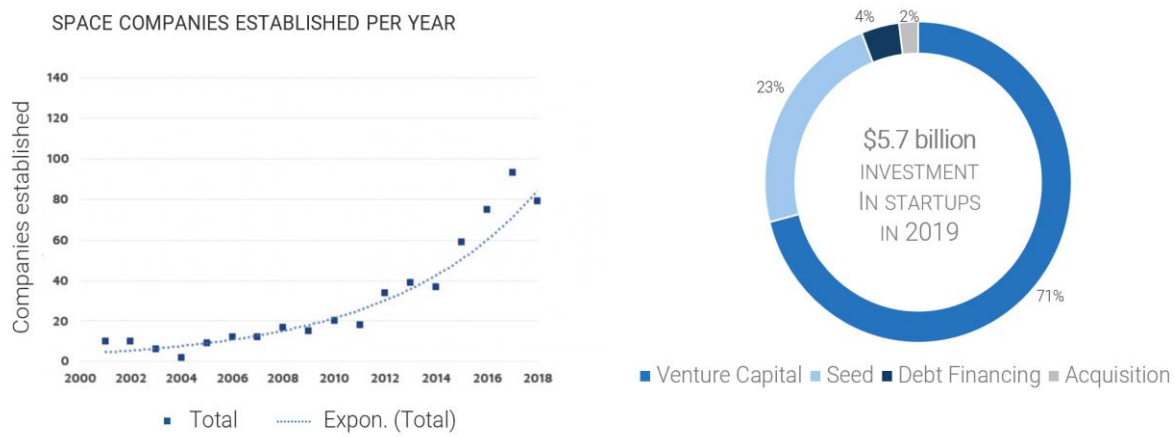


Figure 2: Establishment of space companies (NSR, 2019); Investment in space start-ups (Bryce, 2020)

The volume of private investment has skyrocketed worldwide over the past few years. According to the Bryce report Start-up Space 2020,[2] a record $5.7 billion was invested in space start-ups in 2019 alone. This amount shattered the previous record of 2018, when $2.7 billion was invested in start-up companies. Although this amount is still rather small compared to public funding (government space budgets totalled $93.5 billion in 2019 according to the same source), it is worth underlining that private investment grew by a factor 10 in just a decade, in 2009, "only" $500 million had been invested in space start-ups.

ESPI reported comparable trends in Europe in the annual Space Venture Europe report.[3] Despite the worldwide impacts of the Covid-19 crisis 2020 found itself to be a groundbreaking year in terms of volume of investment in Europe with more than €500 million invested in European space start-ups over 60 deals. This represents a 168% increase compared to 2019.

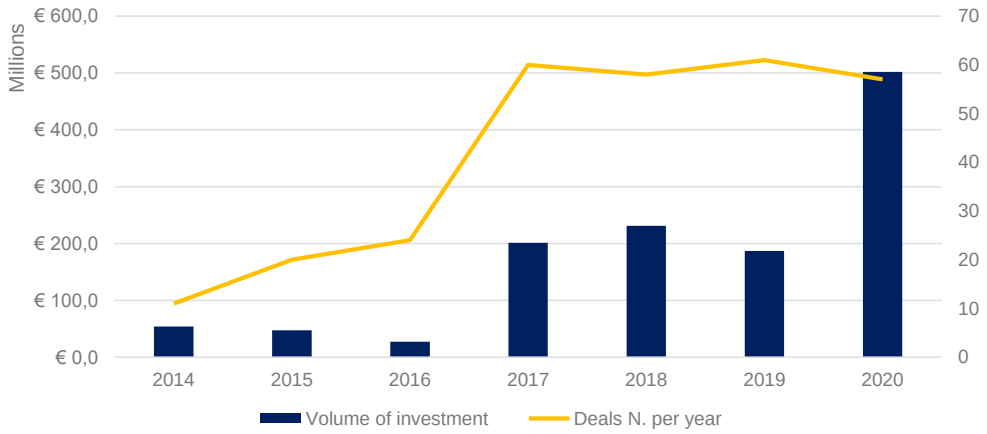


Figure 3: Investment in European space start-ups in 2014-2020 (ESPI, 2021)

[2] Bryce Space and Technology, Start-Up Space 2020
[3] ESPI, Space Venture Europe, available at: www.espi.or.at

New Space in Asia

While Europe paid much attention to the development of New Space trends in the United States, in particular for what concerns private investment, entrepreneurship, innovation and competition, the emergence of New Space trends in other regions have probably been overlooked until now.

Yet, a more careful examination of global commercial and industrial dynamics in space would reveal an equally important need to look eastward, and more specifically at the emergence of potentially disruptive trends in the Asian region. Partly inspired by the undertakings of U.S. companies such as SpaceX, and partly driven by national strategic considerations, countries such as Japan, China, India or South Korea have started to actively support the emergence of innovative space businesses, with an increasing number of entrepreneurs now kick-starting space ventures to market end-to-end solutions in both the upstream and downstream segments. Governments in these countries are also increasingly supporting the development of commercial services for tasks traditionally under government responsibility and therefore repositioning their agencies according to new mandates.

Even though some analogies can be drawn between the development of New Space trends in America, Europe and Asia, the regional contexts of space activities remain very different. Spacefaring countries in Asia have developed their own approach and ecosystem for space activities, rooted within their broader political, industrial and economic national landscape. The development of New Space trends in Asian countries can therefore only be fully appreciated in their respective domestic contexts. For this reason, and with the overarching objective to support a sound overview of New Space trends in Asia, ESPI decided to investigate the issue with the support of local experts able to provide informed insights on developments in their respective countries including:

- Public strategies and plans to support the emergence of New Space
- Insights on commercial space sectors and New Space ecosystems
- Perspectives on major trends and prospects for growth

Contributors to this report are experts based in Asia with diverse professional profiles – from research analysts and space lawyers to astropreneurs and officials from public institutions. They provide independent analyses of national New Space dynamics from industrial, technical, legal and policy angles. The list of contributors is provided at the end of the report. The report addresses six Asian countries: Japan, China, India, South Korea, Malaysia and Thailand.

Japan. In the first article, Masayasu Ishida, founder and president of the SPACETIDE Foundation, a non-profit organisation focussing on the promotion of new businesses in the Japanese space sector, provides a precise and comprehensive overview of the Japanese New Space landscape in terms of actors, business areas, and investment sources and volumes, based on the extensive data collected and analysed by the SPACETIDE Foundation. He demonstrates how the Japanese space industrial landscape has shifted from the absolute domination of large corporations relying on State demand to a diverse and multifaceted landscape of small service providers, university spin-offs, working in synergy with the traditional non-space industry, and a variety of investors, from specialised venture capitalists to large corporation willing to revive a pioneer spirit. In the second contribution, Professor Kazuto Suzuki of The University of Tokyo proposes a detailed analysis of the policy and legal evolution orchestrated by the government of Japan to foster the emergence of new commercial actors in the national space sector since the late 2000s. In particular, he provides a precise overview of existing regulatory and promotional instruments developed by the Japanese government to connect space and geospatial technology experts with business specialists and potential investors, such as the trademark S-Booster, S-Matching, S-Experts and S-Net quartet.

China. The first contribution sheds light on the key features and unfolding trends shaping the commercial space ecosystem in China. The paper is written by a team of three authors, Chen Lan, Jean Deville and Blaine Curcio, contributing their complementary expertise and making it possible to look at China's New Space ecosystem from a technical, financial, and socio-economic point of view. In addition to a detailed outline of the players composing China's commercial ecosystem (institutional actors, state-owned enterprises, non-space industries, start-ups and investors), the authors provide an innovative assessment of the country´s investors typologies and levels of investment as well as of the technical choices made by China´s New Space companies. In the second contribution, space lawyer Zhouyan Lu offers a clear-eyed overview and analysis of most recent policy and legal measures to encourage the participation of private actors in the space sector and support the consolidation of a robust commercial space ecosystem in the country. Particular emphasis is placed on the regulatory measures that, in the absence of a national space legislation, are meant to manage private sector´s undertakings.

India. Two papers by renowned Indian experts make up a comprehensive analysis and appraisal of India´s New Space dynamic. The first contribution, by Narayan Prasad, offers an educated examination of the changing dynamics of India´s commercial space ecosystem. It provides a comprehensive mapping of this emerging ecosystem, shedding lights on both its structural limits and its potential for growth and international influence. The second contribution, written by space law expert Ashok G.V. offers an assessment of regulatory and policy measures implemented by the Indian government to enhance and enable the private sector to access markets for satellite products and services. Emphasis is in particular placed on the two recent drafts of the Spacecom Policy, 2020 and of the Space-Based Remote Sensing Policy, 2020, released by the Indian Government in 2020. The paper reviews the history of India's policy shortcomings while dealing with investments in satellite communications and telecommunications industries and review whether or not the new domestic space policies can avoid the mistakes of the past, mitigate legal risks and promote investments in the space sector.

South Korea. The contribution of Sangwoo Shin, senior researcher at KARI, offers a thorough and clear-eyed view of the new commercial ecosystem taking shape in the Korean peninsula. The paper first provided an introductory overview of Korea´s development path in the space sector; it then offers a detailed mapping of both the traditional and emerging players engaged in commercial space activities and eventually analyses the national strategies and plans to support the further emergence of New Space in the country.

Malaysia. After a brief review of Malaysia's past space development effort, the team led by Norilmi Amilia Ismail of Universiti Sains Malaysia provides a comprehensive overview of the domestic space ecosystem with a strong focus on commercial players and on nationwide initiatives for qualified human capital development. This contribution then introduces current governmental initiatives aiming to strengthen Malaysian space efforts, and the Malaysia aerospace industry: the Malaysia Space Exploration 2030 program, the National Space Policy 2030 and the Malaysian Aerospace Industry Blueprint 2030.

Thailand. In a short contribution, Ekachai Phakdurong and Onanong Sa-nguantongalya of Thaicom Public Company Limited present the early history of Thai space activities, starting with their company's pioneering role in the provision of satellite communication services to the Southeast Asian region, until the emergence of new private actors from the 2010s. They then introduce a few governmental initiatives and policies for the development of new actors in both the upstream and downstream segments, such as the Space Krenovation Park, housed on the Geo-Informatics and Space Technology Development Agency's main campus in Sri Racha.

Report takeaway: a fast-growing New Space ecosystem in Asia

Experts insights provided in this report clearly show that New Space trends are at work in Asian countries as a result of both determined public strategies and fast-developing commercial space ecosystems. Asian countries are developing their own approach to New Space independently from each other and should therefore not be considered and addressed as a homogeneous ensemble. As a consequence, the development of the situation in the region is complex to assess and analyse, especially given the scarce and fragmented information. Nevertheless, the development of New Space in Asia should not be overlooked given the potential implications on international space markets and competition. Public measures implemented by Asian governments may also provide interesting case studies for Europe.

New Space ecosystems in the Asian region

Comparably to what is witnessed in the United States and in Europe, space businesses in Asia have quickly grown in number and size, thanks to a combination of actions taken by both industrial/commercial actors and governmental stakeholders. A fertile commercial ecosystem for space has progressively emerged in all the analysed countries, although with varying degrees of maturity. The New Space dynamics unfolding in the Asian context, however, are not one-generic, for there are visible differences among the different national ecosystems, especially between the big three leading space powers.

The big 3: Japan, China and India

Japan, India and China have fully entered into the New Space era. Each of these three countries has witnessed the emergence of internationally competitive actors, easily rivalling with their Western counterparts and having already unfolded aggressive expansion strategies. Among these well-funded start-ups can be counted the Japanese Astroscale and ispace, the Chinese LandSpace and Galactic Energy or the Indian SatSure and Astrome Technologies.

According to experts' estimations, there are now around 50 major New Space start-up companies in Japan, 120 in China and 50 in India.[4] These companies cover a wide range of business segments, from traditional ones (e.g. launch, satellite design) to niche activities (e.g. space foods).[5] Even highly complex and costly activities such as the development of commercial launch systems, has been soaring. As highlighted by Blaine Curcio, Jean Deville and Chen Lan in their analysis on China, "there are far more commercial launch companies with over USD 50 millions of funding in China than in any other country", which would have been unimaginable even ten years ago. Similarly, who could have imagined that a debris removal and on-orbit servicing company like the Japanese Astroscale could raise almost USD 200 millions in a few years?

Apart from the emergence of new space-related businesses, the space industries of China, Japan and India have seen an intense diversification of investor profiles. While investments in the space sector have traditionally been overwhelmingly governmental in major Asian countries, venture capital firms and non-space large corporations have made a remarkable entrance recently. Top companies like All-Nippon Airlines and Shimizu Corporation in Japan or high-tech giants like the Chinese Tencent, Alibaba and Huawei have also started to invest significantly in space ventures and devote important resources to internal space-related projects.

[4] For Japan, see 1.2. For China, see 3.2.2. For India, see 5.2.1.
[5] For an overview of Japanese New Space companies' business segments, see 1.3. For China, see 3.2.2. For India, see 5.2.2

Nascent ecosystems in other Asian countries

In the three other countries part of this report, industrial initiatives have been comparatively more modest, and, for most of them, still retain characteristics of old space with a strong involvement of the government in the development of space activities. The emergence of a New Space entrepreneurship in these countries is at a nascent stage and hence understandably centred on start-up companies that are yet to consolidate their offerings in the domestic market. In the case of South Korea, however, the growth of a New Space ecosystem is proceeding at very high speed, with the number of private companies increasing from 61 in 2010 to over 340 in 2020.[6]

With the exception of South Korea, when compared to the private sector of the big three Asian space powers, the space start-up ecosystems of other Asian countries do not only lag behind in terms of entrepreneurs, but also in terms of venture capitalists, mentors, accelerators, and incubators. Despite various success stories that are progressively emerging, the overall enterprise readiness level of New Space companies in the covered countries remains rather low, with an extremely small number of companies having reached technological and operational maturity.

Governmental initiatives to foster the development of New Space

In the Asian region, there proves to be growing public awareness about the importance of governments' role in supporting the growth of a robust and commercially competitive space industry. Asian government have thus been supporting space industry with a variety of measures. The various contributions compiled in this report show a diversity of measures taken by Asian governments to nurture a mature and commercially competitive space industry.

National laws and policies to develop a favourable ecosystem

All the countries reviewed in this report have adopted policies and some form of national legislation aiming to foster domestic space businesses.

Since the enactment of the Basic Space Law of 2008, the Japanese government has conducted a major overhaul of its space activities with a combination of legal and policy instruments. The Basic Space Plan, frequently revised to fit the evolution of the Japanese public and private space sectors, serves as the main national roadmap. In Ch 2., Kazuto Suzuki provides a precise overview of all the tools set up in the last decade, in particular the 'S-series' of initiatives aiming to construct an enabling ecosystem by connecting different traditionally segregated stakeholders, such as engineers having developed disruptive technologies with interested investors (S-Matching), or start-ups in infancy with seasoned experts (S-Experts).[7]

In China, the driving factor of the emergence of New Space companies has been the relaxation of private investment rules in the space sector in 2014 by the "The State Council's Guidelines on Investment and Financing Mechanism Encouraging Social Investment in Innovation and Key Areas".[8] Whereas, before 2014, investments were primarily coming from the State, from 2015 to 2019, the number of Chinese companies investing in space more than quadrupled (from 24 to 100).[9] The focus of the Chinese government on building a robust commercial space ecosystem was reaffirmed and reinforced as part of the National Development and Reform Commission's 2015 "National Civil Space Infrastructure Medium- and Long-Term Development Plan of 2015-2025".[10]

[6] See 7.3.1.
[7] For a detailed overview of such tools, see 3.3.
[8] For a summary of Chinese policies on private investment in the space sector, see 4.2.2.
[9] See 3.2.2.
[10] See 4.2.2.

In addition, the "White Paper: China's Space Activities" of 2016 (revised every 5 years, valid until 2021) puts an emphasis on the diversification of commercial players in the space sector.[11] Finally, foreign investments are also part of the promotion strategy of the government, via the space sector's inclusion in the "Catalogue of Industries Encouraged for Foreign Investment".[12] Other existing policies are skilfully reviewed by Zhuoyan Yu in 5.2.5.

The core role of ISRO as concurrently the lead national space R&D organisation and the main regulatory agency, is a double-edged sword for Indian space sector. Benefitting from ISRO's strength and stability while ensuring a free and open domestic space market is at the centre of Indian national space policies. In particular, the two draft policies released in 2020 provide a bright outlook on the future of the Indian space industry. The "Spacecom Policy, 2020" aims to support the emergence of businesses focussing on setting up a communication infrastructure in geostationary and low-Earth orbits, as well as necessary ground stations. Then, the "Space-Based Remote Sensing Policy of India, 2020" proposes to simplify the access to satellite remote sensing data by clarifying data sensitivity levels and related licensing processes.[13]

Smaller and emerging Asian space countries have also developed national policies to foster their domestic space industry.

In South Korea, the government enacted several support policies, including a Space Industry Strategy that aims to expand the size of the space industry from 2.7 trillion won in 2016 to 3.7 trillion won[14] in 2021 by expanding the private-led space industry market, creating new industries to grow the space market, strengthening global competitiveness of space companies.

In Malaysia, the government has released a set of policies and strategies for the development of an indigenous space industry. The "Malaysia Aerospace Industry Blueprint 2030", the "Malaysia Space Exploration 2030" and the "National Space Policy 2030" have outlined a comprehensive ecosystem development plan aiming for the country to "be one of the aerospace nations by 2030", by relying on support to both the upstream and downstream segments of the space economy, on human capital development and on international cooperation.[15]

Finally, although Thailand still retains inherent characteristics of old space, with an overwhelming domination of the public sector on domestic space activities, the government has been making efforts to foster private initiatives, namely the creation of a space innovation campus, the Space Krenovation Park, and the enactment of a 20-year space development roadmap, the "National Space Master Plan for 2017-2036".

Direct funding of innovative space technologies

A straightforward form of support that can be provided by governments to New Space start-up companies in their infancy is funding for the development of innovative technology and their commercialisation, as shown in the two examples below.

In Japan, government organisations traditionally involved in providing direct funding to innovative ventures are increasingly including New Space companies in their portfolios, the most notable being the Ministry of Economy, Trade and Industry 's Innovation Network Corporation of Japan (INCJ) as well as the Ministry of Finance's Development Bank of Japan (DBJ).[16]

[11] See 5.2.1.
[12] See 5.2.2.
[13] A detailed presentation of both policies is available in 7.2.
[14] Respectively, approximately USD 2.4 and 3.3 billion.
[15] For a precise outline of these three policies, see 9.3.
[16] See 2.4.

As shown by Narayan Prasad (Ch 5), the Indian Department of Space is currently working to enhance its support to the nascent domestic New Space industry, in particular through the creation of the Indian National Space Promotion and Authorisation Centre (IN-SPACe), which will provide various kind of support, including the "co-development and co-funding of high stakes projects between SMEs and IN-SPACe".[17]

Provision of manufacturing and testing infrastructure

Apart from the access to funding, a major hurdle faced by newcomers in the space sector is the lack of available assembly, integration and, most importantly, testing infrastructure. Space agencies and research organisations of the central government possess such capabilities and are often using them intermittently. By providing access to their testing facilities to academic or commercial actors, they can combine the provision of a much-needed help to small actors unable to set up they own equipment with opportunities to rent underused infrastructure.

Example of such practices can be found in most countries such as Japan, where JAXA provides access to its facilities to nascent space ventures as part of its J-SPARC program,[18] in China as well as in India with ISRO, although a simplification of access procedures to testing equipment has been listed as a priority area of improvement by representatives of the Indian New Space community.[19]

Growing importance of regional/provincial governments

In very large countries like China or India, provincial governments for the former and state governments for the latter, have been playing a growing role in the development of the local space industry.

In China, a large number of initiatives were set up by provincial governments, willing to develop poles of competitiveness relying on space technology: the National Aerospace Industrial Base in Hubei Province, the National Satellite Manufacturing Base in Zhejiang province, etc.[20]

In India, numerous state governments have concluded strategic partnerships with ISRO focusing on mainstreaming the use of domestic satellite remote sensing and positioning, navigation and timing data to support a wide range of local activities, including through the establishment of Regional Remote Sensing Service Centres (RRSSCs). Other states have even gone further than space data applications by promoting the development of upstream activities. The most prominent of such initiatives is undoubtedly the SpacePark Kerala, a space innovation campus established in Thiruvananthapuram by the Government of Kerala.[21]

It is also true in Japan to some extent. In particular, Fukui Prefecture has been branding itself as a new space hub with testing facilities, the development of prefectural satellite and the creation of education programs in local universities.[22]

Support to foreign market access

The two most advanced countries in the region, Japan and China, have also sought to promote business ties within their 'sphere of influence'. A typical example of such initiatives are Japanese efforts to foster the development of space data utilisation ventures in Thailand. It comports a variety of initiatives such as direct governmental support to GISTDA's Space Krenovation Park, the promotion of the use of data from Japan's QZSS regional navigation satellite system through the Multi-GNSS Asia initiative and the

[17] See 5.3.
[18] See 4.3.
[19] See 5.3.
[20] See 3.2.
[21] See 5.2.
[22] For an overview of space activities conducted by the Fukui prefectural government, see: https://www.japantimes.co.jp/news/2020/11/14/national/satellite-japanese-government/

extension of the Japanese Cabinet Office business competition S-Booster to Southeast Asian participants ('S-Booster in Asia').[23]

A perhaps more evident example is offered by China´s efforts ongoing construction of a "Belt-and-Road Spatial Information Corridor" to connect all countries along the New Silk Road Economic Belt and Maritime Silk Road. The corridor, which is an integral part of China´s Belt-and-Road Initiative (BRI), entails the construction of several elements ranging from Earth observation, communications, navigation and ground systems up to space application product development. Already in 2018, 10 virtual Earth observation ground stations in the countries along the Belt-and-Road were installed. Although not directly intended to support New Space, this multi-dimensional infrastructure network is laying the ground for a more active participation of Chinese commercial ventures in the provision of services in BRI-associated countries.

Obstacles and growth potential of New Space in Asia

From an overall perspective the consolidation of a New Space sectorial dynamic in the Asian region is proceeding at a fairly rapid speed, particularly in China and Japan, and to a lesser extent of India and South Korea.

It is undeniable that from a comparative perspective, Asian countries are lagging behind in their capacity to trigger and embrace private business leadership. In particular, the gap between the New Space dynamic in Asia and the United States is still considerable. Although private investment and space start-ups in Asia have exhibited massive growth in the past decade, the emergence of this dynamic remains in general more cumbersome and the overall enterprise readiness level of Asian companies is still lower than in Europe and the United States. Despite some Asian businesses are slowly gaining their footings, most of the companies presented in the report (see also Annex A for a list of notable New Space companies in different Asian countries) are still far from reaching technological, operational and commercial maturity.

A number of elements can be highlighted to explain the limited development of new private actors among the emerging Asian countries in particular.

- First, Asian initiatives to foster entrepreneurship and/or leverage a more prominent role of private actors in space programmes are rather recent in comparison to the United States and Europe. The involvement and capabilities of private industries in the national space programmes continue to be rather marginal in comparison to the US and Europe. This is true for both established space powers such as China, India and South Korea and emerging space nations such as Thailand and Malaysia. The reason is the fact that in both the upstream and downstream segments of their space industry, the role of the public actor is still predominant, with national space agencies (such as KARI and ISRO) or state-owned enterprises (such as CASC) acting as the main manufacturer and provider of space-related products and services.
- Second, the private investment base to support the growth of start-ups remains very small compared to the United States and European ecosystems. With the exception of China and Japan, the value of private investment in Asian space start-ups is still far from the multi-billion figures reported in the US. This can be imputed to the fact that the availability of private equity and venture capital funds in emerging Asian space nations is more limited. But even in a large country like India too, most astropreneurs have been self-funded or sponsored by grants from high net-worth individuals like Tata, Mohandas Pai, and Rajan Anandan, a situation that is in stark contrast to India's broader start up ecosystem (particularly in the IT sector), which has a well-organized community of venture capitalists.

[23] See 2.3.

- Third, unlike New Space companies in the major spacefaring nations, 'astropreneurs' in emerging Asian countries cannot count on dedicated start-up support programmes. There is also no real case of institutional capital investment for these companies and very few dedicated support structures like incubators or accelerators. More broadly, the level of institutional sponsorship, which has proved key in the emergence of New Space companies in the US, Europe, China and Japan has been thus far negligible.
- Fourth, in some instances (including in the case of China and India), these countries are yet to adopt transparent and comprehensive regulatory mechanisms that are supportive of private space business in the country. A sound policy, legal and regulatory framework is indispensable for any industry in any geographic location and has been instrumental also for the emergence of New Space in the US and Europe. With the exception of Japan, national laws and regulations in the other case studies are not by any measure comparable to the pro-business legislations earmarked by the US or Luxembourg. These national frameworks - while acknowledging the existence of commercial activities – do not fully ensure predictability, transparency, responsiveness, efficiency - in short, what the private sector demands.

Despite the many shortcomings that are still to be overcome, the mapping and analyses provided in this report have shown that there is also a wealth of factors that underpin an inherent growth potential for the New Space dynamic in the region and the eventual success of Asian astropreneurs in the national and international space markets. Three macro-factors underpinning this projection can be identified.

- First, conditions on the demand side prove to be particularly favorable. Given their size and scale, (particularly in the case of China and India), Asian countries are already an immense data marketplace, providing huge business opportunities for satellite data providers. And as demonstrated in this report's contributions, a large share of New Space companies in Asia is targeting the downstream segment, because of the absence of important upfront satellite technology development cost. The growth potential is therefore concrete. What is perhaps more remarkable than this already huge demand is that the projections associated with Indian demographic and economic growth highlight an even higher potential for growth in demand for satellite capacity and for new downstream services. In this respect, it can be noted that space-based services in several Asian countries are reaching a stage where demand is outpacing public supply and is creating a unique opportunity for developing a space industry.
- In addition to the favourable conditions on the demand, a second important factor that can boost the future growth of New Space in the region is given by the valuable assets and talent that many Asian countries boast on the supply side. The analysed case studies all have strong innovation skills, robust R&D expertise, academic/scientific excellence including outstanding tertiary education, a strong manufacturing sector and ICT services backbone. Countries such as China and India can also benefit from the availability of large, well-trained workforce and relatively lower costs of labour and operations. Whereas innovation inputs (such as education and R&D expenses) still lag behind those of the advanced economies of the OECD world, the availability of highly skilled employees at low prices (budget-conserving talent), as well as the need to serve a market with low purchasing power (budget-constrained customers) has been helping commercial space companies in those countries to propose innovative low-cost solutions that could for example disrupt existing markets with aggressive pricing, to address new mass markets.
- A third macro-economic factor underpinning positive projections about Asia's New Space growth are the possibilities offered to new space companies to leverage positive externalities that can help this nascent ecosystem to move towards long-term growth. Several externalities can be identified. For instance, thanks to the relaxation of the foreign investment threshold in the space sector by several Asian countries (including China and India) there are growing prospects for Asian SMEs and New

Space companies to attract attention for potential B2B solutions with international partners through Foreign Direct Investments (FDI), Mergers & Acquisitions (M&A) or Joint Ventures (JV). Similarly, the level of public sponsorship, which has proved key in the advent of New Space companies in the US, is expected to grow substantially, helping to turn the solutions proposed by Asian astropreneurs into viable business cases.

Taken together, these three macro-factors (favourable conditions on the demand side, valuable assets on the supply side, and growing externalities to be leveraged) substantiate the argument that Asian countries are bound to become an even more fertile and robust ecosystem for New Space entrepreneurship. Were the current growth trajectory to solidify, also as a result of an increased level of sponsorship by respective public institutions, it can be argued that Asia's New Space companies hold not only the potential to disrupt the way space activities are conducted in their home country, but also to exercise an increased influence in the global space economy, at least from a medium- to long-term standpoint.

Whereas the exact positing and relative weight of these companies in the global space economy are certainly hard to disentangle and no conclusive projections on what their growth will mean for the global space industry can be drawn at this point, it will be essential for European institutions and industries (both small and large) to monitor these developments closely. It is the hope of ESPI that the expert insights offered in each individual chapter will help draw a holistic picture of these dynamics and bestow European policymakers with more informed views about the possible engagement opportunities or competition challenges for European businesses.

NEW SPACE IN JAPAN

1 Commercial space ecosystem and trends in Japan

By Masayasu Ishida, Chairman and CEO, SPACETIDE Foundation; Director, A.T. Kearney; Member, National Space Policy Committee, Cabinet Office, Government of Japan

1.1 Introduction: key characteristics of the Japanese space sector[24]

Japan has more than 50 years of history in government-led space development, mainly driven by a "science and technology" perspective, which led to significant achievements in the past decade, such as the successful deep-space asteroid sample-return mission Hayabusa. The Japanese space programme encompasses a comprehensive list of space development activities such as communications, remote sensing, and positioning, navigation and timing (PNT) satellites, launch systems, the Japanese Experiment Module on the International Space Station, as well as numerous space exploration and human spaceflight missions.

Under such government-led space development, the Japanese Aerospace Exploration Agency (JAXA) plays a core role as the primary governmental research and development (R&D) institute. On the other hand, private large space-focused corporations and related vendors such as Mitsubishi Heavy Industries, IHI, Mitsubishi Electric, and NEC are involved in policy programmes. While these private companies expect the domestic government demand to remain their core business, they have been, in recent years, expanding their activities to serve the demands of both foreign governments and private sector.

Since the enactment of the Basic Space Law in 2008 and the first Basic Plan for Space Policy in 2009, the Japanese government has been paying more attention to space technology applications. Consequently, the current total market size of the Japanese space industry is estimated to be around JPY 1.2 trillion[25]. The market for the terrestrial use of satellite data, Global Navigation Satellite System (GNSS) chipsets and navigation devices has been especially growing in the last few years.

Recently, the global space industry has been undergoing major transformations. In addition to government-led space development, new efforts are pumping up from the private sector. Over the past decade, more than 30 countries and regions have invested in space-related businesses, influenced by different factors and with entirely different goals that vary from region to region, and country to country. Japan, too, shows a great interest in space industry and the signs of a new ecosystem development. Today's environment is characterized by new policies, new players, new financial schemes, and new technology. Various factors are coming into play at the same time, as briefly summarised below.

[24] Most of the data provided in this contribution originates from the Compass product of the SPACETIDE Foundation. If not, specific reference is provided in footnote.
[25] Approx. 10 billion EUR (1 EUR ~ JPY 120 as of November 2020)

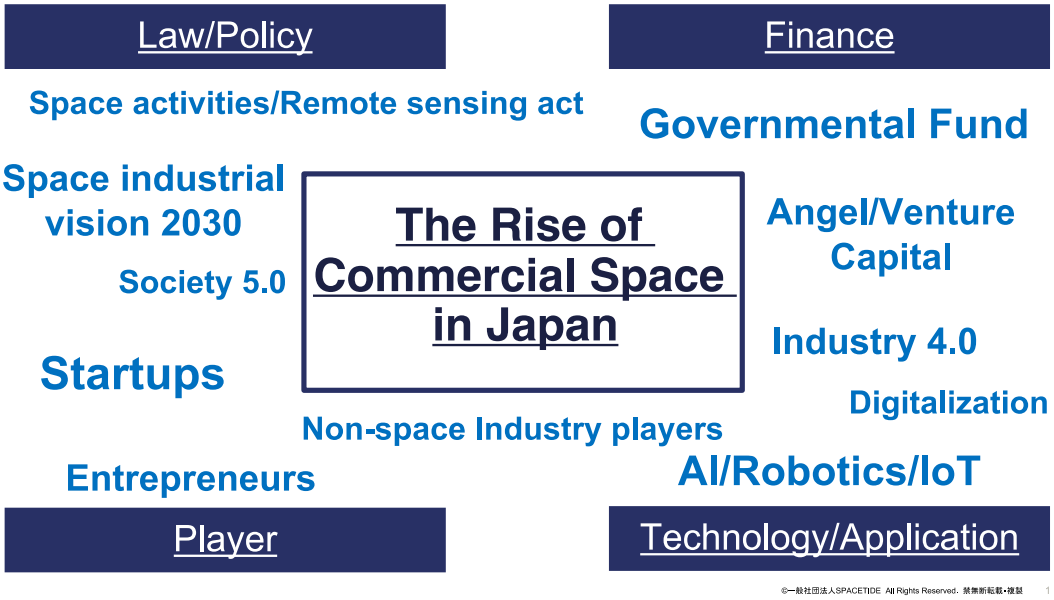


Figure 1-1. The Rise of Commercial Space in Japan

Law and Policy. The Japanese government has been playing a key role, as it sees commercial space as a potential area of industrial competitiveness in the future. Over the past five years, the Japanese government has been implementing a variety of measures to energize and accelerate space activities in the private sector (figure 1-2).[26]

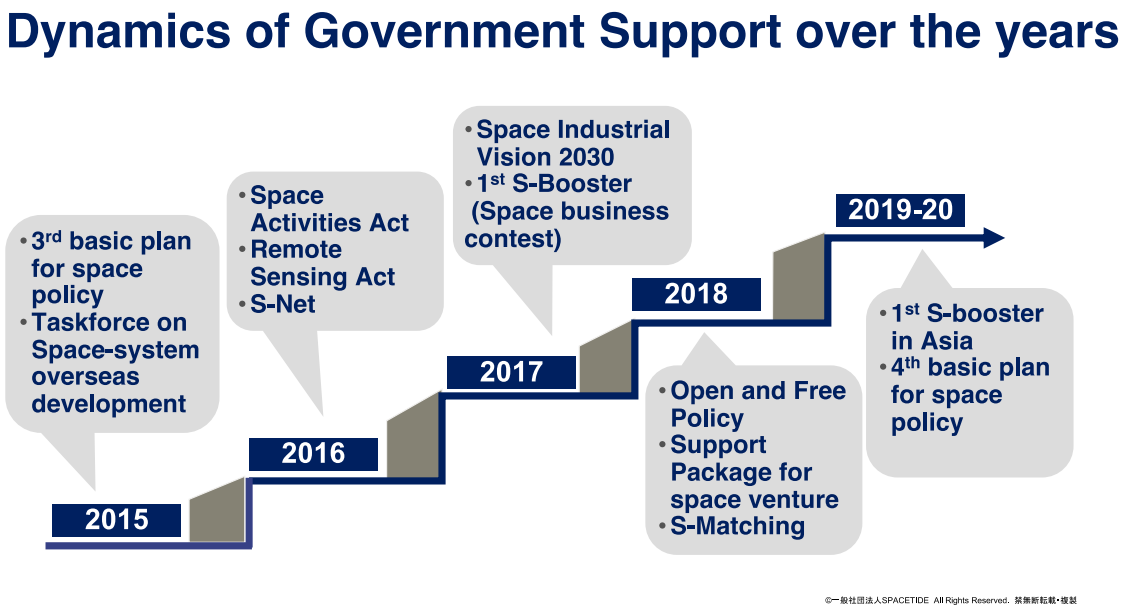


Figure 1-2. Dynamics of Government Support over the years

Players. In addition to established aerospace companies, a variety of actors (50 start-ups and over 100 non-space industry players) are entering into various space business segments. Such a wide spread of diversified sectors participating in the space community is not seen in any other country, and is, therefore, a distinctive characteristic of Japan.

[26] For a detailed analysis of the role of the government in the recent evolutions of the Japanese space sector, cf. Kazuto Suzuki, "Analysis of Japanese policies and tools to support commercial space", next contribution of this report.

Funds. The Japanese national space budget, of about JPY 300 billion,[27] has traditionally supported the aerospace industry. In recent years, government funds and private venture capital have continued to make active investments, amounting to more than JPY 10 billion per year,[28] and large companies have started making investments as well. However, massive individual investments such as those made by tech billionaires in the US (e.g. Elon Musk, Jeff Bezos) are non-existent in Japan.

Technology. Japan has a variety of technological assets that have been cultivated in the automotive, electronics, and information and communication technologies (ICT) industries. Combining these advanced technologies with traditional aerospace technologies accelerates the innovation in the aerospace industry. Conversely, space technology can serve as an enabler to create a wide variety of types of values such as mobility automation and robotics, geo-intelligence, ubiquitous connectivity, etc. The space industry is expected to contribute to solving numerous social and economic issues facing Japan.

1.2 Industrial space activities in Japan: a review of domestic actors

The industrial ecosystem for government-led space development forms a pyramidal structure, with JAXA at the top. Meanwhile, thanks to a new ecosystem for commercial space business, the sector is becoming more diverse, with the number of stakeholders increasing rapidly. This wide variety of stakeholders must act harmoniously to achieve progress for the whole industry (figure 1-3).

1.2.1 Established actors: large aerospace corporations

Major aerospace companies, such as Mitsubishi Heavy Industries, IHI, Mitsubishi Electric, and NEC, have been involved in government-led space development as prime contractors. As they gained business capabilities in civil space, they also expanded their business into the commercial space. For instance, Mitsubishi Heavy Industries is the launch service provider for the H-IIA/B launchers while Mitsubishi Electric offers a variety of communications satellites in the global market. In addition, IHI Aerospace, a subsidiary of IHI, has founded SpaceOne, a joint venture currently working to develop a dedicated launcher for small satellites.

Large companies in a wide range of terrestrial industries, such as the telecommunications, automation, trading and construction, have shown a great interest in space. Their investment motive in the space industry can be roughly divided into three categories: frontier spirit, advance investment in new business, and enhancement of current business. First, space development is considered as an iconic display of frontier spirit. It raises the engineers' motivation to work on technological innovation, and represents a cutting-edge corporate image to the public. Second, the space industry is an emerging attractive investment target. The global space industry is expected to be a 'hundred-trillion-yen' market in 2040.[29] Large companies are making advance investments in space business, anticipating that it is both a growth opportunity and a threat to their current businesses. Third, space technology contributes to enhancing current business. Communications, remote sensing, and navigation satellites can be utilized as enablers to create a myriad of different types of values such as mobility automation and robotics, geo-intelligence, ubiquitous connectivity, etc.

[27] Approx. 2.5 billion EUR.
[28] Approx. 83 million EUR.
[29] This is a reference to United States Secretary of Commerce Wilbur Ross's catchphrase of "trillion-dollar economy" (USD 1 ~ JPY 100).

1.2.2 Emerging actors: New Space start-ups

There are more than 50 start-ups in Japan that are engaged in a wide range of space businesses, such as small satellite development, data analytics, small rockets, space debris removal, space mining, and artificial shooting stars. The number of space start-ups has doubled since 2015, encouraged by increasing social awareness and government activities to support the private sector. A list of existing Japanese New Space start-up, compiled by the SPACETIDE Foundation, can be find in Appendix.

The Japanese government has been implementing a variety of measures to energize and accelerate space activities in the private sector. JAXA, the Japanese space agency, strongly supports the private sector. It is conducting an open innovation program called J-SPARC, with the aim of partnering with private companies to generate new applications and build a strong ecosystem. JAXA is also promoting the utilization of the Japanese Experiment Module on the International Space Station. [30]

1.2.3 Non-profit organisations and industry associations

A variety of NPOs and professional firms are engaged in cross-industrial activities in Japan. The SPACETIDE Foundation (which the author founded) is a neutral hub for new space business. It holds the largest space business conference in Japan, which has gathered around 500-600 people every year since 2015, and also publishes semi-annual trend reports, called Compass. [31] Likewise, other NPOs and industrial associations are exploring new space-related markets such as Space Port Japan (space tourism), Frontier business working group (lunar development), and Space Food Sphere (space foods).

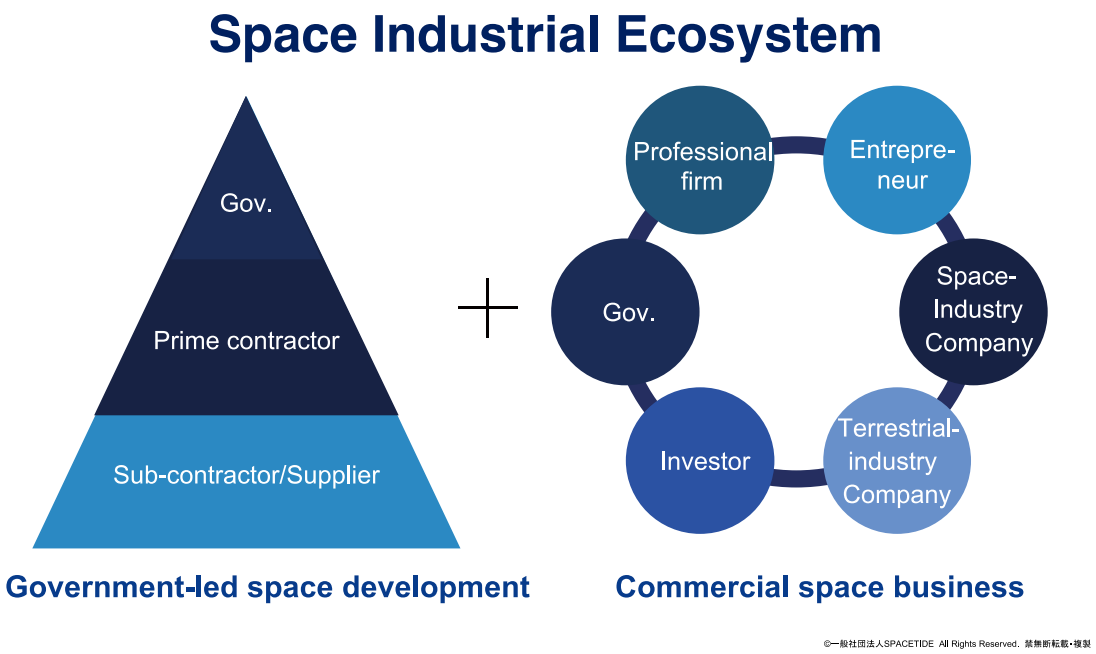


Figure 1-3. Space Industrial Ecosystem

[30] For a detailed account of the Japanese government's initiatives to support the emergence of a domestic space commercial industry, cf. Kazuto Suzuki, "Analysis of Japanese policies and tools to support commercial space", next contribution of this report.
[31] The SPACETIDE Foundation's Compass reports are available at https://spacetide.jp/en/whatwedo#compass.

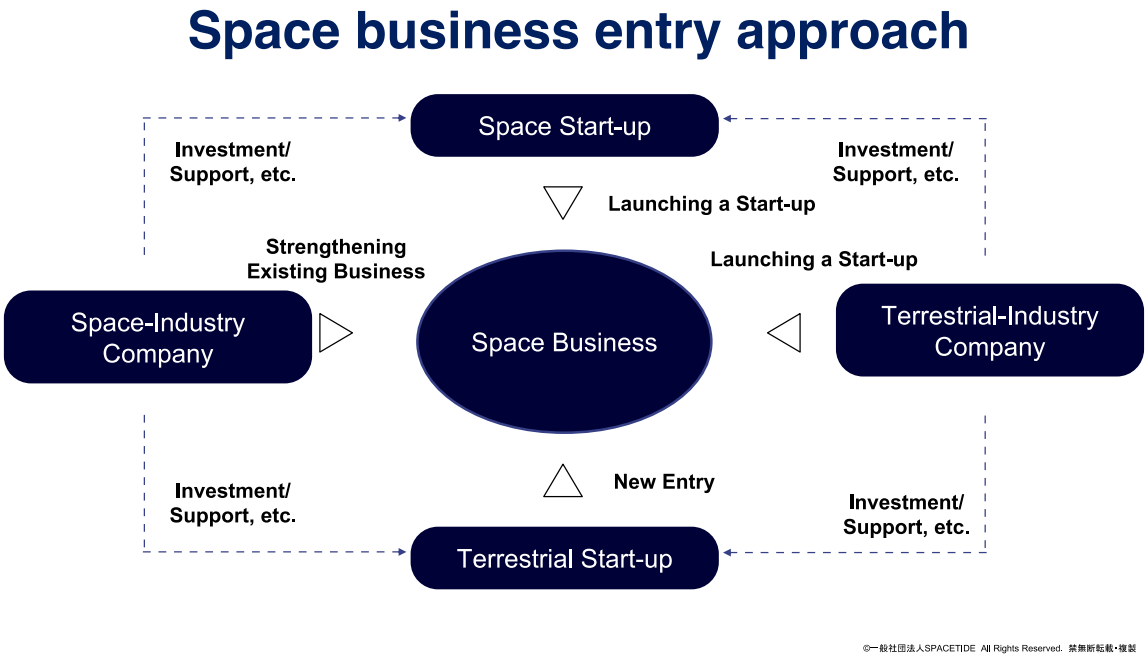


Figure 1-4. Space Business Entry Approach

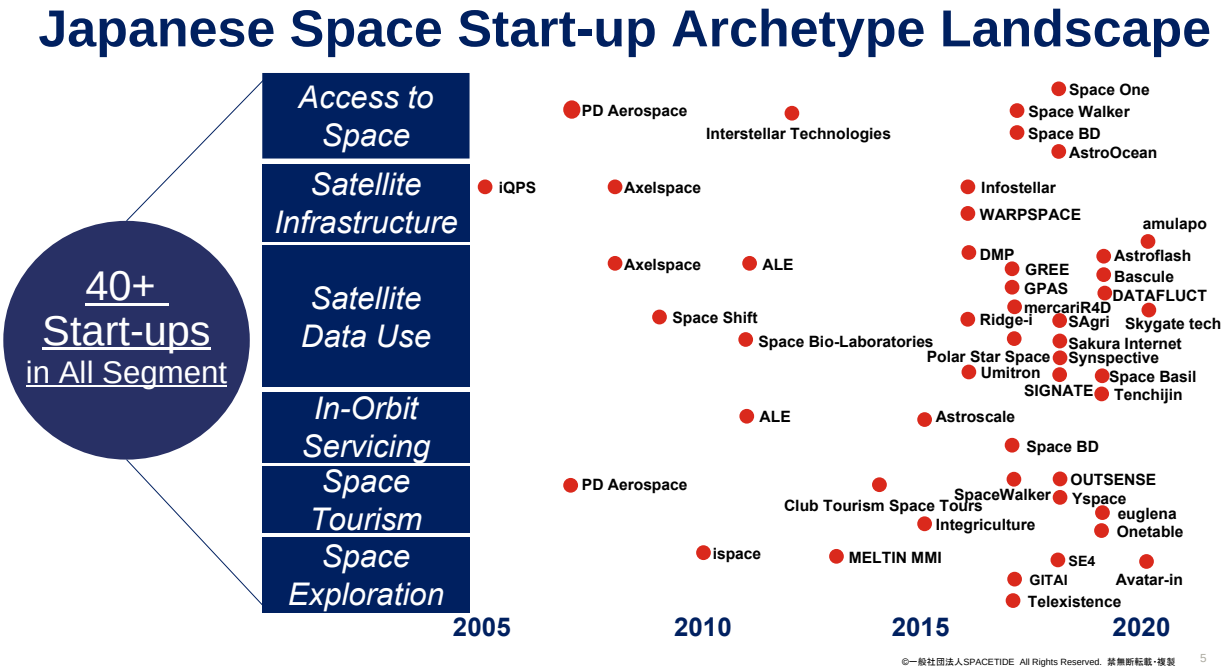


Figure 1-5. Japanese Space Start-up Archetype Landscape

1.3 Business segments

Current space businesses in Japan can be categorized into 6 segments: launch services, satellite deployment and infrastructure development, satellite applications, on-orbit services, space tourism, and space exploration and mining (figure 1-6).

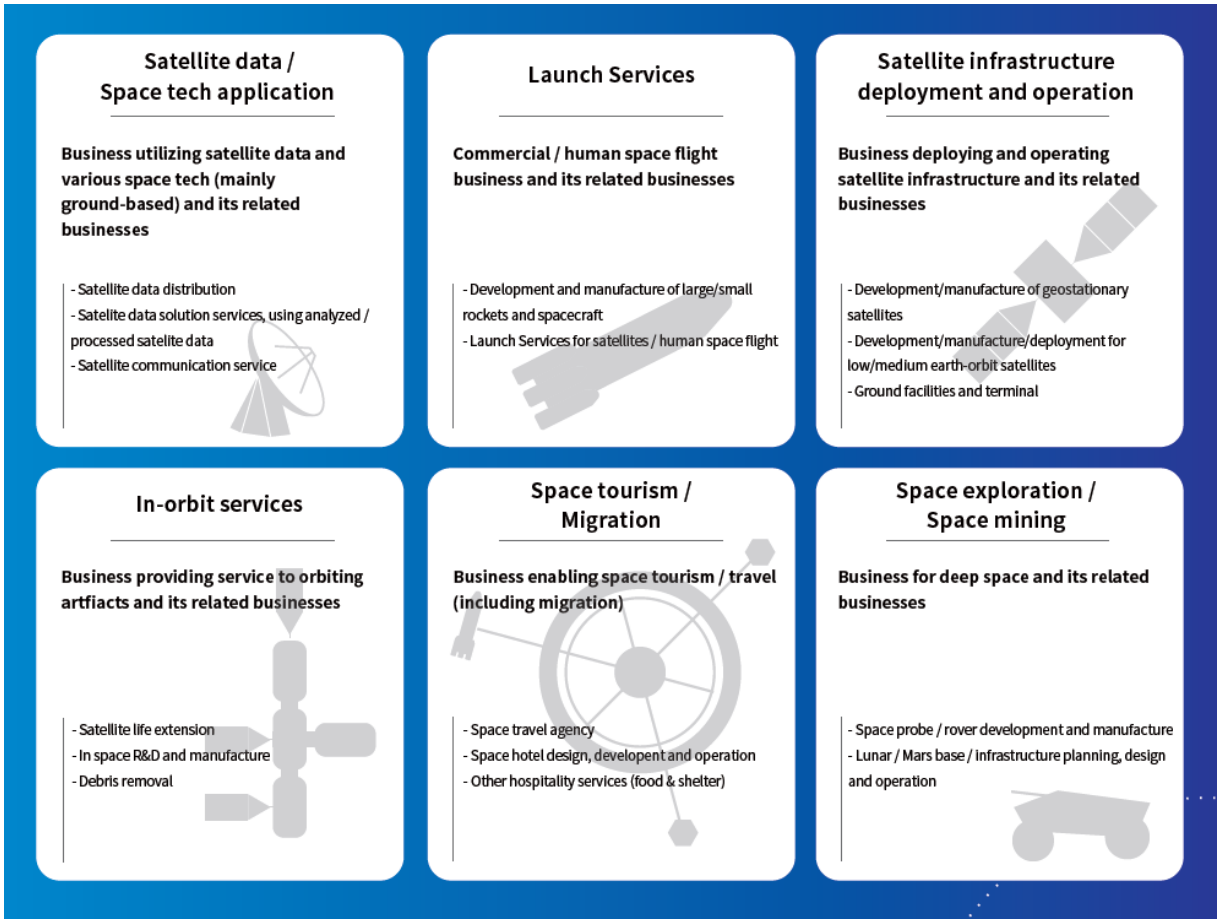


Figure 1-6. Space Business Segments

1.3.1 Launch services

Mitsubishi Heavy Industries is now commercially operating large-size rockets H-IIA/B, developed as part of a government-led space programme, while IHI is operating the mid-size rocket Epsilon. Meanwhile, to address the increasing demand for small satellite launches, start-ups such as SpaceOne and Interstellar Technologies are developing small dedicated launchers. Notably, Interstellar Technologies' MOMO sounding rocket no. 3 reached an altitude of 113 km for during a flight test in May 2019 (only successful attempt among five from 2017 to 2020).

1.3.2 Satellite deployment and infrastructure development

Remote sensing. Although satellite development for the government is mainly conducted by Mitsubishi Electric and NEC, start-ups have begun building small satellite constellations in recent years. Axelspace is working on optical satellite constellations, and Synspective and QPS on radar satellite constellations. Also, ALE is working on the world's first artificial shooting stars with a free flyer satellite.

Communication. In Asia, SKY Perfect JSAT is the largest satellite communication and broadcasting operator. But in recent years, IT companies have also accelerated market entry. Softbank has invested in Skylo, an IoT satellite start-up, and Rakuten has invested in AST & Science, a low-orbit communication satellite start-up.

Navigation. The government is leading the deployment of the Quasi-Zenith Satellite System (QZSS), which has already begun operating four satellites and plans to expand to seven satellites by 2024.

1.3.3 Satellite applications

Under the governmental policy to provide Earth observation satellite data to the public, Tellus, the first satellite data platform in Japan, is being constructed through public-private partnership by SAKURA internet Inc. At the same time, the government is promoting its use through data contests and e-learning.

The deployment of the first Quasi-Zenith satellites has enabled a wide variety of uses of high-precision position information, such as for automation of agricultural machines or snow removal machines, drone delivery and observation, and high-precision map creation for autonomous vehicles.

Additionally, "Space Biz for the SDGs" (which the author founded as a member of the committee on national space policy) was launched as a public-private initiative to solve socio-economic issues on the ground through space business. Fifteen industry players are involved in this initiative and the Cabinet Office supports it. Discussions are ongoing on leveraging various space technologies such as satellite data, satellite communication, robots and space food technology.

1.3.4 On-orbit services

Japanese start-ups and large companies are making efforts, especially in space debris removal technology. In particular, Astroscale has raised over USD 100 million so far,[32] and is leading the field as a global start-up company. Commercial services around the Japanese Experiment Module on the International Space Station are also being developed. JAXA is partnering with several private companies to develop different kinds of services: SpaceBD for satellite deployment services, Bascule and SKY Perfect JSAT to launch the first livestreaming studio in space, avatar-in and GITAI to demonstrate robotics technology, etc.

1.3.5 Space tourism

Space tourism is a totally new market that is being driven forward by new players. Start-ups, such as SPACE WALKER and PD AeroSpace, are developing future crewed spacecrafts. Club Tourism, a travel agency in Japan, is the distributor for Virgin Galactic's space travel business. Regarding space travel infrastructure, Space Port Japan, a general incorporated association, is working together with local governments to open Asia's first spaceport in Japan.

1.3.6 Space exploration/space mining

The Japanese government announced that it will participate in the Artemis programme through JAXA. At the same time, the private sector has joined in on space exploration. For example, automobile giant Toyota is partnering with JAXA to develop a crewed pressurized rover for future lunar exploration.

A start-up, ispace, has developed its own lunar lander and rover and works on a future cargo transportation service to the Moon. Furthermore, companies from the food and chemical industries are

[32] Approx. 85 million EUR

participating in SPACE FOODSPHERE Association, aiming to build a resource and energy recycling system to sustain permanent human settlements on the Moon.

1.4 Levels and sources of investments

In the *Space Industry Vision 2030*, published in 2017, the government of Japan set forth a policy to stimulate new investments in the space industry. Later in 2018, Prime Minister Shinzo Abe announced that the government and the private sector would make a total of JPY 100 billion of investment over the next 5 years.[33] In fact, over the past 5 years, Japanese space start-ups have raised JPY 50 billion in total,[34] and some companies have even raised more than JPY 10 billion individually.[35] The increasing amount of funding and investment in the space industry has encouraged start-ups to venture into space businesses.

1.4.1 Japanese investors profiles

Japan's investors profiles are unique compared to other countries. Globally, the main investors are private venture capital and angel investors, whereas in Japan, they are governmental funds and corporations (figure 1-7).

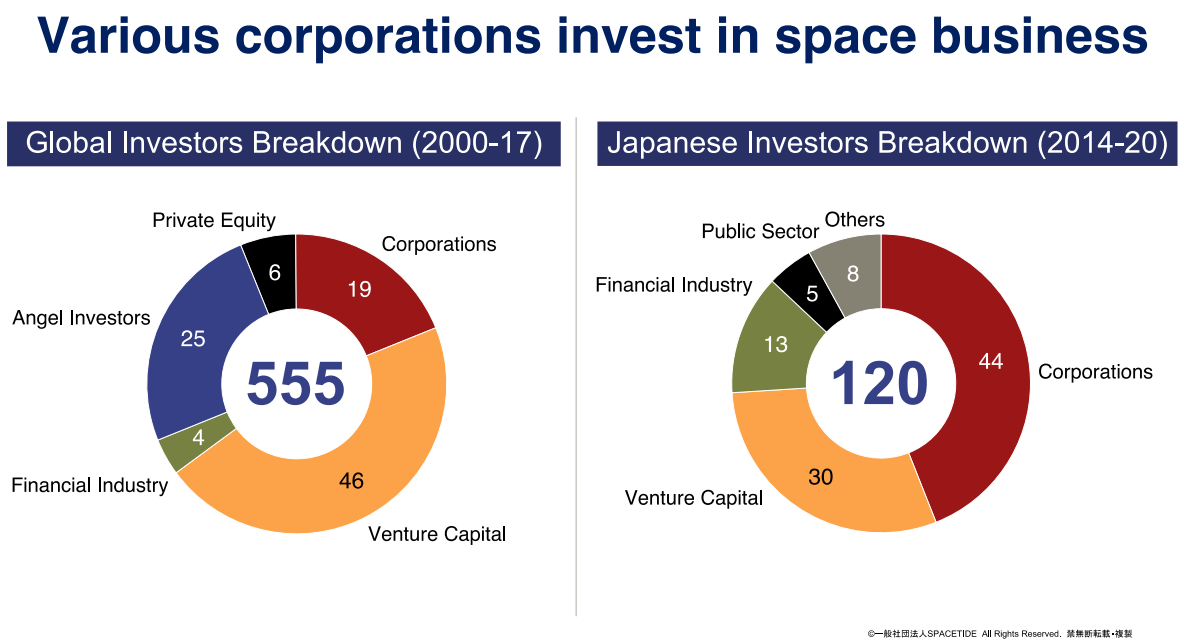


Figure 1-7. Various corporations invest in space business

Investors who can provide long-term support are essential for space businesses, which generally require a long payback period. In Japan, two government funds play this role: the Innovation Network Corporation of Japan (INCJ) and the Development Bank of Japan (DBJ). The INCJ has invested in ispace (lunar surface exploration), Astroscale (debris removal) and QPS (radar satellites), and the DBJ has invested in SpaceOne (small rockets).

[33] Approx. 830 billion EUR.
[34] Approx. 415 billion EUR.
[35] Approx. 83 billion EUR.

In addition, investment from the private sector is increasing as well. In the last two years, multi-billion-yen-scale funds specializing in space business have been launched, such as the Space Tech Fund managed by aStart and the Space Frontier Fund managed by Sparks Innovation for Future. The amount of investments in the space industry continues to increase year by year and reached JPY 65 billion in total over the past 5 years,[36] driven by both the public and private sectors (figure 1-8).

In terms of the number of investments, companies from other industries (e.g. automotive, telecommunications, airlines and trading) account for the largest share and are investing in domestic and foreign space start-ups. The space industry in Japan is quite distinctive because of its diverse investors community.

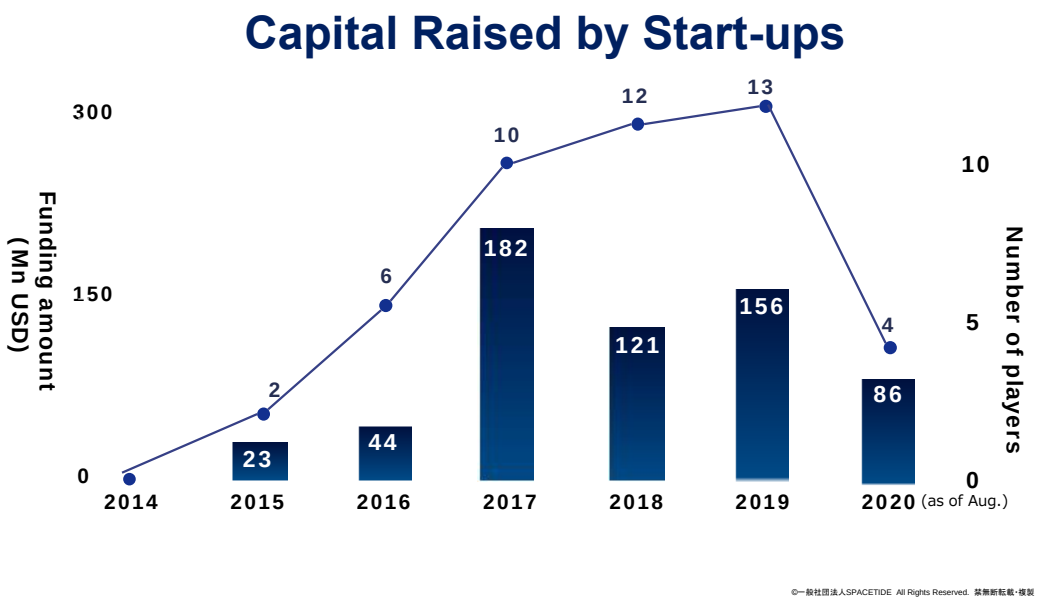


Figure 1-8. Capital Raised by Start-ups (2014-2020)

1.4.2 Breakdown by business segment

Regarding the total investment amount, satellite data and space technology applications are the largest segment, followed by space exploration, space mining and on-orbit services. Investments in launch services, satellite deployment and operation and space tourism are relatively small. Regardless of the size of the investment, the numbers of start-ups and investors differ in each segment, as does the type of investors (figure 1-9).

[36] Approx. 540 million EUR.

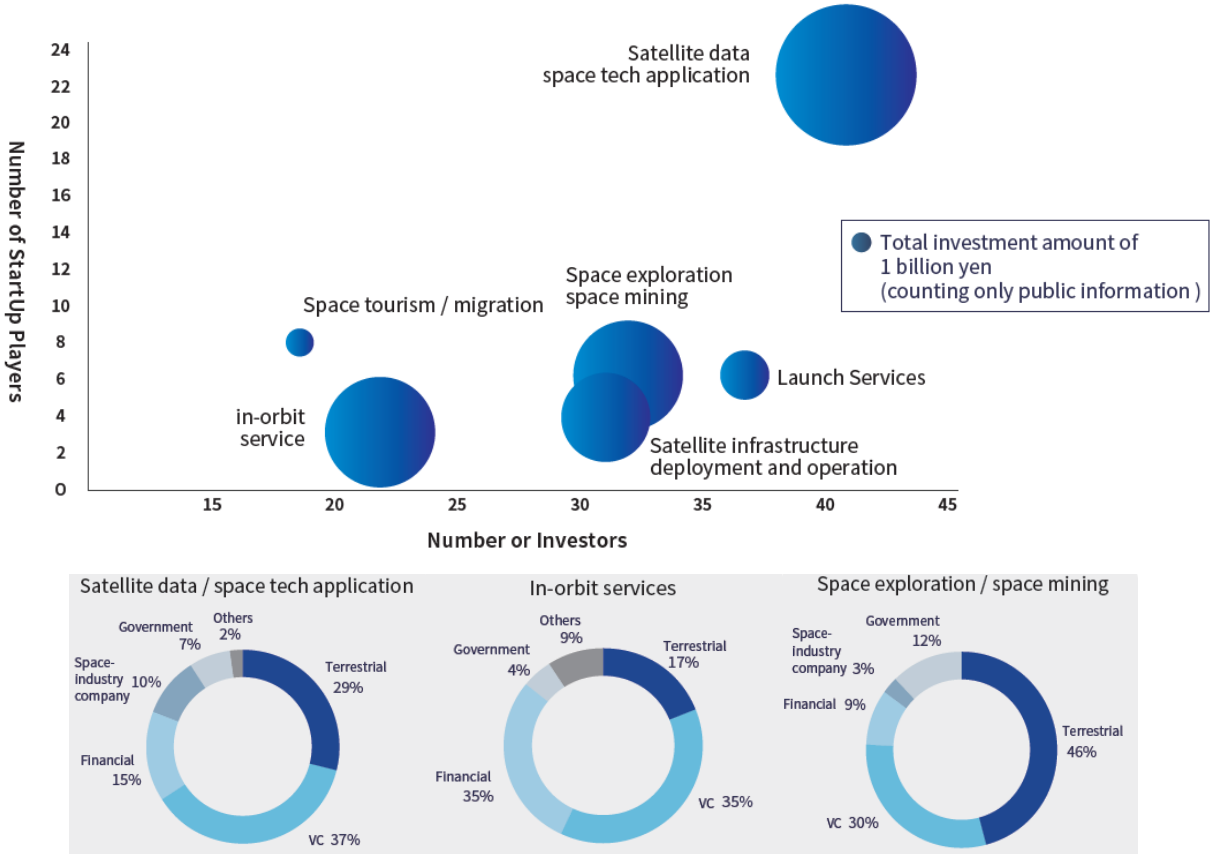


Figure 1-9. Investors profiles per business segment

Satellite applications. Satellite applications attract investments from all types, including VCs, non-aerospace corporations, financial firms and aerospace companies. This is a reflection of robust applications of satellite data, which makes it easier for investors to anticipate a return on their investments. In other words, investors are aiming at values that space technologies bring to augment their current businesses.

On-orbit services. On-orbit services such as debris removal are dedicated to the use in outer space, and terrestrial companies can hardly anticipate a synergy with their own businesses. Consequently, investments in on-orbit services are made mainly by professional financial services, such as VC and banks.

Space exploration and space mining. Investments in space exploration and space mining from non-aerospace companies account for about half of the total amount. Most start-ups in this segment, such as ispace, are working on lunar exploration and cargo transportation that will be realized in near future. Non-aerospace companies are interested in long-term business opportunities in telecommunications, energy and living infrastructures for future permanent human lunar settlements. In addition, they value enhancement in their public perception such as having a frontier spirit by associating themselves with space exploration.

1.5 Conclusion: strengths and weaknesses of the Japanese commercial space ecosystem

1.5.1 Strengths

A 50-year-long history of space development has brought world-leading space technologies to Japan. These strengths are not limited to rocket and satellite technologies, but also the Japanese Experiment Module on the International Space Station and the robotic spacecraft Hayabusa, to name the most prominent. This comprehensive technological foundation is the key factor behind multidisciplinary space start-ups and space businesses in Japan.

Strong interest in the space community from companies from a variety of non-aerospace industries is another strength. These companies not only invest in space business, but also bring new technologies and human resources to the space industry; they have great potential to become business operators themselves or customers in the future.

Furthermore, both the government and private organizations are supporting the growth and expansion of new space businesses. The government has implemented numerous policies to accelerate activities in the space industry since 2015, and several organizations in the private sector have emerged, including the SPACETIDE Foundation (which the author presides).

1.5.2 Weaknesses and opportunities for improvement

In the US and Europe, the role of the government has been evolving. Although the traditional approach is to create government owned and operated systems, working in a government/contractor relationship with the industry, the government is now implementing a different approach where they serve as a lead investor and customer of services which the private industry creates. This is the starting point of a virtuous cycle that stimulates private demand and promotes further investment. However, in Japan, although the government has been implementing a variety of measures to energize and accelerate space activities in the private sector, governmental service procurement from industry is not often the case, due to the traditional system and the limited budget. The role of the government is expected to evolve in the future to partner with industry to build a stronger ecosystem.

International market penetration and customer development are another challenge. Because the domestic market is not as large as other markets like the American and European ones. While aerospace development was historically dominated by a limited number of countries, the market has opened up for businesses from more countries. It is imperative for Japanese players to develop business internationally and build global partnerships. Some major Japanese companies and start-up companies have already started these activities, but it is necessary to further strengthen them in the future.

Since most commercial space businesses are still emerging, regulations and guidelines need to be established, as technology matures. New private companies have been entering the space industry at an accelerated pace recently and the number of stakeholders is increasing rapidly as well. It is important that we make an effort to build a common understanding on the current state of affairs and the wide variety of stakeholders will have to act harmoniously with one another to achieve progress for the whole industry.

2 Public policies to support commercial space in Japan

By Kazuto Suzuki, Professor, Graduate School of Public Policy, University of Tokyo

2.1 Drivers to support the space industry and commercial space

Traditionally, Japanese space policy paid little attention to commercial space. Its primary objective was to develop technological capabilities that were missing in comparison to the United States or Soviet Union. In this regard, Japanese commercial and industrial space policy was driven by the government, and its industry became accustomed to seeking governmental projects instead of finding opportunities to exploit commercial market.

However, the success of technological achievements, such as participating in the International Space Station programme and the failure to capture global market share have led the Japanese government to realize that it needed to change the course of its space policy. Thus, in 2008, three political parties – the ruling Liberal Democratic Party and its partner, Komeito, as well as the Democratic Party of Japan, the largest opposition party – collectively submitted a draft bill on space policy, aiming to change its commercial and industrial policy for space. The Basic Space Law, adopted in 2008, underscores the importance of governmental role in space industrial policy. It identified that the government had invested in developing space technologies, but that technology alone could not improve international competitiveness, and therefore, that the government needed to spend money on using space applications to demonstrate the capabilities of the Japanese space industry. In this understanding, the Japanese government has launched several projects including the Quasi-Zenith Satellite System (QZSS), a regional positioning, navigation and timing (PNT) satellite system.

The emergence of small satellite constellation businesses in recent years has made the Japanese government, again, realize that this is a new game changer, not only about business models but also regarding applications for security-related space activities. The dominance of new space ventures, such as SpaceX in the launch market and Planet Labs in the Earth observation data market, further pressured the Japanese government to develop measures to encourage Japanese engineers and managers to involve in the commercial space market and Japanese investors to invest.

The Basic Space Law defines the role of the government in commercial activities in its Article 16. It says that the government should promote private space development and utilization activities and improve their international competitiveness. The government will take financial and taxational measures to encourage investors, and it will actively engage in procuring goods and services provided by the private industry. The key issue in Article 16 is that the government will take so-called “anchor tenancy” measures. There are so many risks for private enterprises to develop new technology and launch commercial services, especially in a business environment like in Japan where investors are conservative and business owners are not willing to take chances to launch new businesses. The purpose of Article 16 is that the government will provide an “anchor” for those new businesses, so that the risk of launching a business will be much lower. The investors will have confidence in those new business since there is a chance that the government will procure such goods and services.

However, the market was moving faster than the Basic Space Law has expected. The emergence of constellations of small satellites has changed not only the way in which the industry provides services but also the way in which satellites are developed and manufactured. Japanese traditional space companies, such as Mitsubishi Electric Corporation (MELCO) and NEC, faced a big challenge on whether

to invest in production for such new business models. Companies producing launchers, such as Mitsubishi Heavy Industries (MHI) or IHI, had to compete with market giants like SpaceX while there are number of companies developing smaller launchers. The Japanese government has to move on to form a new policy to encourage investors to invest in new start-ups to make sure that they would take the risks for exploring new market and competing with foreign competitors.

The reason why "anchor tenancy" was not sufficient to foster commercial space actors was that the size of governmental demand was too small to make the industry sustainable following traditional procurement practices. Although the Japanese space budget was constant under low inflation, the size of the space market, especially the commercial one, is getting much bigger. The Japanese industry failed to capture this market without significant investment in commercial ventures. Thus, the government has to launch new initiatives to encourage young generation of engineers to launch start-ups and investors to support them.

2.2 Objectives the country aims to fulfil

The first objective is to build internationally competitive start-ups. From the Japanese government's point of view, the weakness of Japanese commercial space activities comes from the lack of funding for start-ups and the lack of innovative leadership. Traditionally, the Japanese economy was driven by the leadership of the government, largely because of the modernization process started in the late 19th century. As a late modernizer, Japan's major objective for its industrial policy was to catch up with advanced industrialized countries. Japan has learned from Europe and United States to develop technologies and industries. Especially, space technology and industry were built in the concept of catching up. The government created NASDA (National Space Development Agency, currently integrated in JAXA) to distribute government funding to build up an industry capable of meeting international standards. NASDA has also learned from the model of NASA for its industrial policy.

What is interesting in this regard is that many countries experienced similar government-led industrial development but were also able to let the private industry take over the role of the government. In Japan, this transformation did not happen. There are some private companies, such as Interstellar Technologies for small launcher or Axelspace for small satellite constellation, that emerged without government support, but their number is still very small. Such lack of dynamic forces of private companies is, in the views of the Japanese government, because of the risk-aversiveness of Japanese investors and innovators.

The second objective, closely linked to the first one, was the aim to explore the global market. The lesson that the Japanese space community has learned from its experience was that the focus on research and development (R&D) does not bring competitiveness. Since catching up was set as the prime objective of Japanese space policy, the government and its space agency have focused on investing in new technologies which would bring Japan to a similar technological level as the United States, Europe and the Soviet Union. This focus on R&D would eventually made the Japanese industry dependent on public funding and the political game rather than improving their competitiveness. Also, R&D programmes do not help improving the industry, either because new technologies are not flight proven, or that the cost of development is put on the price of the launcher and satellites.

Thus, in order to explore the global market and become internationally competitive, the Japanese industry needs to focus on applications. In many cases, Japanese satellites developed through public funding end up demonstrating new technologies but are not used for applications. Although satellites like GOSAT or ALOS have missions to monitor environment and land use, they are technically defined as R&D satellites and Japanese industries were not able to capitalize on the outcome of these programmes. In other words,

those satellites were not designed and developed for companies to build their industrial capabilities through them.

In this way, the third objective of the commercial space policy is to encourage government agencies to develop application programmes to use space data in support of their policy practices. For example, the Ministry of Agriculture is encouraged to use satellite data to monitor crops in the field and use it for market regulation, or the Ministry of Land, Infrastructure and Transportation would use QZSS signal for traffic control. It would probably sound strange in other spacefaring nations because it is common sense to use satellites for these purposes, but in Japan, such public use of space capabilities was not encouraged for some reasons: 1) satellites were designed for R&D purposes so they are not particularly easy to use for the users; 2) user ministries were not interested in investing in space technologies which may take away their budget; 3) user ministries were not encouraged to improve their efficiency for implementing policies since it may impact the employment of their staff; and 4) the Diet resolution on the use of space for exclusively peaceful purposes in 1969 practically prohibited the Ministry of Defence to invest, own, operate and use space systems. Even though the Basic Space Law of 2008 has lifted the ban on the use of space for military purposes, institutional inertia remained strong.

The idea for commercial space, therefore, is based on the assumption that the government would become the first customer, to develop international competitiveness through application programmes. This is not only for the traditional space industry but also for new space players. The role of government in commercial space policy is extremely important in this regard.

2.3 Tools to Achieve the Objectives

There are numerous policy initiatives to foster a vibrant commercial space ecosystem in Japan. Some measures focus on encouraging investors to invest in new start-up companies such as "S-" series (S-Booster, S-Matching, S-Experts and S-Net) while other emphasize Japanese space technology exports or increased links between the industry and space and geospatial government agencies.

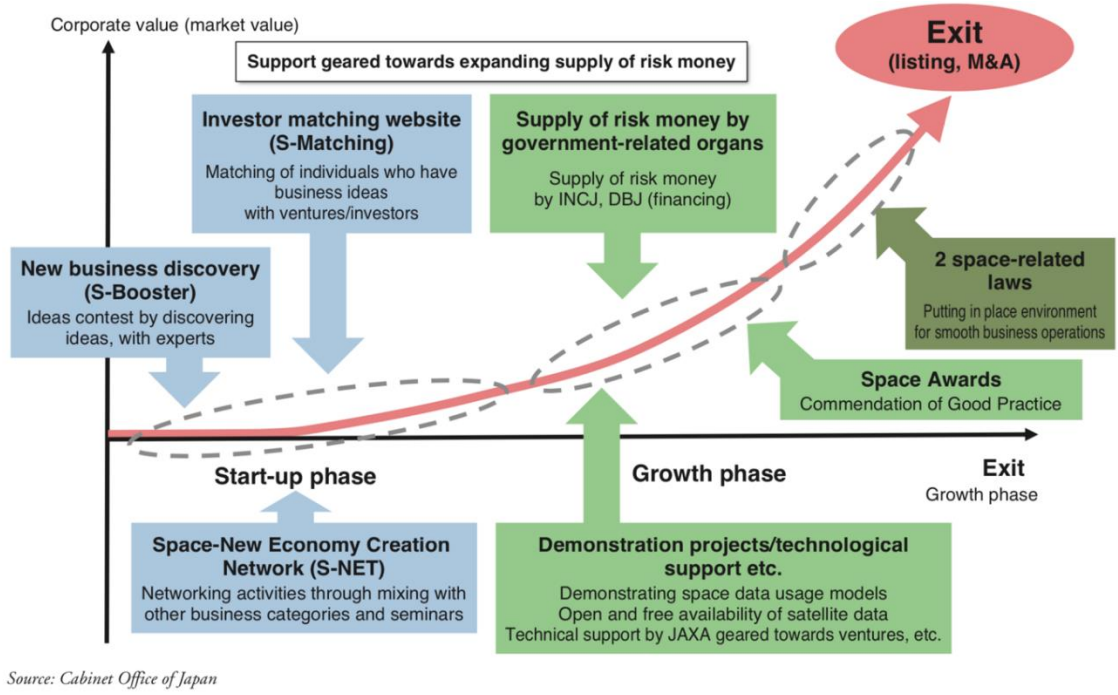


Figure 2-1: Tools to Support New Space in Japan (credit: Cabinet Office of Japan)

2.3.1 S-Booster

The first one, called S-Booster, invites companies and individuals to pitch space-based business ideas and facilitates these ideas' realization by providing financial support, business coaching and other services. S-Booster commenced in 2017 and is held annually, although there was no opening in 2020 due to the COVID-19 pandemic. There is a number of business idea contests in the world – for example, ESA conducts the "Space Business Idea[37]" contest with prize money – but the uniqueness of this Japanese contest is that it provides prize money as financial package for winning idea, as well as business consultancy for free. There are several "mentors" who have experience in start-up businesses in non-space industry, who provide valuable advice for those who are willing to realize their ideas into a business. In fact, the short-listed candidates have to consult with mentors and to revise their ideas before applying for the final selection.

This uniqueness comes out of a particular Japanese investment environment. As discussed above, there is limited enthusiasm among investors to take high risk in space start-ups. In addition, start-ups with engineering ideas often do not have fundraising know-how. Thus, the idea of matching them with consultants with fundraising experience is crucial to transform those ideas into a real business.

Another uniqueness of this programme is that it is open not only to Japanese companies and individuals but also to applicants from Asia-Pacific countries. This attempt started from the idea that Japanese space assets should be used not only by Japanese service providers but also by providers in Asia. The winners of the Tokyo final of the 2019 "S-Booster in Asia" were overwhelmingly Japanese[38], but there were many candidates who applied from various places in Asia and competed in the first round which took place in Thailand.

The idea of S-Booster in Asia was to enhance the user base of Japanese space assets. Applicants from Asia should include either one of these themes: a) Quasi-Zenith Satellite Systems (Japanese Positioning/Navigation/Timing satellites); b) new business idea using Japanese space assets with Japanese companies; or c) business ideas for collaborating with Japanese companies. This attempt demonstrates the direction of the Japanese space industrial policy. On the one hand, the government is trying to promote a wider use of Japanese space assets and to build industrial networks with other Asian countries. But on the other hand, it shows that Japan will take the leadership in the commercial space activities in Asia. Given the emergence of China as an influential spacefaring nation in Asia by providing various services to Asian countries in the context of the "Belt and Road Initiatives (BRI)", the Japanese government needed to do something to counter such initiatives. S-Booster in Asia was one of the tools for the government to compete for the leadership in the region.

2.3.2 S-Matching

The other policy tool to achieve the government's objectives is S-Matching[39]. S-Matching is a platform to connect investors willing to invest in space activities with entrepreneurs having ideas for starting new business in space. The government set up such a platform because there are many entrepreneurs with engineering background and without a network including finance people. This platform provides an easy access to investors to find attractive space business ideas, which entrepreneurs would present in more business-oriented, instead of technology-oriented, forms. As of October 2020, there are 387 entrepreneurs and 61 investors registered on this platform. The entrepreneurs have already posted 167 new business ideas on this platform, but it is not disclosed how many of these are matched with investors. Nevertheless,

[37] https://business.esa.int/news/space-moves-business-idea-competition
[38] https://s-booster.jp/en/2019/final/index.html
[39] https://s-matching.jp/

it is extremely important to have such platform to make sure that new start-ups would easily find a network of investors who are interested in space business.

2.3.3 S-Experts

In addition to S-Matching, there is another matching platform for technical experts for new start-ups, called "S-Experts". This is a designated site for experts having experience in engineering, material sciences, and space-related businesses and for start-ups which want to expand their businesses and solve problems affecting their programmes. The government outsources this platform to the private human resources industry to facilitate building networks of experts and companies. The idea behind this platform is that many start-ups tend to carry on their projects with founding members, which eventually limits their business scopes and opportunities. Experts who may have experience in JAXA programmes or other commercial activities in space may provide critical expertise to overcome glitches in the start-ups' programmes or to find new customers. Many of those start-ups are coming out of university laboratories or small groups in engineering companies, so that they often lack experience of complex business cases. S-Experts is another policy tool set up by the government to help new ventures penetrate the global market.

2.3.4 S-Net

The fourth and final policy tool is called "S-Net". Unlike other "S-" initiatives, S-Net provides direct contact with government officials and entrepreneurs, local governments interested in hosting new start-ups, and other industries interested in linking up with space activities. The Cabinet Office encourages prefectural governments to hold seminars and conferences to build networks of local businesses and local start-ups. Number of prefectures such as Hokkaido, Fukui and Kagoshima are building solid local networks among their local industries such as the precision machining industry or the electronic industry. These prefectures use this opportunity to revitalize local small and medium sized enterprises (SMEs). For example, Hokkaido developed its own networks of industry actors, centred around Interstellar Technologies, a start-up building small launchers. There are numerous SMEs in the metal processing industry or machine tool manufacturers involved in this network for providing parts and components for Interstellar Technologies. S-Net also provides consultancy work for any space-related question for SMEs interested in space activities. Those are not only limited to manufacturers but also open to service providers. For example, a nursing service company for disabled people contacted the government to use space data to find optimum routes for wheelchairs. S-Net provides assistance for those who may have any ideas from non-space companies. Furthermore, S-Net puts up several successful cases of start-ups as best practices and role models for new entrants in the space business. Those cases include using space data to estimate the amount of melted snow water and design drainage for local governments, to provide virtual space trips with high altitude balloons or to use earth observation data to build 3D models of landscape. Some of those activities come out of the S-Booster idea contest and are funded through S-Matching.

2.3.5 J-SPARC

Along with the government (mostly Cabinet Office) initiatives, JAXA is also transforming itself to meet the challenges of the commercialisation of space. Traditionally, JAXA defined itself as an R&D agency, so that it showed limited interest in commercial and industrial activities. However, given the changes which took place in NASA and ESA, and with the pressure from the government, JAXA established the Business Development and Industrial Relations Department to encourage private businesses to work together with JAXA. The policy tool developed by JAXA is J-SPARC (JAXA Space Innovation through Partnership and Co-operation). This framework allows industry to propose new ideas and to collaborate with JAXA by using JAXA's facilities and funding for joint project as well as helping marketing. If the industry has plans

to build up its business but lacks test opportunities, then JAXA can use this framework to support the industry in the operationalisation of those plans. JAXA also supports the industry to find appropriate funding agencies such as the Development Bank of Japan (DBJ) or the Innovation Network Corporation of Japan (INCJ). J-SPARC is transforming the relationship between JAXA and the industry, which used to be a "contract giver-taker" relationship, into a more equal partnership.

2.3.6 Task Force on Space System Overseas Development

Given the weakness of Japanese spacecraft exports, the government decided to set up a task force to support the marketing and sales of Japanese space products in 2015, at the Cabinet Office's National Space Policy Secretariat. The mission of the Task Force on Space System Overseas Development is to support industry to sell their products by using government networks. Embassies and bilateral relationship as well as Official Development Aid (ODA) are the tools for the task force to support commercial sales. Traditionally, diplomacy and foreign policy were considered to be different from commercial activities, so that the Ministry of Foreign Affairs is not heavily involved in such commercial processes. However, the government launched an initiative for "exporting infrastructure" in the early 2000s in competition with the Chinese Belt and Road Initiative (BRI). The Task Force was set up in this context, so its aim is to support commercial exports to strategically important countries in particular. There are numerous successful cases, such as exporting synthetic-aperture radar (SAR) satellites to Vietnam and small satellites to Egypt and other developing countries. The government offers not only financial support through ODA but also administrative and academic support by inviting students to study space engineering in Japan.

2.3.7 Tellus

Inspired by the European Union's Copernicus programme and some commercial activities such as Google Earth, the Ministry of Economy, Industry and Trade (METI) launched an initiative to allow open and free access to Earth observation data. The prototype of Tellus began in 2019 and plan to be fully operational in 2021. The idea of Tellus is to foster data market and industry using space data. Traditionally, Earth observation data was distributed through government agencies such as the Remote Sensing Technology Center of Japan (RESTEC) or the Earth Remote Sensing Data Analysis Center (ERSDAC, now part of Japan Space Systems) with a strong focus on academic use. Since Japanese Earth observation satellites are designed to be engineering testing or R&D satellites, the images they take are not fully fit for commercial needs. The Japanese data industry tends to use commercially available data instead of buying from RESTEC or ERSDAC. The launch of Tellus is to turn this trend around and encourage the data industry to use data from Japanese satellites. Tellus is operated by a commercial operator, Sakura Internet, to strengthen the link between the data industry and Tellus's services. The ultimate aim of Tellus is to encourage the Japanese data industry to provide much wider services such as tourism or marketing, and that eventually such demand for data would be reflected in the development of more market-oriented Earth observation satellites.

2.4 Assessment of the strengths and weaknesses of these initiatives

Traditionally, the Japanese space industrial policy was based on the concept of "contract-giving", where a government agency, JAXA, chooses competent companies and provides contracts to them to develop their space capabilities. Many of these industrial actors collaborate with US and European industries to learn know-how and technical competence, from their experience. This was the shortcut to realize the "catch-up" strategy. In this space industrial strategy, it was the government which planned and executed

technical programme that may have improved Japanese industrial competitiveness. However, this mode of industrial policy became obsolete in the time of the new space industry.

Thus, the Japanese government, after the enactment of the Basic Space Law in 2008, transformed its policy principle from "contract-giving" to "network-centric" strategy. The government has now become the matchmaker between investors, entrepreneurs, local governments, users of space data, and space experts. The government recognized that the weakness of Japanese space industrial policy was not the lack of technical expertise but the lack of platform and opportunities for those space players to connect with one another and to build networks. Due to its education system, talented engineers tend to be isolated from social and economic activities while investors would have limited knowledge about science and technology that may provide breakthrough in new businesses. Thus, these new government initiatives to connect space players address this weakness and provide government support in networking.

The strength of this approach is that it does not require huge public investment. Building up platforms does not cost much and most of the risks will be taken by investors and entrepreneurs. The government plays the role of matchmaker without using too much funding. However, it also has a weakness. Since Japanese investors are strongly risk-averse, they may not find incentives to invest in space activities. Even though entrepreneurs brought up new ideas, investors may not fully engage in those activities. This is one of the reasons why there are not many Japanese new space start-ups competitive enough in the global market.

On top of that, there is a fundamental weakness in this approach, which is the lack of international dimension. Although S-Booster is opened to foreign applicants, very few remained in the final round due to the lack of international promotion for this initiative. The government has launched the "Task Force on Space System Overseas Development" and designated experienced individuals in international business, but the focus of this Task Force is mainly to promote large-scale projects such as launching the Mars orbiter of the United Arab Emirates. There is no coherence between what "S-" initiatives do and what the Task Force does. Only a few companies such as Astroscale, private active debris removal and on-orbit services company, have strong international presence and penetration in the global market.

However, these new industrial policy initiatives have just started, and there is a lot of opportunities to revise and improve them. Because of the COVID-19 pandemic, investments in space activities are not very active since major investors such as All Nippon Airways are struggling with their own businesses. Nevertheless, some start-ups were successful in raising funds such as Astroscale's Series-E. New space business ideas from S-Booster are gradually moving up from feasibility studies to actual business development. There are numerous venture companies using space data for applications. If the government continues these policy initiatives, it is likely to see more Japanese new space start-ups playing a significant role in the global market.

NEW SPACE IN CHINA

3 Commercial space ecosystem and trends in China

By Blaine Curcio, Founder, Orbital Gateway Consulting; Associate Senior Consultant, Euroconsult; Jean Deville, Founder, China Aerospace Blog; Co-founder, Dongfang Hour; and Chen Lan, Space Analyst, Go Taikonauts!

3.1 Introduction

"China will have [a] private company better than SpaceX sooner or later". This is how China Global Television Network (CGTN) reported the statements made by Professor Yang Yuguang from China Aerospace Science and Industry Corporation (CASIC) in July 2020[40]. Prof. Yang is one of the central figures behind the China (International) Commercial Aerospace Forum (CCAF), convening annually in Wuhan since 2015 and having become one of the main meeting places of China's commercial space sector.

The initial spark for the emergence of commercial space companies – what is commonly understood as "New Space" – was set by the Chinese government in 2014 in its document no. 60 "The State Council's Guidelines on Investment and Financing Mechanism Encouraging Social Investment in Innovation and Key Areas".[41] Since then, a dynamic commercial space ecosystem has emerged. As of 2020, it is unquestionably the world's second-largest country-level commercial space ecosystem by funds raised, and in some segments the largest (e.g., there are far more commercial launch companies with over U.S.$50M of funding in China than in any other country). However, it is an ecosystem that has not yet settled into maturity. A well-known commercial saying is that the first five years of a business are the most crucial for its survival. Yet, five years is not long, and particularly not for big endeavours. In fact, it is notoriously short for a complex industry such as space - even more so in a highly complex nation such as China.

This paper aims to shed light on the key features and unfolding trends shaping the commercial space ecosystem in China. It is written by a team of authors contributing their complementary expertise to the subject. This has made it possible to look at China's New Space ecosystem from a technical, financial, and socio-economic point of view. Likewise, each author is connected to a different part of the Chinese commercial space community and to a different expert network.

40 Guan Xin, and Jin Yang. "New Money: China's private space start-ups lift off." CGTN, 10 July 2020, https://news.cgtn.com/news/2020-07-10/New-Money-China-s-private-space-start-ups-lift-off-S0jCrO1Yzu/index.html. Accessed on 25 August 2020.

41 "国务院关于创新重点领域投融资机制鼓励社会投资的指导意见." *Official Website of the Government of the People's Republic of China,* 16 November 2014, http://www.gov.cn/zhengce/content/2014-11/26/content_9260.htm. Accessed 10 September 2020.

The team kicked off the work for the report by disentangling the scope of the analysis and seeking to define New Space in China and what the hallmarks of Chinese commercial space companies are[42]. By compiling a list of the known private space companies, collecting pivotal information about them, and discussing the findings, certain trends within this industry became apparent. Wanting to examine the Chinese New Space sector from their own perspective, the authors decided to illustrate China's New Space sector by explaining its trends.

Five major trends have been isolated:

- Government policies steer the development of commercial space
- Rapid growth of commercial space companies
- Growth and diversification of funding sources
- Integration of non-space companies and competition with incumbents
- Focus on incremental innovation and technological self-sufficiency

The specifics of those trends were worked out incrementally, involving several rounds of debate and cross referencing. The resulting content should give readers an overview of the potential of the commercial space sector in China and the ability to draw their own conclusions on the near future of "New Space in China".

3.2 Key Features and Trends of China's New Space

The lack of a commonly agreed definition of the term "New Space" makes it even harder to define "New Space in China". China's commercial space landscape is not comparable with other nations' New Space ecosystems, and especially with the U.S. One of the reasons is that private space companies in China emerged rather quickly, primarily as a consequence of the 2014 governmental deregulation of certain parts of the space industry, but also because of the initial success of the early companies[43]. But the most apparent reason is the different nature of China's economic system and the different role of the government therein.

For the purposes of this paper, the key features distinguishing New Space from what is commonly considered as "old space" are the following:

- Chinese New Space emerged mainly after 2014.
- Private capital enabled the foundation of companies.
- Diverse shareholder structure including private venture capitalists, private equity funds, provincial governments, municipalities, and university venture funds (which in China are quite large).
- New Space companies have to generate profits to keep the business running and to reinvest in the business.
- New Space creates jobs with competitive salaries and with generally faster and more meritocratic opportunities for advancement.
- The customers are only exceptionally from the government but mainly from the open market.

It must be stressed that in China the lines between commercial and non-commercial companies are and will remain blurred. This leads to the unfortunate situation where different sources report different figures on the number of commercial space companies. Another challenge with China's New Space is the limited

[42] Ground-breaking work in providing information on China's New Space was done in 2019 with the field study by IDA Science and Technology Policy Institute[42] and the 2019 Statement by Dr Namrata Goswami, and these works among many others have been consulted extensively during the course of this study[42].
[43] Some analysts talk about a "first wave" of companies, founded in 2014-2016, which was followed-up by a "second wave" founded in 2017-2020, with some analysts distinguishing a "third wave" from 2019-2020.

amount of information available. Also, some entrepreneurs prefer not to disclose information since the New Space sector benefits from the military-civil integration policy. In this regard, the distinction between civil and military also remains unclear. Other companies, for various reasons, prefer to operate in "stealth mode" be it because they are still in an early stage, or there is no obligation to disclose information to the public, or for the simple reason that transparency is not considered to be important. Finally, many start-ups may raise money through subsidiaries or affiliated companies, which makes tracking fundraising more difficult.

3.2.1 Government policies steer commercial space development

What distinguishes the economy "with Chinese characteristics" from the rest of the world is the strong and long-term strategic control of the economy by the state. "The mainstay status of public ownership and the leading role of the state-owned economy must not be altered" was a recent core statement by President Xi Jinping. The principle of the socialist market economy reform means that the socialist system as the foundation is combined with the market economy, to make the most out of those two principles.[44]

The Chinese State is ready to nurture State-Owned Enterprises (SOEs) and private players alike but keep control over indispensable infrastructure, frequency allocation, satellite operator licence, and launch permission. Space is no exception. Space blends well with Xi's signature initiative of the "China Dream" that embraces the "Space Dream" and the overarching mantra that innovation is the "primary driving force" to boost economic and social development, as reinforced by the President during a high-level science forum on 11 September 2020 in Beijing. He also encouraged universities and academic institutes to cooperate with companies that then could be recognised as high-tech companies and consequently benefit from preferential policies.[45]

While in other economies the state is also responsible for setting the frame conditions for entrepreneurial activities as well as setting incentives for preferred business areas, in China this stretches to the extent where the state controls which activities or businesses are allowed. It was the Chinese government with its 2014 directive, rather than entrepreneurial drive that made Chinese New Space possible (though entrepreneurial drive has certainly helped). The call by the government was quickly met with enthusiasm by a young generation of Chinese engineers. While the U.S. has accelerated the emergence of SpaceX with the COTS programme, a similar instrument is not yet to be seen in China. The Chinese way of promoting commercial space tends to put less emphasis on the economic viability and more on the contribution to the country's general development and infrastructure. At the Commercial Space Forum on 23 April 2019 within the National Space Day celebrations in Changsha, Wu Yanhua, Deputy Director of the China National Space Administration (CNSA), pointed out that commercial space companies can count on governmental support in creating a solid foundation for the healthy development of the sector. It is in the government's interest to improve its procurement processes for commercial aerospace products and services, modernize the government's current service models, guide more private capital towards the industry, and stimulate more public interest for space activities.[46]

The Chinese government's support to New Space is driven by a variety of objectives:

- Serve as an example of the governmental policy of reform and opening up.

[44] Xi Jinping, "Continuously Exploiting the New Realm of Contemporary Chinese Marxist Political Economy" *Qushi,* issue no 16, 16 August 2020.
[45] "Xi Focus: Xi stresses development of science, technology to meet significant national needs." *Xinhua News Agency*, 12 September 2020, http://www.xinhuanet.com/english/2020-09/12/c_139361891.htm. Accessed on 13 September 2020.
[46] Curcio, Blaine, and Myrrhe, Jacqueline. "China Space Day 2019 - A Retrospective." *GoTaikonauts!* issue no 25, June 2019, pp. 20-23, 2019.

- Keep pace with emerging global developments, most of all the rise of SpaceX and other commercial space players in the U.S.
- Promote the domestic high-technology sectors.
- Meet the growing national market demand through innovative, flexible, and fast-moving companies.
- Raise the overall efficiency and innovation potential of the space sector, lower the cost, and complement as well as challenge the SOEs.
- Enable and support mass entrepreneurship by building a new ecosystem with downstream space-based applications.
- Give private business the opportunity to access foreign markets some of which are becoming increasingly open to Chinese companies with the Belt-and-Road Initiative (BRI) and other governmental policies.
- Prepare for a modern society where terrestrial applications rely strongly on space-based assets and the integration of artificial intelligence (AI), Big Data, navigation, and where the mobility of goods and persons requires new solutions.
- Leverage the downstream sector to support climate action and decision-making, both economic and political, based on spatial data.

While a dedicated analysis of the strategic objectives and policy tools is provided in Ch. 4., it must be stressed that governmental policies have been playing a crucial role in steering the advancement of New Space. These include initiatives undertaken at both the central and provincial level. Indeed, whereas the framework for the development of New Space is defined by the Central Government, the implementation is left with the regional and provincial authorities. The latter take measures and decisions based on how space and high-tech accompanies their overall planning for economic development. Authorities at the provincial and municipal level provide substantial financial support, allocate land or even build facilities for commercial space start-ups.

Many local officials are convinced that the aerospace industry is having a positive impact on other parts of the economy (see Table 3-1). They understand the strategic importance of commercial aerospace which in turn is an emblematic indicator of the overall industrial strength of a region. Furthermore, disruptive technologies, regularly emerging from the aerospace sector, are leading other industries to develop new applications, known as cross-fertilising innovation. The intention is to diversify the existing economic base and implement the governmental directive for innovation and high-end production. Also, it is hoped that the active integration of resources will translate into more business opportunities and services. New Space attracts national and global talents and experts. It is hoped that this will have a reverse effect as well: bringing the development of New Space from a regional level to a global expansion. Provincial support for New Space can be seen as a major factor for the thriving of New Space.

Province	Project
Nantong, Jiangsu	Nantong Economic and Technology Development Area (NETDA)
Chengdu, *Chongqing*, *Sichuan*	ADA Space IoT constellation as part of the city's new infrastructure 2020-2022 plan
Chongqing, *Chongqing*	Liangjiang New Area Aerospace Comprehensive Industry Development City
Hangzhou, Taizhou, Huzhou, *Zhejiang*	National Satellite Manufacturing Base / Modern Digital City Project

Shanghai, *Shanghai*	New Infrastructure 2020-2022 Plan
Changchun, *Jilin*	Jilin Province Aerospace Information Industry Park, as part of the larger Changchun New Area
Wuhan, *Hubei*	National Aerospace Industrial Base
Haiyang/Yantai, *Shandong*	Haiyang Eastern Coastal Space Port / Yantai Economic and Technological Development Area

Table 3-1 Overview on selected provincial projects supporting for commercial space industry development

For more details on some space industry parks and development zones, consult ANNEX B: Major provincial projects supporting commercial space industry development.

3.2.2 Rapid growth of commercial space ventures

One of the most evident trends shaping China's New Space ecosystem is the rapid growth of commercial companies investing in space. In the span of 5 years, the number of commercial companies grew from approximately 24 to over 100, as shown in Figure 3-1.

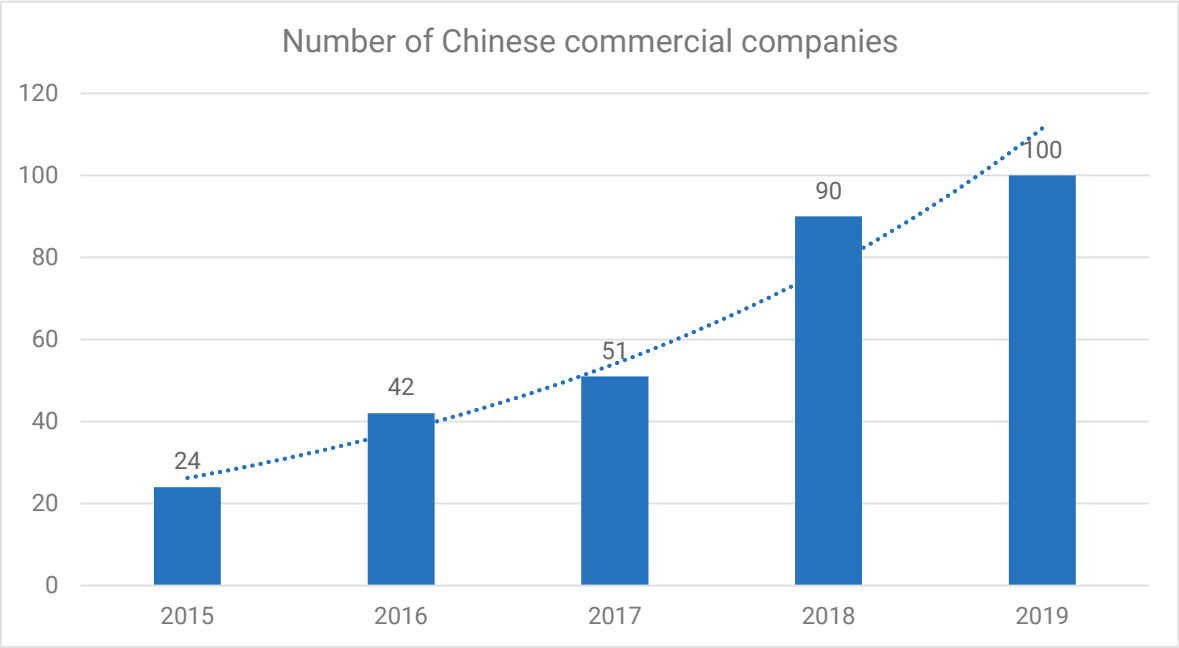


Figure 3-1: Growth in the number of Chinese commercial space companies

Alongside this rapid growth, another key feature of China's New Space is its diversity in terms of sectors of involvement. Chinese astropreneurs have been kick-starting space ventures to market end-to-end solutions in both the upstream and downstream segments of the space industry value chain. According to Future Aerospace and the Commercial Aerospace Industry Alliance, by the end of 2018 China could count on more than 50 companies involved in the upstream segment and more than 70 companies in the downstream.

A list of the most relevant examples is provided in Figure 3-2 while a more detailed overview of the breakdown by sector of Chinese companies in Figure 3-3.

Satellite manufacturing (35+ companies)

- 21AT
- ADA Space
- Changguang Satellite
- Galaxy Space
- Hong Kong ATG
- MinoSpace
- OK-Space
- SpaceTY

Launch manufacturing (20+ companies)

- Chinarocket
- Deep Blue Aerospace
- Expace
- Galactic Energy
- iSpace
- LandSpace
- LinkSpace
- One Space
- S-Motor
- Space Transportation
- Space Trek

Satellite operators (35+ companies)

- 21AT
- ADA Space
- Changguang Satellite
- Galaxy Space
- Hong Kong ATG

Downstream applications (40+ companies)

- Centispace
- HEAD
- Synertone
- Space Vision
- Zhuhai Orbita

Figure 3-2: Overview of notable commercial companies by sector

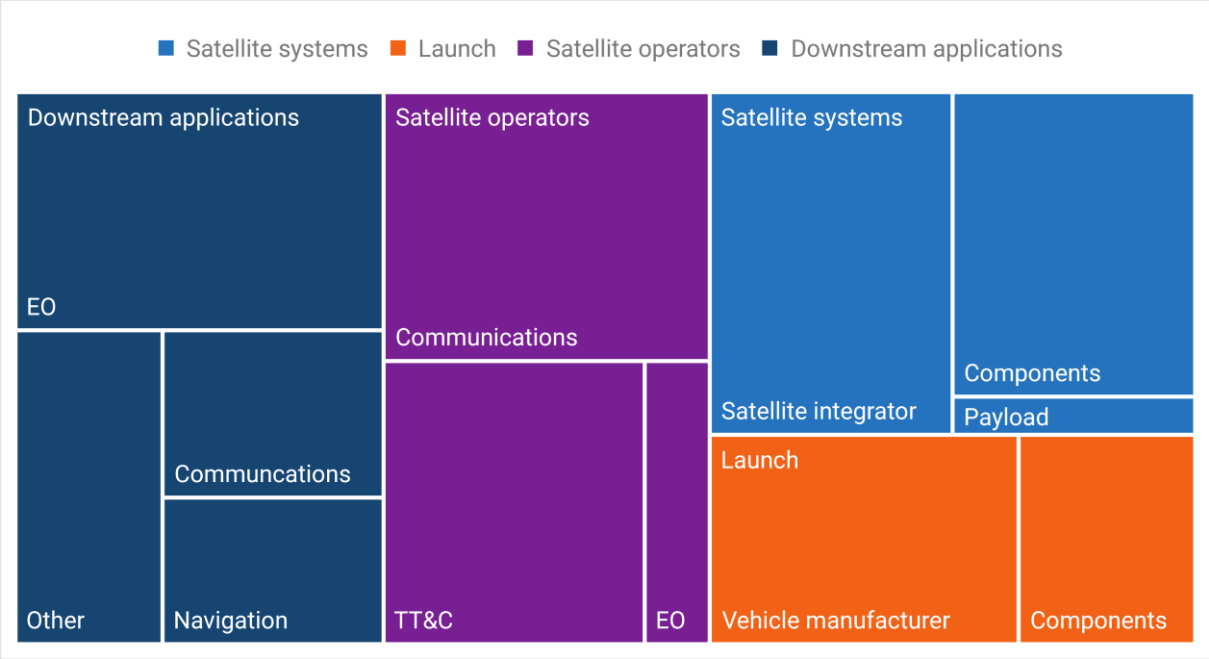


Figure 3-2: Breakdown of China´s commercial companies by sector

3.2.3 Growth and Diversification of Funding Sources

Funding of the Chinese space industry was essentially 100% state-derived as recently as 2014. Until that time, the major sources of funding for space activities included national-level government entities (CNSA, CAS, and others), universities, research centres, and in some cases provincial governments. Broadly speaking, the level of competition in the space sector was minimal. The result was a space sector that was tightly controlled by the state, one that was centralized and relatively well-designed for the purpose of acquiring and catching up to western technology and carrying out governmental space missions.

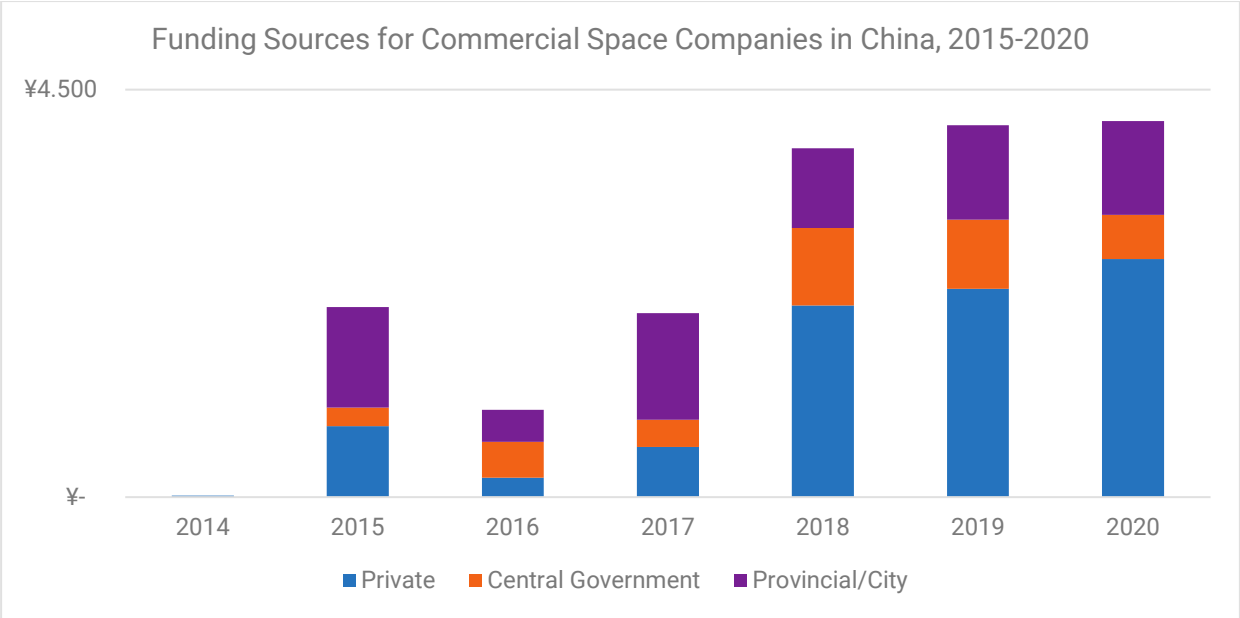


Figure 3-4: Funding sources for commercial space companies in China, 2015-2020 (Source: Euroconsult)

In 2014 the Chinese government decided to allow private money to enter specific sectors, including space, as a way to improve domestic innovation capabilities. This opening of the space sector to financial competition has had many effects, the most important being the diversification of funding sources. No longer are the Central Government and its associated research institutes the only source for space funding, with venture capital (VC) and private equity firms, local governments, tech companies, and even real estate companies pouring money into China's commercial space ventures.

Investors and investment typologies

The most apparent new source of funding in the Chinese space sector is venture capital (VC), which can be further divided into private and government VC. Overall, state-backed VC is still estimated to represent the majority of funding in China, with a 2019 article pointing out 26.5% of funds controlling 60% of the funding as being state-backed[47], though the space sector has a disproportionate amount of private VC funding. Essentially, non-existent in the space industry as recently as 2014, VC is now the largest source of private funding within the Chinese space sector. Private funding (including VC, private equity and other financial institutions) has accounted for close to half the funding raised by commercial space companies since 2014, according to a recent report by Euroconsult[48]. 2020 has thus seen the largest share of private funding with more than 60% of financing having come from private sources. The funds investing into China's space sector can be divided into several categories, namely:

1. Large, diverse VC or private equity funds with broad areas of focus, of which space is a small part of their portfolio. Several such funds in China are affiliated with western funds, with the two most noteworthy being Matrix Capital China (10 investments into space companies) and Sequoia Capital (2 investments into space companies), both of which are affiliated funds of American-headquartered companies.
2. Small, niche funds with narrower focus, of which space is a larger part of their portfolio. The most notable such firms in China include Essential Capital and Source Code Capital. It should be noted that many cities and provinces have similar funds with emphasis on a handful of specific industries, such as AI, Fintech, Big Data, satellite internet, et al. These funds tend to invest in earlier funding rounds. For example, during a July 2020 interview about the company's investment into Galactic Energy, Essential Capital noted that the company invested in an early round, when the sums of money were considerably smaller, and implied that investing in later, larger rounds would be difficult for the fund to justify[49].
3. Provincial/city government VC or other funds. China's political economy is such that provincial/city governments are very large and important entities, with significant control over their budgets. With the space industry considered a high-growth sector in China, many cities and provinces have targeted specific space verticals for economic development. This has led to several of the nation's leading space companies having benefited from partnerships with provincial or city governments. With that being said, provincial or city governments tend to participate in a smaller number of funding rounds, focusing on 1-2 major "local champions" to support. While specific government initiatives are discussed in Ch 4., several government funds are worth noting here. These include the Jilin Province Aerospace Information Investment Fund (RMB 500M[50]), the Harbin Hi-Tech Industrial Park (funded

[47] Sheng, Wei. "VC Roundup: State-backed big funds manage 60% of China's VC and PE Money." *Technode*, 2 July 2020. https://technode.com/2020/07/02/vc-roundup-state-backed-big-funds-manage-60-of-chinas-vc-pe-money/
[48] "China Space Industry Report 2020 Executive Summary." *Euroconsult*. http://www.euroconsult-ec.com/research/CSI20_Brochure.pdf. Accessed 10 September 2020.
[49] Liu, Xiaoyue. "元航资本陈东：看"天"吃饭更看技术 商业航天需要伯乐." *Essential Capital Blog*, 31 July 2020. http://www.essentialscapital.com/news/post/133082/. Accessed 10 September 2020
[50] Xiao, Yun. "民营商业卫星企业异军突起，「长光卫星」完成 2.5 亿元天使轮融资". *36 Kr*, 25 January, 2019. https://www.36kr.com/p/1723171454977. Accessed 10 September 2020.

with RMB 1.6 billion from Harbin[51]), the Chongqing Liangjiang Aerospace Industrial Investment Group[52], and the Yangtze River Industry Fund[53], which itself has a separate aerospace fund that has invested into, Expace and Mino Space[54], among other companies. In China overall, state-backed funds are believed to represent the majority of funds, with large amounts of this capital going into industries such as construction, infrastructure, and larger-scale, less niche technology.

4. Central Government funds. Central Government-controlled funds include, but are not limited to, those controlled by national-level state-owned enterprises or institutes (for example, CASSTAR or Cash Capital, both of which are VC funds of the Chinese Academy of Sciences, CAS), and funds that are directly controlled by the Central Government, including CNTEC, among others. Such funds tend to invest in companies that have spun off from research institutes (such as Spacety spinning out from the CAS).
5. SOE funding. Funding from SOEs can sometimes overlap with other categories, but generally should be viewed as distinct from private capital and also distinct from purely government capital. SOEs fund commercial space companies for a variety of reasons. In the case of CASC or CASIC, the companies may fund commercial space companies to boost their own supply chain. For example, CASIC's Wuhan Aerospace Industrial Base, a major project in Wuhan, has involved CASIC investing >RMB 1 billion into Expace, a nominally commercial rocket subsidiary that would count on CASIC as a major customer, via CASIC's Yangtze River Aerospace Industry Fund[55]. Other SOEs have invested in commercial space start-ups as a way of branching into related businesses, often because their core businesses are heavily regulated. For example, the Aviation Industry Corporation of China (AVIC), an aviation-focused SOE, has invested in an increasing number of commercial space start-ups, including leading the most recent round of funding for Commsat in May 2020[56].

At least 9 entities have participated in 4 or more funding rounds for Chinese commercial space companies. Noteworthy, the majority are either private funds, or otherwise Central Government funds (i.e., CAS).

Investor (Type)	No. of Rounds (August 2020)	Notable Rounds
Matrix Partners China (1) 经纬中国	10	iSpace (Aug '20, Jan '19), Origin Space (Oct '19)
FutureSpace (2) 未来宇航	10	MinoSpace (Mar '20, Sep '19)
Shunwei Capital (1/2) 顺为资本	8	iSpace (Aug '20), Galaxy Space (Sep '19), Deep Blue Aerospace (Jan '19)

[51] Ma, Xiao. "哈尔滨打造航天高新技术创新产业园." *Heilongjiang Government Official Website*, 26 December 2012. http://www.hlj.gov.cn/zwdt/system/2012/12/26/010468563.shtml. Accessed 10 September 2020.

[52] "两江航投集团." *Liangjiang Aerospace Industrial Investment Group*. http://www.aiig.cc/. Accessed 10 September 2020.

53 "长江产业基金." Yangtze River Industry Fund. http://www.yangtze-fund.com/. Accessed 10 September 2020.

54 "长江航天产业基金." Tianyancha. https://www.tianyancha.com/organize/bcbb915170. Accessed 10 September 2020.

55 "刚刚，国内首家火箭公司上海融资逾 10 亿." CASIC 4th Academy Official Press Release, 18 December 2017, https://webcache.googleusercontent.com/search?q=cache:Td9_8ZO-yRMJ:https://news.qimingpian.cn/weixin/edc701dfc22feb664f58870ef1e66b68.html+&cd=1&hl=en&ct=clnk&gl=hk. Cached version accessed 10 September 2020

56 Shen, Junhan. "九天微星完成 2.7 亿元 B 轮融资：2019 年营收近 1 亿元，投后估值超 20 亿元." Securities Times China (STCN), 15 May 2020. https://news.stcn.com/news/202005/t20200515_1776775.html. Accessed 10 September 2020.

Casstar (4) 中科创星	7	MinoSpace (Sep '19), Commsat (Feb '18)
Cash Capital (4) 国科嘉和	6	Jiahe Info (Jul '18), LaserFleet (Dec '17)
Essential Capital (2) 元航资本	5	Satellite Herd (Dec '18), Galactic Energy (Oct '18), Mino Space (Dec. '17)
FutureCapital (1) 明势资本	5	Satellite Herd (Dec '19, Dec '18), Qiansheng Exploration (Sep '18)
LegendStar (1) 联想之星	4	One Space (Mar '19),
Source Code Capital (2) 源码资本	4	Space Transportation (Dec '19, Mar '19), Galaxy Space (Nov '18)

Table 3-2: Overview on major investors and its investments

The absence of provincial governments in the above list is due to their investment strategy. Provincial governments tend to participate in fewer, larger rounds, and thus no provincial government fund appears on the "most active" funds list.

The final major outside funding source in China today is "big tech". China's largest tech companies are some of the country's biggest investors, with giants Tencent and Alibaba, for instance, each having dozens of investment stakes in other tech companies. Broadly speaking, tech companies in China have, and will continue to interact with space companies in two ways:

- As a customer. For example, EO satellite manufacturer/operator Charming Globe (CG) made a deal with Chinese online video platform Bilibili, whereby Bilibili would utilize video and imagery data from CG's satellites for a "space channel" on Bilibili's website[57]. A press release from June 2020 noted that within 2 hours of announcing its video satellite, the Bilibili page for the satellite reached 111,000 followers, indicating the general popularity of space in China[58]. Likewise, over the past 12-18 months, both Alibaba and Huawei have announced plans for EO data portals[59,60]. While the business model for these data portals is not entirely clear, implicitly the portals will seek to bring EO data to a wider audience by combining the tech giants' scale with the space companies' specialisation in space.

[57] Chen, Caiwei. "Bilibili Launches Satellite to Inspire Interest in Science Among Chinese Youth." *Pandaily*, 2 June 2020. https://pandaily.com/bilibili-launches-satellite-to-inspire-interest-in-science-among-chinese-youth/. Accessed 10 September 2020.
58 Cong, Guan and Jia, Denise. "Bilibili to Launch Satellite for Science Education Content." Caixin Global, 3 June 2020. https://www.caixinglobal.com/2020-06-03/bilibili-to-launch-satellite-for-science-education-content-101562319.html. Accessed 10 September 2020.
59 "Alibaba Cloud Planet Engine - A Powerful Satellite Imaging and Remote Sensing Platform". Alibaba Cloud Blog, 28 April 2020. https://www.alibabacloud.com/blog/alibaba-cloud-planet-engine---a-powerful-satellite-imaging-and-remote-sensing-platform_596179. Accessed 10 September 2020.
[60] "The Global Value of Sharing Satellite Data." *Huawei Official Website*, 24 April 2020. https://www.huawei.com/en/publications/winwin-magazine/36/cloudai-global-value-sharing-satellite-data. Accessed 10 September 2020.

- As an investor. Thus far, this has been limited, with China's big tech firms taking relatively few stakes in commercial space companies, but there have been some exceptions. Xiaomi's Shunwei Capital has been one of the most prolific investors into commercial space companies, while Lenovo's Legend Holdings has also made several strategic space investments. Investments made by China's largest tech firms (Tencent, Alibaba) have been either into non-Chinese space companies (Tencent into Argentinian EO constellation Satellogic, for example), or otherwise have been of unannounced size (for example, it is not clear if Alibaba or Huawei financed some/any of the above-mentioned EO data portals).

It should be noted that the different types of funding sources discussed above often coordinate with one another. For example, the Sichuan Provincial Government announced its New Infrastructure Development Roadmap (2020-2022), which includes plans for the local government, the University of Electronic Science and Technology of China, and ADA Space, to establish a satellite production science and technology research centre[61].

The increased diversity in funding sources has not, however, made it easier for all Chinese commercial space companies to raise money. As the industry has begun to mature, we have witnessed a concentration of funding, with the largest funding rounds being larger than before, and with the biggest 10-15 companies commanding an increasingly large percentage of funds raised. This is best exemplified by the fact that from 2018 to 2019, the total number of funding rounds by Chinese space companies decreased from around 50 to around 35, yet the total amount of funding raised increased from ~RMB 4 billion to ~RMB 5 billion. In short, we are seeing fewer, larger rounds, making it easier for existing companies to grow, but making it more difficult for start-ups to enter the industry. This has been exacerbated by a large increase in the number of start-ups looking for funding.

Exit strategies and Financial markets

As Chinese commercial space companies get larger and more mature, more attention will be paid to exit opportunities for early investors. Until now, in both China and the West, the implied exit path for most early-stage venture investors has been an Initial Public Offering (IPO). Historically, this has been less easy in China given stricter listing rules for companies not making a profit.

However, this has changed more recently with the creation of the Shanghai Stock Exchange Science & Technology Innovation Board (aka STAR Market), a tech-focused stock exchange in Shanghai that aims to make it easier for early-stage Chinese companies to IPO[62]. Opened in July 2019, the STAR Market has already seen several Chinese space-related companies conduct IPOs, including PIESAT[63], which sold around 25% of its ownership shares in its July 2019 IPO, raising more than RMB 700 million[64].

Separate from the STAR Market, space industry IPOs on the broader Shanghai and Shenzhen stock exchanges have been generally successful. The most impressive listing has likely been that of China Satellite Communications Company Limited (ChinaSat), the national satellite operator of China. Having sold ~5% of its share capital in an IPO in mid-2019, the company's market capitalization has increased sixfold since then, from just under RMB 4 per share to RMB 23 per share as of 31 August 2020,

[61] "今天，国内首个 AI 卫星科研机构落户电子科技大学." *Spaceflightfans*, 28 February 2019. http://www.spaceflightfans.cn/51433.html#more-51433. Accessed 10 September 2020.
[62] Harper, Justin. "China's Star market aims to take on the Nasdaq." *BBC,* 23 July, 2020. https://www.bbc.com/news/business-53509651. Accessed 10 September 2020.
[63] Platonov, Ivan. "To the STARs: PIESAT Prices Its IPO at CNY 17.25 per Share." *EqualOcean*, 12 July 2019. https://equalocean.com/news/2019071211344. Accessed 10 September 2020.
[64] Meng, Qi. "十年磨一剑，航天宏图科创板展宏图." *21st Century Business Herald*, 20 July 2019. https://m.21jingji.com/article/20190720/e79baff7352c2226395657129542c611.html. Accessed 10 September 2020.

corresponding to a market capitalization of more than U.S.$13 billion. The company's valuation, when compared to industry peers from Europe or Hong Kong, is seen as extremely elevated.

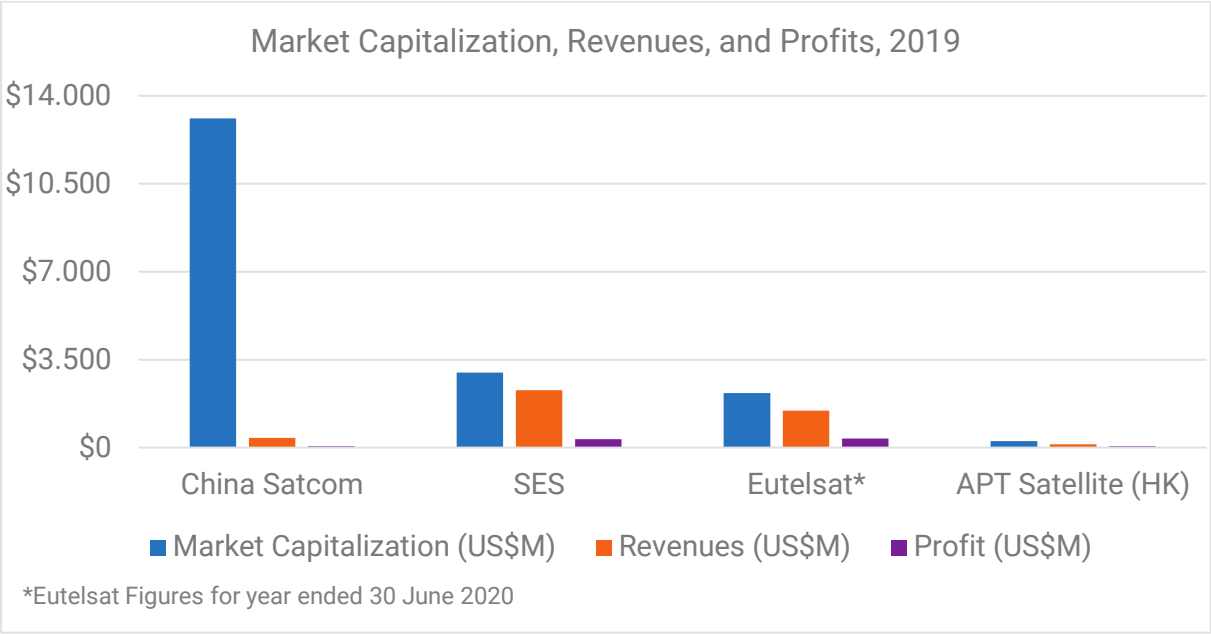


Figure 3-5: Market capitalisation, revenues, and profits (source: Company Annual Reports)

As Figure 3-5 shows, ChinaSat's market capitalization is currently ~35x revenues and ~220x earnings, compared to 1.3/8.8 and 1.5/6.0 for SES and Eutelsat, respectively. Even APT Satellite of Hong Kong – a partial ChinaSat subsidiary – sees a price/revenues ratio of ~2 and a price/earnings of 4.7. This elevated valuation is seen as an indicator of the relative lack of mature space industry companies available to investors in China, with most space companies being either much higher risk (i.e., New Space start-ups), or otherwise not publicly traded (i.e., most other CASC subsidiaries). However, the lack of investment opportunities may be soon starting to correct itself, since companies such as iSpace have now announced plans to IPO.

Recent years have seen high-level political actors advocating more open and flexible regulations for the space industry, both in terms of financing and more generally. For instance, prior to the 2020 National People's Congress (NPC), the largest annual legislative meeting in China, billionaire tech founder and NPC Delegate Lei Jun published a detailed manifesto on deregulation in the satellite industry in China. Therein, Lei emphasized the importance of lowering the threshold for companies to list on the STAR Market so as to allow for faster exits for investors, while also calling for deregulation in the satellite internet sector specifically, and for increased levels of coordination between the government and private sector[65].

3.2.4 Integration of non-space industry and competition with incumbents

Start-up companies are not the only players in China's New Space arena. The two established space giants, other SOEs, big tech companies and large companies in traditional industries are also closely watching the development of New Space as an avenue for future growth. The result is that commercial space is becoming more integrated with non-space industries and intertwined with SOEs or private companies. Such integration has also happened and happens in the U.S.. Motorola created the Iridium system more than 20 years ago. Google/Alphabet invested in O3b, Terra Bella/Planet Lab, Orbital Insight

[65] Lu, Qing. "全国人大代表雷军：鼓励民营商业航天企业在科创板上市." *Yicai*, 21 May, 2020. https://www.sohu.com/a/396675461_114986?spm=smmt.mt-business.fd-d.19.15900364318797fhtGBg. Accessed 10 September 2020.

and SpaceX, with a focus on LEO communications and Earth observation. Amazon is planning its own Kuiper LEO internet constellation. Many founders of U.S. top tech companies and wealthy individuals from the IT industry were involved in New Space, such as Jeff Bezos, Paul Allen, John Carmack, Charles Simonyi etc. It is foreseeable that in the development of the next generation communications technology - 6G, the telecommunication industry will be directly involved and part of New Space.

Non-space industry involvement

Like in the U.S., Chinese tech companies were the first non-space players that showed interest in New Space, though the involvement has been relatively limited thus far. Up to now, tech companies in Chinese New Space have primarily acted as either an investor or a small-scale customer, for instance launching smallsats as a marketing stunt. However, the situation is changing, with big tech's interest in commercial space increasing over the years. Following is a non-exhaustive list of previous interactions between Chinese tech and space:

- At the end of 2019, Tencent and CASIC announced the WeEarth digital Earth plan based on a 300-satellite Earth observation constellation[66]. Prior to that, since 2013, Tencent had invested in the U.S. space companies Moon Express, WorldView and Planetary Resources and Argentina company Satellogic[67].
- In 2016, Alibaba, China's largest eCommerce company, announced a joint plan with CALT and Aerospace Wanyuan (under CASC) to launch an eCommerce satellite[68]. On 25 October 2018, Alibaba launched its first space payload - the Candy Can Mini-Station as an attachment at the CZ-4B upper stage and on 7 December 2018, its Tmall International smallsat was launched into space by a CZ-2D together with the SaudiSAT 5A/B and other nine smallsats. These and other ongoing initiatives make it clear that Alibaba sees significant marketing potential in the space industry.
- In July 2020, Bilibili, one of the largest online video companies in China, launched its first video satellite - Bilibili Video. Unfortunately, this maiden flight of the CASIC Kuaizhou 11 launcher failed, however in a testament to "China Speed", manufacturer Charming Globe announced some months later that a replacement satellite was en route to the launch facility. On 15 September, the satellite was launched by a CZ-11H from the East China Sea as part of the Jilin 1 EO constellation.
- In June 2020, Huawei and China Unicom announced that they will work together to develop the LEO-5G fusion communication system[69].
- Xiaomi's founder Lei Jun has invested in Galaxy Space, Qiansheng Exploration, Interstellar Glory (iSpace) and Deep Blue since 2017 through his Shunwei Capital.

Besides tech companies, traditional companies are also eyeing New Space opportunities. One particularly noteworthy case is Geely, China's largest private car maker. Geely's satellite company Geespace was founded in 2018 with a team mostly from CAS's Innovation Academy for Microsatellites (formerly Shanghai Engineering Centre for Microsatellites) and Space-OK, a commercial smallsat manufacturer based in Shanghai, not far from Geely's HQ in Zhejiang Province. In March 2020, Geespace's satellite AIT centre in Taizhou, Zhejiang, started construction[70]. The first two satellites, as demonstrators of its

---

[66] "航天海鹰卫星运营事业部联手腾讯，打造商业航天新服务模式！". *Sohu News*, 10 December 2019, https://www.sohu.com/a/359507737_120250695?. Accessed 27 August 2020.

[67] "小马哥和他的天文梦：如何影响了腾讯的产品气质和太空投资？". *Sohu News*, 1 October 2017, https://www.sohu.com/a/195794489_99981833. Accessed 17 September 2020.

[68] "马云要上天了，阿里重磅发布卫星计划进军太空", Sohu News, 2 October 2016. https://www.sohu.com/a/115412660_470082. Accessed 27 August 2020.

[69] "玩大的！中国联通与华为宣布合作：进军低轨卫星", Sina Financial, 8 June 2020, http://finance.sina.com.cn/stock/relnews/cn/2020-06-08/doc-iircuyvi7270678.shtml, Accessed 27 August 2020.

[70] "吉利全面布局商业卫星领域 卫星智能 AIT 中心落户浙江", Phoenix New Media, 5 March 2020, http://auto.ifeng.com/c/7uapgIT0DoW, Accessed 27 August 2020.

planned augmented navigation system, are now under testing and are expected to be launched in 2021[71]. In August 2020, Geely Group signed an agreement with Qingdao, a coastal city of Shandong Province to set up a satellite manufacturing facility in Qingdao[72]. Geely plans to establish the OmniCloud space-based cloud service to support autonomous driving and other applications on the ground. Worth noting as well, Geely has invested in a number of aerial mobility start-ups, such as Volocopter and Terrafugia, which could benefit from the company's space infrastructure.

Another recent development is that Country Garden (Biguiyuan), a massive real-estate company with more than 100,000 employees and more than $150 billion in assets, has invested in LandSpace, which further shows that commercial space has attracted more and more non-space players, and space and non-space integration are speeding up.

Competition with aerospace SOEs

Besides the similarity of tech companies' interest in space, there is also another analogy between New Space in the U.S. and China: in both countries New Space companies face powerful competitors. In the U.S., they are the established giant aerospace / defence contractors such as Boeing, Lockheed Martin and ULA. In China, they are CASC and CASIC. Both corporations have claimed that they will also enter the field of commercial space - meaning that they will develop products purely for the market (instead for the government) and will invest their own money. CASIC's rocket and satellite companies running the Kuaizhou launcher and the Hongyun constellation are examples. As the SOEs have huge advantages in scale, human resources, government backing and monopolistic market positioning, and as they have shown that they are very determined, there are concerns that private start-up companies will have difficulties in competing with the SOEs.

As always, government policy is key to decide the fate of the private space start-ups. According to the "socialist market economy" theory that is the foundation of China's economic structure, the market's decisive function in resource allocation and the government's power have to work together. SOEs have to play the leading role in strategic sectors while private companies fill in the gaps. The objective is to leverage the advantages of both SOEs and private companies so that both are equally important. It is also a balance of efficiency and fairness. "Strategic" means national defence, infrastructure, public services etc. Undeniably, space belongs to the strategic category, and the government is very unlikely to give up the current leading role of SOEs in the space industry to private companies. But China sees space as a booming industry with potential for rapid innovation and creating significant economic growth. The government also realizes that SOEs' efficiency and level of innovation is insufficient to catch up with the U.S. New Space players like SpaceX. So, to leverage private companies' advantages under guidance of the government becomes a "best of both worlds" solution, which has been indeed reflected in the government's policies.

This is similar to the Civil-Military Integration Programme in which both sides are allowed to enter the area of each other. The line between commercial and non-commercial companies will remain fuzzy. It is expected that the government will coordinate and balance the two sides using the policy lever, and will give enough space, or even the majority share to the private space in some areas. SOEs and the private sector will compete and at the same time will also complement each other. For example, SOEs are still responsible for national-level projects such as the future Chinese space station, deep-space missions and military projects, while the private sector pursues market-oriented projects. Also, among New Space insiders runs the narrative that once "you have a company with a number of engineers and decent

[71] "吉利年内完成双星发射，进阶中国商业航天领域第一梯队", TechSir, 24 April 2020, https://www.techsir.com/a/202004/62999.html, Accessed 27 August 2020.
[72] "吉利卫星互联网项目落地青岛，商业航天版图加速扩张", iResearch, 13 August 2020, http://news.iresearch.cn/yx/2020/08/334301.shtml, Accessed 27 August 2020.

technology, it's rather hard to die. You might struggle, you might not have a lot of money", but companies can pivot and adapt quite well in China.

In the past few years, there have been some cases of conflict due to competition between SOEs and private companies. The government handled the cases carefully, consistent with the above analysis of the Chinese policy regarding the private sector. A first case emerged with regard to LandSpace's LS-1 solid small launcher. The agreement LandSpace signed with CASC to purchase the motor from the latter was terminated for the reason of "violating technology transfer regulation" suggesting it was military related. But the more important reason behind this may have been that LS-1 was a direct competitor of CASC's CZ-11 launcher. The government later set a regulation allowing private companies to develop their own solid motors, but the propellant charge had to be outsourced to established SOEs, which was thought of as a balance.

A second case, also related to LandSpace, happened in 2018, when a propulsion engineer in the Sixth Academy of CASC (AAPT) resigned and joined LandSpace, allegedly for a higher salary. AAPT then appealed to the government to ban such behaviours in SOEs and threatened to launch a legal case against the former employee. However, there has been no consequence, an aspect that signals the government's support for private space companies. This may ultimately present a longer-term challenge to CASC and CASIC with regard to talent retention, as the two companies have already suffered serious "brain drain" since the establishment of commercial space companies as a viable employment alternative to China's space-skilled workforce.

However, for private space start-ups, it is still harder to challenge their SOE competitors than the U.S. start-ups challenging traditional aerospace contractors. Perhaps the biggest reason for this is the large difference in the two institutional set-ups for space activities. In the U.S., NASA has a large budget and manages many projects. This gives NASA the ability to award many commercial contracts to a variety of start-ups - something that Boeing, ULA, etc., could also do, but clearly have less incentive to do.

On the other hand, China's closest equivalent to NASA is the China National Space Administration (CNSA), which is more of a figurehead organisation tasked with coordinating projects, conducting international cooperation initiatives, and so on. Noteworthy, CNSA has not awarded contracts to commercial space companies, with most major CNSA missions involving CASC as the main contractor and delegating sub-contracting responsibilities to CASC. This gives CASC considerable power to award sub-contracts and would be akin to NASA awarding all contracts to Boeing or ULA, and then trusting Boeing or ULA to award sub-contracts to private companies, many of which would be striving to compete with Boeing or ULA in certain areas. Put simply, the incentive structure in China is not conducive to commercial space companies winning government contracts, at least not compared to the United States.

To survive, New Space companies have begun to adjust with various strategies as summarised below:

- Avoid direct competition with CASC and CASIC's core businesses. For example, many LEO comsat companies (Galaxy Space may be the only exception) have avoided the broadband system and instead have focused on the relatively simple and low-cost narrowband or IoT systems.
- Differentiations by innovations that few competitors possess. Some examples include LandSpace and iSpace's methane engines, LinkSpace's VTVL launcher, and integrated communication, navigation and Earth observations constellations as planned by some New Space companies. All these are technologies that CASC and CASIC do not have, and in some cases technologies in which western competitors are making rapid progress. Many such innovations could also be used by CASC or CASIC - for example, LandSpace could sell methane engines to CASC for CASC's own rockets.
- Seek niche markets. Focus on sub-systems, components or services that SOE competitors neglect. For example, AstroCruise develops micro electric thrusters for smallsats. SatelliteHerd and Space Wisdom provide commercial TT&C services.

- Attract professionals from SOEs with competitive pay and better opportunities. In China, SOEs tend to offer extremely stable, usually lifetime employment, with a trade-off of below-market wages and highly bureaucratic structures that limit promotion opportunities. For those who seek better career opportunities, New Space companies are good options, with this being particularly true for high performers that may be marginalised by the SOE apparatus. In fact, employees from the two SOE giants were actually a key factor supporting the fast growth of New Space in China in recent years.

It is expected that in the next few years, China's commercial space will enter a new stage as many companies will have been closed, sold, merged, or changed their business models. As a result of this consolidation coming from such a crowded field of companies, the winners are likely to be among world leaders in their fields.

3.2.5 Incremental Innovation and Technological Self-Sufficiency

With the rapid emergence of many dozens of Chinese space start-ups comes competing strategies regarding technology & technical solutions. This section provides an outline of the main technology trends, with a focus on launch and satellite manufacturing, two R&D-heavy verticals of the New Space ecosystem. Due to the fast-evolving landscape, such an assessment may be necessary on an annual basis to account for the many transformations the sector is yet to see.

Launch systems: Reusability, Speed, and SpaceX

Among the 10-15 Chinese private rocket start-ups which have emerged since 2014, a common although increasingly irrelevant practice has been to categorize them into two groups: first- and second-generation launch companies. The first-generation generally consists of the four early movers between 2014 and 2016 which are LandSpace, iSpace (a.k.a Interstellar Glory), LinkSpace and One Space, while the second-generation were companies founded in 2017 or later. Up to late 2019, it seemed that the first-generation had a significant advance on the latter, having attempted suborbital and orbital launches with solid rockets and leading the development of heavier launch vehicles. In 2020, however, the "generational gap" has been closing fast, with some first-generation companies showing limited signs of progress (One Space, LinkSpace) and second-generation companies gaining momentum (Galactic Energy, Deep Blue Aerospace)[73].

Technology and innovation are critical to New Space launch companies, and even more so in China. In the early stages of China's New Space, many observers hypothesized that the Chinese state-owned space conglomerate CASC would focus on mid-heavy launchers (the Long March 5-9 series), leaving the small lift launchers to New Space companies. As of 2020 however, it is clear that Chinese private and state-owned launch companies are on a confrontational path in terms of market, with an advantage to the latter due to the substantial financial and engineering resources. CASC has spun-off China Rocket, a company manufacturing the small to medium lift Jielong and Tenglong series rockets, while CASIC, China's other space conglomerate, has been working fairly successfully on growing Expace, its nominally-commercial launch spin-off. Expace was the first company to break the status quo of the CASC-dominated launch market, with multiple commercial launches of the Kuaizhou-1A rocket since 2017.

Furthermore, China's launches have been overwhelmingly serving Central Government missions (Beidou, Gaofen, Fengyun, …), and these will invariably continue to be launched by state-owned launch services. Unless China undergoes a major shift in space policy and consents to hand out future state-owned launch

[73] Jones, Andrew, "Chinese private launch firms advance with methane engines, launch preparations and new funding", 5 June 2020, https://spacenews.com/chinese-private-launch-firms-advance-with-methane-engines-launch-preparations-and-new-funding/

contracts to commercial companies, this leaves a crowded Chinese private launch ecosystem to compete exclusively for private satellite constellations, domestically and internationally.

The intense competition among Chinese private launch companies for an uncertain market has made low launch costs the cornerstone of their future success and has been driving innovation strategies. This has implications on technical choices, with three major trends:

- Reusability. In contrast to state-owned companies, nearly all Chinese private start-ups have rapidly considered reusability as the major leverage to bring the costs of launch down to a competitive level. This is achieved through the development of reusable liquid propulsion engines, with an equal share of companies going for liquid oxygen & methane (LOX/CH4) and liquid oxygen & kerosene (LOX/KP1) engines (see Table 3-3)
- SpaceX as a model. In most interviews with Chinese launch start-ups, there is a recurring comparison with SpaceX and Elon Musk. Undoubtedly, SpaceX's technical choices are closely scrutinized. Noteworthy as well, most Chinese rocket companies are backed by venture capital firms that have the reputation of being eager for early results. The underlying consequence is that many Chinese companies have picked a policy of not "reinventing the wheel" and have adopted many of SpaceX's technical choices. This is verified from a macro-standpoint with private launch companies aiming for reusability and a VTVL first stage. The choice of liquid methane by SpaceX's upcoming Raptor engine and also Blue Origin's BE-4 have also inspired the adoption of methane as a rocket fuel for around half of the Chinese start-ups. Others such as Galactic Energy have pushed instead for the use of kerosene (KP1), justified by the maturity of this technology (and by the precedent set by SpaceX's kerosene/oxygen Merlin engine)[74]. In some cases, the layout of rocket engines in the first stage has a striking resemblance to the Falcon-9, as can be seen in the star-like setup see in Table 4-3 (Galactic Energy Pallas-1, iSpace Hyperbola-2). This was a technical solution adopted by SpaceX for the vertical landing of the Falcon-9.
- Speed: In the early stages of Chinese New Space, most of the launch start-ups had initially designed a first generation of small solid rockets before developing liquid propulsion, and despite the uncertain market perspectives of the former. Examples of this are the Hyperbola-1 and Zhuque-1 rockets, designed respectively by iSpace and LandSpace. This was seen as an enabler for a faster time-to-market, as well as a way to cope with the steep learning curve of rocket launch. This strategy has since been revised by many launch companies, and some such as LandSpace have renounced developing a solid rocket, while others such as Deep Blue Aerospace have decided to develop directly liquid propulsion. According to interviews with some launch start-ups, the push for solid rocket technology in the early stages of Chinese New Space was also due to the pressure from early VC investors, as well as a way to generate interest from potential future investors for the company.

Despite the undeniable rapid progress among China's commercial launch companies, the technology being developed, and strategies being pursued today are still, by and large, catching up to the global state-of-the-art, rather than creating wholly new innovations. A rapid time-to-market and the minimisation of risk have led to no major technical breakthroughs in rocket technology as we know it today. Chinese companies have been re-implementing a number of successful technology choices already adopted by other non-Chinese launch companies. Engine cycles are generally simple gas generator cycles, with no resemblance to the sophistication (and efficiency) of the staged combustion cycles of engines such as the SpaceX Raptor engine or the NPO Energomash RD-180. This is in line with China's incremental innovation policy seen in other industries such as high-speed rail and civil aviation.

[74] YANG, Yang, "商业航天企业星河动力完成近亿元"天使+"轮融资", 14 April 2019, https://legacy.iyiou.com/p/97218.html

Company / Engine / Associated launcher	Fuel	Engine Cycle*	Reusable	Landing technology*[75]
LandSpace Tianque engine ZQ-2	CH4/LOX	Gas generator cycle	First Expendable, then converted to reusable	NA
iSpace Jiaodian-1 engine Hyperbola-2	CH4/LOX	Gas generator cycle	Yes	Retropropulsive landing (VTVL), grid fins
LinkSpace Lingyun engine (built by JZYJ) RLV-T6 demonstrator	CH4/LOX	Gas generator cycle	Yes	Retropropulsive landing (VTVL), grid fins
Deep Blue Aerospace Leiting-20, -100 engines Nebula-1, -2	KP1/LOX	Gas generator cycle	No for Nebula-1 Yes for Nebula-2	Retropropulsive landing (VTVL), grid fins
Galactic Energy Cangqiong engine Pallas-1	KP1/LOX	Gas generator cycle	Yes	Retropropulsive landing (VTVL), grid fins
SpaceTrek NA XT-3, XT-4	KP1/LOX	NA	Yes	NA
Space Transportation (Tianxing-II, III)	NA	NA	Yes	Spaceplane, horizontal landing
JZYJ (engine manufacturer) Lingyun engine Longyun engine	CH4/LOX	Gas generator cycle	Yes	NA
Aerospace Propulsion (engine manufacturer) Canglong-1 engine	CH4/LOX	Gas generator cycle	Yes	NA

*Table 3-3: Overview on engine developments (*based on publicly available information or visual observation of images of the engine/launch vehicle)*

75

Satellite systems: incremental innovation & growing maturity

Over the past 6 years, at least 15-20 constellation projects have been announced, with a significant portion of these being backed by private capital (see Figure 3-6). Some of these projects were quite innovative on paper, such as LaserFleet's laser-based broadband constellation aimed at in-flight connectivity. Similar trends in private launch start-ups can also be found here: intense competition, regulatory uncertainty, and the fact that again within this vertical, Chinese state-owned spin-offs would be rolling out at some point their own constellations and with a significant financial advantage (Hongyan, Hongyun, Xingyun). In recent years, many constellation companies have seemingly put aside their satellite projects and pivoted instead to less capital-intensive and risky verticals such as satellite platforms or the manufacturing of specific payloads, with these plans being less directly competitive to CASC/CASIC.

Figure 3-6: China´s satellite constellations overview credit: China Aerospace Blog)

While no significant technological breakthrough (comparative to the global state-of-the-art) has been observed in China's New Space satellite industry, a number of noteworthy technical choices show that China's ecosystem is indeed growing in maturity. Some of the more interesting ones are listed below:

- Laser Intersatellite Links (ISL): LaserFleet, a Chinese start-up founded in 2017, has developed China's first laser-based ISL in low-Earth orbit, which were launched on Xingyun-1 and -2 in May 2020, and deemed functional in August 2020[76]. The company is also working on satellite-to-ground laser links. Laser ISL had previously been tested in China, notably on Beidou satellites in 2019, but these were in MEO/GEO orbits[77]. While laser ISL is a technological "first" in China, it has been implemented previously by NASA, JAXA, and is already operational on Starlink. Telesat, as well as Hongyan and Xingyun are all planning to use laser ISL on their future constellations.
- Fusion of 5G and satellite communication: satellites have long held the important role of backhauling terrestrial networks, notably in remote areas. Some Chinese constellation companies such as Galaxy Space are building a broadband satellite constellation with 5G network backhauling as one of their main businesses, branding the activity as a "5G constellation". In June 2020, China Unicom, one of

[76] Hua, Xia, "China's IoT satellites verify laser links technology", 13 August 2020, http://www.xinhuanet.com/english/2020-08/13/c_139288478.htm
[77] Shi, Yaqiong, "航星光网：即将交付星间通信终端、星地终端、光学地面站"，15 August 2020, https://36kr.com/p/1724180004865

China's three telecommunication companies, signed two separate Strategic Cooperation Agreements with Galaxy Space and Huawei to explore the convergence of satellite and terrestrial connectivity within the context of 5G. It is worth noting that at the 6G Summit in March 2019 in Finland, Huawei mentioned for the first time their interest in building a potential 10,000-satellite constellation for global coverage of a 6G network. Details of this constellation project were not revealed, nor if the constellation would be performing a backhauling service or connecting directly to end-user terminals.

- Mixed-payload constellations: a growing trend both outside and within China has been satellite constellations with multiple different payloads. Among such Chinese projects are Hongyan (narrowband L & broadband Ka), automobile company Geely's yet-to-be-named constellation (broadband & PNT services), and Qiansheng Exploration's future constellation which will combine EO, telecommunication and PNT services. Noteworthy, Qiansheng Exploration has already launched a first test satellite, Qiansheng-1, which has remote sensing and narrowband capabilities. It has claimed in interviews that there is a growing market for applications that require communications, remote sensing and PNT services simultaneously[78].
- "AI satellites": some satellite start-ups such as ADA Space are building Earth observation satellites with so-called "AI capabilities", defined as an increased autonomy of the satellite with the ability to decide which part of the data is relevant to the mission and to upload to ground stations. The first satellite, "Dayun Hao", is planned for launch in 2021[79]. ADA Space is also building an EO live streaming app (Live Earth) and a cloud infrastructure (ADAcloud). Qiansheng Exploration, mentioned previously, has also hinted at smarter satellites.
- New frequency bands for future broadband constellations: Chinese constellation companies have repeatedly expressed the concern that the "first come first served" policy regarding frequency distribution would put Chinese broadband constellations at a severe disadvantage due to their latecomer position. Galaxy Space, one of the leading Chinese private constellations, has been experimenting with the higher Q/V frequency bands as an alternative to Ka, to solve band shortage issues.
- Synthetic Aperture Radar (SAR): While until recently SAR has been the affair of large and costly state-sponsored satellite projects, the New Space fundamentals (cheaper, smaller, COTS), as well as the miniaturisation of space electronics[80] have enabled the emergence of commercial SAR companies such as Iceye (Finland) and Capella Space (USA). Several Chinese start-ups, such as Spacety, F.Squares Technology, Beijing Smart Satellite, and more recently PIESAT[81], have also unveiled a roadmap including a SAR-based EO constellation.

New Space Self-Sufficiency or Enhanced Cooperation?

An interesting question regarding these technical developments within China's New Space is the extent to which China will pursue self-sufficiency, as opposed to engaging in technical cooperation with other non-Chinese space companies. China's space industry, represented until recently mostly by SOEs CASC and CASIC, has been isolated from international markets and cooperation, due largely to U.S. trade restrictions and lobbying. U.S. regulations like ITAR have prevented China from sourcing any major components from Western suppliers or launching non-Chinese manufactured payloads. The consequence is that over the past 20 years, China has pursued end-to-end in-house developments for its

[78] Gu, Zhenyu, "太空经济新时代打造商业航天产业创新生态圈-商务部航天云峰会演讲实录", 26 April 2020, http://www.uni-explore.com/news.aspx?pkid=699
[79] Wang, Yi, "ADASpace set to star in AI satellite constellation sphere", 30 June 2020, https://www.globaltimes.cn/content/1156263.shtml
[80] Filippazzo, Giancarlo; Dinand, Ségolène, "The Potential Impact Of Small Satellite Radar Constellations On Traditional Space Systems", 2-3 November 2017, http://golkar.scripts.mit.edu/fss/wp-content/uploads/2017/10/Paper-6.pdf
[81] 3SNews, "拟建设 SAR 遥感卫星星座并提供发射、测控、运维等服务，航天宏图拟定增募资不超 7 亿元", 8 August 2020c, http://www.3snews.net/startup/246000063867.html

space systems, covering all of its needs. The current China-U.S. tensions and notably the latest U.S. restrictions on Huawei have also aggravated this trend and serve as an incentive for Chinese New Space companies to avoid unnecessary reliance on foreign components & technologies.

The founders of Chinese New Space start-ups are to a large extent former employees of Chinese state-owned space conglomerates (CASC, CASIC, and also CAS). Due to the already established close proximity with China's traditional space providers, the complexity of importing space parts, and the competitiveness of Chinese manufacturing, self-sufficiency and reliance of Chinese New Space has been a continuous part of the practice of SOEs. The complexity of importing foreign space parts & services has remained a challenge, even for Chinese New Space. A noteworthy example is F.Squares Technology, a Beijing-based EO data processing company currently envisaging the development and launch of its own EO satellites due to the difficulties in obtaining imagery from some foreign providers.

The massive use of mostly non-ITAR COTS parts has however enhanced the possibility of exchanges between Chinese and (non-U.S.) western companies. China is a significant market for many Western suppliers due to its numerous constellation and launch projects and, as discussed previously, the confrontational competition between Chinese SOEs and private companies encourages the latter to find markets abroad. Examples of cross-border New Space exchanges include LandSpace with D-Orbit (Italy) and Open Cosmos (UK), UK's SSTL manufacturing satellites for 21AT, electric propulsion company ThrustMe (France) with satellite company Spacety, OpenCosmos (UK) with Tongchuan City, and Chinese TT&C company SatelliteHerd's presence in Europe.

3.3 Ecosystem Assessment

While the Chinese New Space landscape is undeniably rooted in a technological catch-up phase at the time of writing, a small number of companies have shown off-the-beaten-path technology roadmaps. Space Transportation has been developing the Tianxing launch vehicles, based on a reusable 2nd stage spaceplane architecture. Another launch competitor, Space Pioneer, is developing HCP liquid propulsion for its Tianlong-1 rocket. Origin Space, another Chinese start-up, is focused on space resources utilisation. These examples, still at an early stage of development, well illustrate the novel technology choices of some New Space founders.

It goes without saying that commercial rockets and satellites are not built without purpose. A crucial component for the success of New Space is the development of the so-called downstream sector i.e., space applications using space data, which has reached a sufficient level of development to sustain the upstream. It is an ecosystem that has not yet settled into maturity in China. On the other hand, there is growing understanding that 21st century technologies such as AI, big data, mobility, block chain and quantum computing will not thrive without space-based infrastructure.

Ultimately, a strong driver of New Space applications and innovation is China's downstream tech ecosystem. China no doubt has one of the most developed mobile ecosystems in the world, which in some cases has enabled an "appification" of some satellite applications. In maritime broadband for example, Chinese fishermen are able to purchase internet packages from maritime broadband companies directly through WeChat or other third-party mobile apps.

China also has a solid lead in many tech-heavy industries such as cloud computing, autonomous driving, unmanned aerial vehicles, etc. Some of the leading Chinese companies in these sectors such as Xiaomi (smartphones and IoT), Geely (automobile), Huawei (telecoms) and Alibaba (cloud) have shown increasing interest in space. The involvement of these large tech companies will likely be a key asset and driver of Chinese New Space innovation.

Taking these trends together, following is a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) of the New Space sector in China.

Strengths	Weaknesses	Opportunities	Threats
sustainable and long-term political support	limited access to Western European and U.S. markets	enormous national market	external threats:
an emerging and partly already mature supportive framework of state policy	little international experience	full scope of governmental space programme is blazing the trail for the entry of commercial New Space	subject to sanctions - the U.S. sanctions regime prevents European countries from cooperating with China, its influence on emerging countries is currently not predictable
in line with overall economic development of the nation	Less diverse labour force than in the West	following state policy for moderate developed society with declared aim of improving the living standard of the nation	possible growing competition from Western businesses or from Japan, Korea, India
continued economic growth	state control over access to resources (e.g., launch sites) and scope of business (e.g., infrastructure will remain under control of SOEs)	following state policy for international soft-power influence (BRI) in new markets in Africa, Central Asia, Arabia, Latin America and possibly Balkan region	internal threats: very powerful incumbents that make innovation less straightforward or even block certain developments outside the SOE sector
entering uncharted territory	National Space Law is needed soon	space business is strongly interlaced with state policy of innovation and opening-up	
availability of venture capital		unprecedented potential of the state policy of interconnecting 5G, IoT, Big Data	

highly motivated workforce/big talent pool			
space - in particular New Space - is an attractive economy with a positive image			

Table 3-4: SWOT with respect to overall assessment of the New Space sector in China

Strengths	Weaknesses	Opportunities	Threats
very young teams	little business and management experience	complementing those areas that are not attractive for SOEs , e.g., small launchers and small satellites	too many Chinese New Space companies
innovative mind-set	finding a viable and independent/emancipated business model	following state policy of innovation and integrated economy	Regulations are not clear
flat company hierarchies	Lack of focus by most companies, due to lack of regulation		Incumbents do not want to see New Space companies succeed
own technology development	limited marketing activities		
nimble companies with several business lines			

Table 3-5: SWOT with respect to capabilities of New Space companies

4 Public policies to support commercial space in China

By Zhuoyan Lu, Global Adjunct Faculty, International Space University

4.1 Introduction

The early stage of China's commercial space activities began with the international launch segment utilising the Long March rocket series in the 1990s. However, in 1999, the United States issued the Cox Report, which accused China of deliberate attempts of espionage and theft through the opportunities created by the launch of U.S. satellites on Chinese rockets. The export of U.S. satellites to China was completely banned afterwards, as were China's launch services to the United States and other major western countries.

Hence, starting from the early 2000s, China explored other ways to seize commercial opportunities in international space markets, including the provision of all-inclusive in-orbit-delivery contracts for many emerging space nations. Since the signature of the first commercial contract with Nigeria in 2004, China has been increasingly successful in exporting its communication and remote sensing satellites to the governments of countries such as Venezuela, Pakistan, Bolivia, Laos, DR Congo, Nicaragua, Sri Lanka, Thailand, and Ethiopia.

This growth in commercial activities, however, has continued to be dominated by state-owned enterprises (SOEs); a situation that has progressively shown some downside effects. These include, for instance, the lack of competitive pressures on the domestic space industry, and the more limited prospects for technological innovation in government-led enterprises.

The Chinese government has thus become cognizant that the space industry has developed to a point where the actual involvement of private actors would prove not only beneficial but also necessary to creating a sustainable space ecosystem, accelerating economic growth and improving competitiveness, as well as contributing to national pride.

Building on these drivers, over the past six years, the Chinese government has enacted a number of policy and regulatory tools to support the development of a commercial space ecosystem in the country. Since 2014, private players have been incentivized to actively engage in the commercial space market and have grown both in number and scale.

The objective of this paper is to provide an overview and analysis of these recent measures to encourage the participation of private actors in the space sector. Policy tools are discussed in Section 2 of this paper, whereas legal and regulatory instruments are covered in Section 3.

4.2 Policies in Support of Commercial Space Activities in China

4.2.1 Commercial Space Policy - the National Space White Paper

The most important national space policy document in China is the *White Paper: China's Space Activities*. The white paper is an essential document in the way that it states the fundamental principles and underlying purposes of China's space program and charts the next 5-year vision and mission of China's space development as a whole.

As of 2020, there have been four versions of the White Paper, respectively in 2000, 2006, 2011 and 2016. The 2016 version is the latest and remains in effect until 2021. Compared to the previous versions, in the White Paper of 2016, new elements were added. First, emphasis was put on promoting the transformation and upgrading of aerospace industry capacity in China.[82] This transformation and upgrading policy was detailed in three parts, the first of which envisioned an integrated and open system with active participation by a diversity of actors, including space contractors and market suppliers. Second, it emphasised the necessity of improving space standards and measurement building, as well as enhancing the development of key technologies. Last, to realize the transformation of space industry towards a digital, informative, and intelligent dimension, the need to integrate industrialization and informatization was emphasized. Clearly, the first part dealing with transformation and upgrading of policy opened the possibility of including private space actors in the industry. One of the driving forces behind this was the increasingly competitive global space market, where low-cost and high-reliability space products will be the next winners. The inclusion of the private space sector in this market will definitely benefit the progress of the industry and improve the competitiveness of the market.

In addition to this, the White Paper also stated that the national standard and quality system would be improved, and a satellite data sharing regime would be established to further provide a friendly environment for the development of the satellite industry sector.[83] If the relevance of these statements still seems to be rather scant in terms of the involvement of private space actors, the following should be sufficient to clarify the ambiguity. Within the policy paper, it was clearly stated that in order to promote the satellite industry sector and improve the industry supply chain, private capital and private entities were all encouraged to participate in the development of various space industries, including space manufacturing, space research and development, space service provision, and many other space activities.[84]

Overall, the White Paper evidenced a policy transition from a state-centric model to an inclusive ecosystem that included private actors. From this perspective, the White Paper could be taken as a signal of the policy transition from a state-dominated enterprise to a field with more active private sector players in space. However, it should be noted that the 2016 national space White Paper was not the first governmental document envisaging the involvement of private actors in the space sector. Rather than initiating, the paper reaffirmed and further expanded the policies contained in previous governmental documents.

4.2.2 The Policy of Private Investment in Space

The turning point in the development of private space activities in China was the enactment of the Guidance on Innovation of Investment and Financing Mechanisms in Key Fields to Encourage Private Investment[85], which was released by the State Council in November 2014. Within this document, private actors were allowed to participate in the development of civil space infrastructure, and private capital was encouraged to engage in the sector as well.[86] In fact, one of the sections of the Guidance was directly dedicated to promoting the diversity of investing bodies in the satellite and applications industry.

The inclusion of space among the sectors open to private participation built on multiple factors. First, it built on the recognition of the pivotal role played by private space actors in industrial and economic development. Since the beginning of this century, the global satellite and application industry has indeed

[82] State Council Information Office (2016) White Paper: China's Space Activities in 2016 (in Chinese). Section 4(3). http://www.scio.gov.cn/wz/Document/1537090/1537090.htm. Accessed 30 September 2020.
[83] Ibid., Section 4(4).
[84] Ibid., Section 4(6).
[85] State Council (2014) Guidance on Innovation of Investment and Financing Mechanisms in Key Fields to Encourage Private Investment (in Chinese). http://www.gov.cn/zhengce/content/2014-11/26/content_9260.htm. Accessed 30 September 2020.
[86] Ibid., Section 7(3).

developed very rapidly, indicating a sustained and high-speed growth trend. In 2014, when the Guidance was released, the revenue of the global satellite industry was USD $203 billion, with satellite applications income accounting for more than 60%, and satellite manufacturing and launching revenue accounting for 11%. The growth rate in the industry was 4% *per annum*, higher than the average growth rate of the global economy, which was 2.6%.[87] China, however, was only marginally part of this global trend and many opportunities had been left unexplored, both in the manufacturing and applications sector. Taking the communication satellite sector as an example: the economic scale of operation and service in the downstream market is relatively large, while that of ground equipment manufacturing is comparatively small. In addition, the application and industrialization market of satellite TV in China is still to be explored, broadband multimedia satellite is yet to be developed, and the application of mobile satellite communications is an urgent need.

Another important factor was the need to accelerate innovation in the public sector, improve its competitiveness and contribute to China's international standing. While SOEs play a fundamental role, relying on SOEs only in addressing all these requirements is not realistic and can even hinder development of a functional and more coordinated space industry. Commercial companies can also have an easier life in accessing global markets as compared to SOEs.

Eventually, the release of the Guidance also built on the recognition that it was necessary to formally endorse the involvement of private actors through a national instrument. Indeed, although the private sector had already been gradually venturing in space activities even before the release of the Guidance, it still required official confirmation from the national authorities and the Guidance bridged the gap in this sense. From this perspective, the private investment in space policy introduced by the Guidance set the fundamental milestone in promoting the commercial and private space industry and economy in China.

Following the release of the 2014 Guidance, the policy of encouragement of private investment in the space sector was further detailed in the administrative document released by the National Development and Reform Commission in 2015, titled National Civil Space Infrastructure Medium- and Long-Term Development Plan of 2015-2025.

The plan lays out the objectives and measures to establish an effective national civil space infrastructure by 2025, including measures to improve innovation and to achieve an internationally advanced level for business, marketing, industrial development. According to this development plan, the investment bodies for the establishment and operation of public[88]and research-related space infrastructure shall be mainly government-led; for combined public and commercial activities the investments shall come from both public and private funding, while private shareholders shall take over commercial projects . The Plan also emphasizes the necessity to stimulate and encourage qualified enterprises to invest in the establishment of satellite ventures.[89]

4.2.3 The Policy of Foreign Investment in Space

In accordance with the *Foreign Investment Law* and the *Regulations for the implementation of the Foreign Investment Law*, the State Council formulates foreign investment policy, guidance and rules in line with the needs of national economic and social development. The policy regarding foreign investment in space

[87] The figure of 2014 is chosen based on the fact that the pivotal policy of involving private space sector in the industry was introduced in that year. See China National Space Administration (2017). The Satellite and Application Industry Market (in Chinese). http://www.cnsa.gov.cn/n6758823/n6758838/c6796694/content.html?COLLCC=118886223&. Accessed 30 September 2020.
[88] The term of public here means non-profit, in opposite to commercial activities driven by profit.
[89] National Development and Reform Commission, National Civil Space Infrastructure Medium- and Long-Term Development Plan of 2015-2025 (in Chinese). Section 8(3). https://www.ndrc.gov.cn/xxgk/zcfb/ghwb/201510/W020190905497791202653.pdf. Accessed 30 September 2020.

is partly embedded in the Catalogue of Industries Encouraged for Foreign Investment, which lists the industrial sectors open to foreign investments.

This catalogue was first issued in 1995 and has been amended 7 times since then. Actually, the revision history of the catalogue provides a miniature of China's economic development. At the end of 1997, in order to offset the adverse impact of the Asian financial crisis on China's economy, China revised the catalogue for the first time, and implemented more favourable tax policies for foreign enterprises. Later, in 2001, China joined the WTO and revised the catalogue in 2002 accordingly. In 2004, in order to coordinate with the national macro-control policy, the catalogue was further adjusted. In the spring of 2007, the financial crisis emanating from the United States spread to major economies such as the European Union, China and Japan; the catalogue was hence adjusted to better address the side effects of the global financial problem. Since 2015, due to several important turning points in China's economy, the catalogue has been revised 4 times within 5 years, specifically in 2017, 2018 and 2019 and 2020.

The 2017 Catalogue[90]opened several space-related fields to foreign investment, including the design and manufacturing of civil use satellites, the design and manufacturing of civil use payloads, the production of civil use satellite components and testing equipment, and the development of civil applications etc. The 2018 version confirmed these sectors. In the 2019 Catalogue[91] the areas of research and innovation of new space materials were also added.

The 2020 Catalogue has not been officially released as of October 2020. With regard to amendments, however, on 10 March 2020, the 85th executive meeting of the State Council called for various measures to stabilize foreign investment, expand the list of industries encouraging foreign investment, and enable foreign investment in diverse fields to benefit from policies such as taxation. Building on this, the National Development and Reform Commission and the Ministry of Commerce created a *Draft Catalogue of Industries Encouraged for Foreign Investment 2020*[92] on the basis of opinions from local governments, relevant departments, business associations and enterprises. The draft was eventually opened for public opinions from 31 July to 30 August 2020.[93] Although the National Development and Reform Commission announced that the 2020 version would be released before the end of the year[94], at the time of writing (November 2020) it remains a draft.

It is however expected that the space-related items will remain the same of the 2019 version. The continuity of the space-related items listed in the most recent Catalogue can be taken as evidence of continued government support for the development of a robust commercial space industry, also through foreign investors.

Overall, whilst foreign investment in the space sector is certainly not newly born, the policy is expected to further increase investment from foreign capital and bring relevant operational entities and offices to China. The policy is also expected to foster a vivid space ecosystem where the sector would considerably

[90] National Development and Reform Commission (2019) The Catalogue of Industries Encouraged for Foreign Investment (in Chinese). http://www.gov.cn/xinwen/2019-06/30/5404701/files/9d2dde75fa054d249dfa16267af42277.pdf. Accessed 30 September 2020.
[91] National Development and Reform Commission (2019) The Catalogue of Industries Encouraged for Foreign Investment (in Chinese). http://www.gov.cn/xinwen/2019-06/30/5404701/files/9d2dde75fa054d249dfa16267af42277.pdf. Accessed 30 September 2020.
[92] National Development and Reform Commission (2020) The Draft of the Catalogue of Industries Encouraged for Foreign Investment (in Chinese).http://www.gov.cn/xinwen/2020-08/09/5533568/files/627e5832aa9340858ee96a4a2be5d9eb.pdf. Accessed 30 September 2020.
[93] National Development and Reform Commission (2020) Announcement on the Public Consultation of the Catalogue of Industries Encouraging Foreign Investment 2020 Draft Version (in Chinese). https://www.ndrc.gov.cn/hdjl/yjzq/yjfk/glwstzml/202009/t20200904_1237659.html. Accessed 30 September 2020.
[94] National Business Daily (2020) National Development and Reform Commission: the Catalogue of Industries Encouraging Foreign Investment 2020 Will be Published before the End of the Year (in Chinese). http://www.nbd.com.cn/articles/2020-10-20/1527090.html. Accessed 30 September 2020.

increase as more capital is injected in it, and where market-oriented operation mechanisms, in return, will speed up industrial growth.

4.2.4 Civil-Military Integration Policy

Together with the above-mentioned policies, another policy of relevance to the development of commercial space activities in China is the Civil-Military Integration (CMI) policy. The CMI was first laid out in the *Suggestions for the Thirteenth Five-year Plan for National Economic and Social Development* which was released by the government in 2015.[95] The Plan recommended the creation of synergies between civil and military stakeholders as a way of accelerating indigenous innovation in several dual-use sectors, including space. This policy was further detailed in the *Opinions on the Integrated Development of Economic and National Defense*[96] whereby civil-military integration was promoted to a national strategy. With specific respect to space, this latter document called for better connecting China's defense industrial base with civil private space businesses in the areas of satellite data sharing, remote sensing resources integration, and dual-use navigation services.

In order to effectively promote civil-military integration, the Central Civil-Military Integration Development Committee was established in 2017, with two meetings held as of 2020: one in June 2017 and the other in March 2018. These meetings further set forth a central-local government system for civil-military integration where the central government provides top-level overall planning, and the local government provides in-depth implementation measures and policies applicable to each administrative jurisdiction. Accordingly, more than 28 local governments have released their local policies to promote civil-military integration. Most of these local policies include support for supplementary facilities, and financial support for civil-military projects and programs in investment, manufacturing, establishment and the like. However, these policies vary from each other and apply only locally.[97] Among the various initiatives undertaken at provincial government level, there are also several relevant projects devoted to stimulating commercial space development. Important examples include the investment frameworks for the Comprehensive Development Base of the Space Industry created in Beijing, Shanghai and Wuhan. A more detailed overview of these initiatives is provided in Annex B.

Apart from the impact on commercial space development at both central and provincial level, the civil-military integration policy has also profoundly influenced the scoping of the regulation-making framework. Previously, both military authorities, the State Council and Ministries under the Council, were empowered to establish regulations, a mechanism that, however, had caused several conflicts over the years. The drafting process of the *Aviation Law and National Defense Mobilization Law (ANDML)* offer clear evidence of the potential ambiguities in regulation-making processes. With the CMI, however, the law was amended by the National People's Congress (NPC), clarifying that the State Council and the Central Military Commission may jointly issue national defense regulations. Moreover, the CMI policy further encouraged relevant authorities to revisit the current regulatory framework and to abolish or update outdated regulations such as, for instance, the *Measures for Military Products Pricing* and the *Measures for National Defense Research Project Pricing*, which were both formulated in the 1990s, but were now ill-fitted to address the current commercial market.[98]

[95] Central Committee of the Communist Party, Suggestions for the Thirteenth Five-year Plan for National Economic and Social Development (in Chinese). http://www.gov.cn/xinwen/2015-11/03/content_2959432.htm. Accessed 30 Jan 2020. Accessed 30 September 2020.
[96] CPC Central Committee, State Council, Central Military Commission (2016) Opinions on the Integrated Development of Economic and National Defense (in Chinese).
http://www.gov.cn/xinwen/2016-07/21/content_5093488.htm. Accessed 30 September 2020.
[97] Lu, Zhuoyan (2020). Chinese Space and Security Policy: An Overview. In: Schrogl, Kai-Uwe. Handbook of Space Security. Springer Nature Switzerland AG, 2020, p 519.
[98] Ibid.

4.2.5 Other policies and initiatives benefitting commercial space

Apart from the policies in support of private and commercial space activities in China as outlined above, other government policies are worth noting for their potential to generate positive spill-over effects on the development of commercial space activities in China. These include:

- Long-Term Space Transportation Roadmap. In 2017, the China Aerospace Science and Technology Corporation (CASC) released the Roadmap for *Space Transportation System Development 2017-2045*, in which the systematic planning of the capacity-building and development blueprint of space transportation are envisaged. In fulfilling the goals of the Roadmap, commercial space transportation and private sector involvement are deemed indispensable.
- Plan for IT infrastructure. On 20 April 2020, the National Development and Reform Commission published a new plan for IT infrastructure, which specified that the communication network infrastructure includes several sectors such as Satellite Internet, 5G, Internet of Things and Industrial Internet.[99] This was the first time since the central government proposed to accelerate the construction of new infrastructure that satellite Internet was explicitly included in the scope of "new infrastructure" of the nation. Later in May 2020, Shanghai announced the action plan for new infrastructure construction from 2020 to 2022 and as a new generation of network infrastructure, Satellite Internet was included in the action plan. Coordination among all forces of state-owned enterprises and private enterprises to better implement the policy was encouraged.[100]
- Made in China 2025. Launched in May 2015, Made in China 2025 is ten-year strategic plan that aims to deeply improve China's manufacturing capabilities in key industrial sectors, including aerospace. The plan puts an emphasis on B2B and B2C innovation and the contribution of private actors to service delivery. The competitiveness of the Chinese space industry in the world is highlighted in the report, which further requires the speeding-up of commercial and private space development.
- Belt and Road Initiative. Launched in 2013, the Belt and Road Initiative (BRI) is an ambitious infrastructure development framework to promote economic development and inter-regional connectivity along the land and sea routes from China to the Middle East and Africa. The initiative is intended to promote large infrastructure projects, including space infrastructure through the Belt and Road Spatial Information Corridor. Already in 2018, 10 virtual Earth observation ground stations in countries along the Belt-and-Road were installed.[101] It is expected that the BRI will help provide commercial opportunities for Chinese companies, including both space SOEs and private space entities.
- Forum on China-Africa Cooperation. The general settings of the forum provide another window open for private space companies to win contracts in international space markets. For instance, China HEAD Aerospace Technology Co. has built a commercial satellite ground station in Ethiopia for receiving Superview data102. Additionally, HEAD has been providing data processing software and training for Ethiopian engineers.

[99] Ministry of Commerce (2020) The National Development and Reform Commission Defines the Scope of New Infrastructure for the First Time (in Chinese). http://www.mofcom.gov.cn/article/i/jyjl/e/202004/20200402957398.shtml. Accessed 30 September 2020.
[100] Xinhua News (2020) New Infrastructure of Satellite Internet Requires Nation-Level Regime Design (in Chinese). http://www.xinhuanet.com/2020-04/29/c_1125920571.htm. Accessed 30 September 2020.
[101] "China Creates Virtual Ground Stations In Ten Countries For EO Data." SpaceWatchGlobal, https://spacewatch.global/2018/09/china-creates-virtual-ground-stations-in-ten-countries-for-eo-data/. Accessed 18 September 2020.
[102] Nyirady, Annamarie. "China's HEAD Aerospace Technology wins contract for Ethiopian Ground Station." *Via Satellite*, 28 January 2019, https://www.satellitetoday.com/ground-systems/2019/01/28/china-aerospace-technology-wins-contract-for-ethiopian-ground-station/. Accessed 18 September 2020.

All these policies and initiatives, while not directly targeting the development of commercial space activities in China, are bound to be of at least indirect benefit to further development.

4.3 Regulatory Frameworks in Support of Commercial Space Activities

4.3.1 National Space Legislation and International Obligations

Currently China does not have a national space legislation, despite being listed as an item under the consideration of the National Congress. Nonetheless, it is worth acknowledging that the importance attached to this item has been growing over the past years. Whereas in 2013, the Standing Committee of the Congress concluded that the legislative circumstances in the 12th legislative plan were not mature for a national space law[103], five years later the Committee, in its 13th legislative plan, asserted that work for a draft of national space legislation would be needed and that the draft should be ready when the conditions require it.[104] The new priority put on space law and the underlying trends reflect developments that have taken place in the domestic space industry, i.e. the increase of private actors and private capitals.

The change of legislative priority and prerequisite condition largely reflects the most recent commercial space developments in the country, principally the increasing participation of private space actors and the growth of private capital. Apart from the driving force stemming from national space industry development, the necessity to draft a national space legislation also derives from international obligations that the country has under various treaties it has ratified and signed. China is a Member State to four of the five international space treaties, namely the Outer Space Treaty[105], the Rescue Agreement[106], the Liability Convention[107], and the Registration Convention[108].

Two obligations deserve particular attention. On the one hand, pursuant to Article VI of the Outer Space Treaty, a state shall bear international responsibility for activities in outer space whether carried by governmental agencies or by non-governmental entities. The treaty further stipulates that for activities of non-governmental entities in outer space, the State Party shall authorize and provide continuing supervision of them. Although national space legislation and regulation are more than implementation of an authorization and supervision process, this article is the foundation of a national licensing and authorization requirement, and acts as the starting point for discussion of the necessity of a national space legislation.

[103] The National People's Congress, Legislative Plan of the Standing Committee of the 12th National People's Congress (in Chinese). http://www.npc.gov.cn/zgrdw/npc/lfzt/2014/2013-10/31/content_1875001.htm. Accessed 30 September 2020.
[104] The National People's Congress, Legislative Plan of the Standing Committee of the 13th National People's Congress (in Chinese). http://www.npc.gov.cn/npc/c30834/201809/f9bff485a57f498e8d5e22e0b56740f6.shtml. Accessed 30 September 2020.
[105] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty, OST), adopted on 27 January 1967 by UNGA Res. 2222(XXI); opened for signature on 27 January 1967; in force on 10 October 1967, 610 UNTS 205, http://www.oosa.unvienna.org/pdf/publications/ST_SPACE_061Rev01E.pdf. Accessed 30 September 2020.
[106] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement, RA), Adopted 19 December 1967 by UNGA Res. 2345(XXII); opened for signature 22 April 1968; in force 3 December 1968, 672 UNTS 199, 19 UST 7570, TLAS 6599, http://www.oosa.unvienna.org/pdf/publications/ST_SPACE_061Rev01E.pdf. Accessed 30 September 2020.
[107] Convention on International Liability for Damage Caused by Space Objects (Liability Convention, LC), Adopted on 19 November 1971 by UNGA Res. 2777(XXVI); opened for signature on 29 March 1972; in force on 1 September 1972, 961 UNTS 187, 24 UST 2389, 10 ILM 965 (1971), http://www.oosa.unvienna.org/pdf/publications/ST_SPACE_061Rev01E.pdf. Accessed 30 September 2020.
[108] Convention on Registration of Objects Launched into Outer Space (Registration Convention, RC), adopted on 12 November 1974 by UNGA Res. 3235(XXIX); opened for signature on 14 January 1975; in force on 15 September 1976, 1023 UNTS 15, 28 UST 695, TIAS 8480, http://www.oosa.unvienna.org/pdf/publications/ST_SPACE_061Rev01E.pdf. Accessed 30 September 2020.

On the other hand, the Liability Convention provides that a launching state shall bear absolute liability for damage caused by its space object on the surface of the Earth or to aircraft in flight, and apart from launching or procuring a launch, the treaty also identifies a launching state as one from whose territory or facility a space object is launched. In this case, the launching state refers either to the state launching or procuring the launch, or to the state from whose territory or facility a space object is launched. Consequently, regulation and management of activities undertaken by private space entities from a national level is quite necessary.

Whereas the participation of private actors in space was never on such an extensive scale as to require a legislative action, this has dramatically changed in recent years. With the increasing numbers of private space entities and the variety of activities they participate in, regulatory needs accumulate and the call for national space legislation is also required for conformity with international space treaties. The kick-off work for proposing a national space legislation in China started in 1998, but now with the legislative plan for a space legislation upgraded to an important level, it is expected that in the near future China will form the law regulating space activities.

Meantime, in the absence of a national space legislation, space activities in China continue to be regulated and managed through several regulatory instruments and policy documents. These include the *Measures for Space Object Registration* of 2001 and the *Interim Measures for the Administration of Civil Satellite Projects* of 2002. These administrative regulations, while deemed insufficient to meet the development of a private space industry, provide specific rules and guidance for the various space actors to follow, including private ones. Some more specific measures for the private space sector have also been enacted.

4.3.2 Regulatory Measures for Commercial Launch Activities

Following the release of the Guidance on Innovation of Investment and Financing Mechanisms in Key Fields to Encourage Private Investment[109] in 2014 and the other follow-on measures by the central and local governments, the commercial launch sector in China experienced an intense period of growth, with a dozen private launch companies, fully or majorly funded by private capital, established since the issuing of the policy. Among them, one private space company, founded in 2016, has been capable of undertaking three successful launches including two suborbital launches and one orbital launch within 3 years. In 2018, the total number of commercial launches reached 13.[110]

Private launch companies require administrative guidance on the process of applying for a licence for testing and for launching. They need and demand certainty in regulatory measures regarding launch activities. As the Interim Measures on the Administration of Licenses for Civil Space Launch Projects[111], provided in 2002, could not meet the needs of both the commercial launch industry side and the administrative management side, the Notice on Promoting the Systematic and Orderly Development of Commercial Launch Activity[112] was published in 2019 by the State Administration of Science, Technology, and Industry for National Defense (SASTIND).

The Notice clarifies the applicable scope of commercial launch activities. It was formulated so as to explicitly include any companies conducting launch related activities by means of self-funding, private funding or other joint venture capital, which means that compared with the 2002 Interim Measures, where

[109] See Section 5.2
[110] National Business Daily (2019) The development of commercial aerospace is in the ascendant with the help of new policies (in Chinese). http://www.nbd.com.cn/articles/2019-06-11/1342005.html. Accessed 30 September 2020.
[111] National Defense Commission of Science, Technology and Industry (2002) Interim Measures on the Administration of Licenses for Civil Space Launch Projects (in Chinese). http://www.miit.gov.cn/n1146295/n1652858/n7280902/c3554585/content.html. Accessed 30 September 2020.
[112] SASTIND (2019) Notice on Promoting the Systematic and Orderly Development of Commercial Launch Activity (in Chinese). http://www.gov.cn/xinwen/2019-06/17/content_5400951.htm. Accessed 30 September 2020.

civil launch projects are defined as non-military and the sources of funding are not mentioned, emphasis in the notice was placed on capital sources and private funding. For commercial launch services, the notice further distinguishes between scientific research licenses and manufacture licenses[113]: whereas the former license applies to research and testing launches, the latter allows for production and manufacturing activities. The Notice here seems to bridge the gap that has been left by the previous Interim Measures, where the category of license is grouped as solely for launch. This two-type of license introduced by the Notice can be seen as a response to the actual needs of industry, especially the requests from private launch companies to conduct research and testing launches before engaging in actual manufacturing.

Lastly, the Notice requires that commercial launch companies shall provide specific information when applying for launch licenses under the Interim Measures, regarding orbit and frequency registration and coordination, space debris mitigation measures, safety measures, third-party liability insurance and other commercial insurance status. [114] Detailed criteria are not expressly laid out, *e.g.,* there is no in-depth guidance on the coverage of maximum probable loss and compensation measures. Still, setting the above-mentioned points as application prerequisites enables the authorities to further review safety and financing issues. Comprehensive measures and regulations on commercial launch activities should follow up to complement the existing framework established by the Notice and the Interim Measures.

4.3.3 Regulatory Measures for Spectrum Allocation

In China, radio frequency matters are managed through a top-down, central-local approach, separating civil from military uses. [115] For the use of non-military radio systems, the central management is under two authorities:

- the Ministry of Industry and Information Technology (MIIT)´s National Radio Administration Bureau (NRSA), which is responsible for the preparation of radio spectrum plans, radio frequency allocation and assignment, supervision of radio stations and radio interference, coordination of satellite orbits and the local-military radio management.
- the MIIT State Radio Monitoring Center (SRMC), which has responsibility for testing and certifying radio equipment, monitoring radio signals, positioning the interference radio and providing technical support for national radio management authorities and local radio management departments.

For management at the local government level, each local Radio Administration Office is responsible for the implementation of national radio policy, regulation and provision, and is entitled to set local radio management rules and licenses for radio stations, and to coordinate radio management matters in the local jurisdiction.

From a policy perspective, in 2016 the MIIT released the 'National Radio Management Plan' (2016-2020). In the Plan, it is reinforced that the government shall also work to improve the legal environment that governs radio spectrum activities. This includes amending the Radio Regulation, cooperating with judicial authorities for the interpretation of Article 288 of the Criminal Law of People's Republic of China, and propelling the legislation of radio activities when appropriate.

At legislative level, the 'Property Law of the People's Republic of China' stipulates that the ownership of radio frequency spectrum resources shall be regulated by the state. For illegal use of the resource, the Criminal Law of 1997 includes the crime of disturbing radio communications, while in 2015 the law was amended to include activities that set up or use a radio station or a radio frequency without authorization,

[113] Ibid. Section 2(1).
[114] Ibid section 3(2).
[115] This section draws on the author's paper: Lu, Zhuoyan (2020). Chinese Space and Security Policy: An Overview. In: Schrogl, Kai-Uwe. Handbook of Space Security.Springer Nature Switzerland AG, 2020, pp. 521-523.

and in violation of State regulations, to interfere with the order of radio communication; such an activity causes severe consequences and is subject to penalties. Moreover, the Administrative License Law of the People's Republic of China (2019 amendment) regulates the general establishment and implementation of the administrative license related to radio management. In addition, the Public Security Administrative Punishments Law of the People's Republic of China (2012 amendment) stipulates the obligation of non-interreference to any normally operating radio stations.

The major regulations for radio spectrum management in China comprise: the Radio Regulations, the Radio Control Provisions, the Radio Spectrum Allocation Provisions and other regulations, provisions, measures and notices from the Ministries of the State Council. Currently there are more than 50 regulations and normative documents issued by the State Council, which are important supplements to the regulations on radio administration.

4.3.4 Other Measures Relevant to Commercial Space Activities

In addition to the on-going work of national space legislation, and the measures formulated for commercial launch activities and spectrum management, there are some other regulatory and administrative instruments that have an influence on commercial space activities in China.

Among those particularly relevant from the perspective of commercial space activities are the regulations and measures related to space debris mitigation and space object registration. With respect to debris mitigation requirements, the 2002 Interim Measures require civil space launch applicants to provide, alongside their applications, supplementary documents on measures to avoid the generation of space debris and prevention of contamination of the space environment.[116] The same requirement is reiterated in the notice of 2019[117].

Since 2016, compliance with space debris mitigation measures has been required also for satellite activities, in addition to launch activities. More specifically, the Interim Measures for the Administration of Civil Satellite Projects of 2016[118] requests entities involved in satellite businesses to undertake their activities in accordance with the Interim Measures of 2002. The SASTIND supervises and manages the work of space debris mitigation and safety of civil spacecraft and launch vehicles, and also organizes the formulation of relevant measures and standards. However, the application scope of this instrument is limited to civil scientific and commercial satellites, and other engineering projects approved by the State Council or relevant Departments of the State that fully or partly use central financial funds.[119]

Additionally, in 2016, the Ministry of Finance (MOF) together with the SASTIND issued the Interim Measures for the Administration of Post-Subsidy for National Defense Science, Technology and Industry Research Projects[120] to further encourage innovation and developments in national defense science, technology and industry. Predominantly, this enables legal entities, research institutions and universities

[116] See supra, article 6(4) of the Measures
[117] SASTIND (2019) Notice on Promoting the Systematic and Orderly Development of Commercial Launch Activity (in Chinese). http://www.gov.cn/xinwen/2019-06/17/content_5400951.htm. Accessed 30 September 2020.
[118] SASTIND (2016) Interim Measures for the Administration of Civil Satellite Projects (in Chinese). http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/35861/36552/xgzc36558/Document/1549898/1549898.htm. Accessed 30 September 2020.
[119] Lu, Zhuoyan (2020). Chinese Space and Security Policy: An Overview. In: Schrogl, Kai-Uwe. Handbook of Space Security.Springer Nature Switzerland AG, 2020, p 521
[120] MOF, SASTIND (2016) Interim Measures for the Administration of Post-Subsidy for National Defense Science, Technology and Industry Research Projects (in Chinese). http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/wg2016/wg201610/201703/t20170317_2559983.html. Accessed 30 Jan 2020.

that are registered in China to obtain funds from a central budget. It further establishes 10 applicable scientific fields eligible for this funding, with space debris scientific research being one of them.[121]

With respect to space object registration, the most relevant regulatory instrument is the Measures for Space Object Registration[122]. The scope of the instrument applies to all space objects launched from the territory of China, or where China is a joint launching state for a launch from a foreign territory.[123] Furthermore, the document provides the definition of the term "space object" as satellites, spacecraft, space probe, space station, space carrier including the part thereof and any other artificial objects entering into space.[124] Consequently, any space entity or natural person, regardless of public or private purposes , must conform to the requirements and obligations set forth in the instrument, and commercial space participants are within the domain. According to this regulatory document, it is required that SASTIND shall maintain a space object registry containing the necessary features of space objects. Apart from the great advantages of maintaining a space registry, there are additional benefits, such as providing space object identification and collision risk analysis and facilitating mitigation during post-mission disposal. Also, in the long run these rules will considerably benefit the establishment of a future space traffic management regime. With the number of space objects blooming in the commercial space era, a regime for space traffic management will be of great need sooner or later.

4.4 Conclusion

The development of commercial space activities in China has historically been under the remit of government-led corporations. While SOEs are still the main driving force behind commercial space practices, the release of the 2014 policy on stimulating private investment in space sector has marked a significant and far-reaching change for the future of the Chinese space industry.

Since then, the engagement of private actors in commercial space endeavour has been not only formally recognised but also actively supported with a plethora of policies and regulatory tools. These policies have successfully sparked the development of a vibrant private space sector in China. To illustrate, over 70 private investors funded around 30 space start-up projects in 2018. In the same year, according to a publication of Future Aerospace, China had 141 commercial space companies registered, of which 123 were private and 61 of them had been founded in the previous three years.[125] These newly-founded space enterprises cover a wide range of industry clusters, from launch to various satellite applications. Geographically they are grouped around Beijing, Xi'an, Shanghai and other administrative regions, with Beijing accounting for over one half of the total.

These blooming industry developments over the past 5 years represent the positive influence of governmental actions in the sector. Nonetheless, it remains undeniable that the journey has just begun. Just as with the inception of private launching services, private/commercial space industry development still largely depends on facilities and infrastructures provided by the public sector, and therefore, there is still a long way to go.

Looking at the future, the policy trend in China's space sector will remain as it is now, which is to promote commercial space activities and to stimulate private and foreign investment in the sector. However, the

[121] Lu, Zhuoyan (2020). Chinese Space and Security Policy: An Overview. In: Schrogl, Kai-Uwe. Handbook of Space Security.Springer Nature Switzerland AG, 2020, p 521
[122] SASTIND (2001) Measures for Space Object Registration (in Chinese). http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/2013/20131216/xgzc29845/Document/1354170/1354170.htm. Accessed 30 September 2020.
[123] Ibid., article 3.
[124] Ibid., article 2.
[125] National Business Daily (2019) The development of commercial aerospace is in the ascendant with the help of new policies (in Chinese). http://www.nbd.com.cn/articles/2019-06-11/1342005.html. Accessed 30 September 2020.

policy process of opening-up will certainly not be completed in one move; instead, it will be gradually implemented.

NEW SPACE IN INDIA

5 Commercial space ecosystem and trends in India

By Narayan Prasad, Co-founder, Satsearch

The Indian space industry is growing rapidly, both due to reforms undertaken at state level to open up the sector to greater involvement of the private sector, and increased penetration of space-based solutions to address the country's pressing challenges. In 2015, more than 1,500 officials of the central and state governments gathered at a national meeting in New Delhi where they identified 170 projects that can leverage space-based technology in areas such as agriculture, energy and environment, infrastructure planning, water resources, technology diffusion, developmental planning, communication and navigation, weather and disaster management, health and education.[126] With a growing population of over 1.3 billion people and over 600 million internet users at present,[127] India is also seen as a significant growth market for the global space industry, offering opportunities for domestic and international stakeholders.

5.1 Introduction

The relationship between India's private sector and the space programme, which is primarily run by the government space agency, the Indian Space Research Organisation (ISRO), began in the 1970s. The engagement was primarily based on the private sector taking on some of the manufacturing activities required by ISRO, and not in the framework of incentives to develop Intellectual Property (IP) independently of ISRO. Since the number of missions conducted by ISRO was quite limited and the risk of failure was quite large, private sector involvement was limited to the following situation: proven IP developed by ISRO was transferred to suppliers willing to invest in the machinery and manpower necessary for the manufacturing. Relevant buy-back schemes were introduced to ensure that there were orders for these companies to receive reliable business from ISRO.[128]

This arrangement meant that ISRO was the main service provider who also built satellites and rockets, and the private sector was only involved in "build-to-print" or other manufacturing/outsourced manpower supply tasks within the nation's space activities. This arrangement worked well to keep the risk low for the industry, since the volume of space missions was also low. However, within the last decade, ISRO has been steadily increasing the number of its missions and this current engagement model is not allowing the greater participation of the private sector in the national space program.

[126] M. Aggarwal and N. Mehta, "Govt partners Isro on 170 projects to use space technology," mint, Sep. 08, 2015. https://www.livemint.com/Politics/IP1TRsmiAhFaec0ouZdi2M/Govt-partners-Isro-on-170-projects-to-use-space-technology-f.html (accessed Sep. 26, 2020).
[127] "Internet users in India to reach 627 million in 2019: Report," The Economic Times. https://m.economictimes.com (accessed Sep. 26, 2020).
[128] K. R. S. Murthi and M. K. Rao, "India's Space Industry Ecosystem: Challenges of Innovations and Incentives," New Space, vol. 3, no. 3, pp. 165–171, Aug. 2015, doi: 10.1089/space.2015.0013.

Figure 5-1 provides an illustration of the India's supply chain for space infrastructure development. The private industry in India is participating mostly as Tier-2/Tier-3 vendors (i.e. build to print manufacturers, component level / subsystem level suppliers) in the space program, there were no specific schemes/incentives for ISRO that allowed them to graduate to a level of full satellite/launch vehicle manufacturers. It is widely acknowledged that there are about 500 firms that are local to India that support the Indian space program.[129] However, as of yet none of them have been able to mature beyond the original form of engagement with ISRO, to enable them to design, develop, build, launch, and operate an entire mission by themselves.

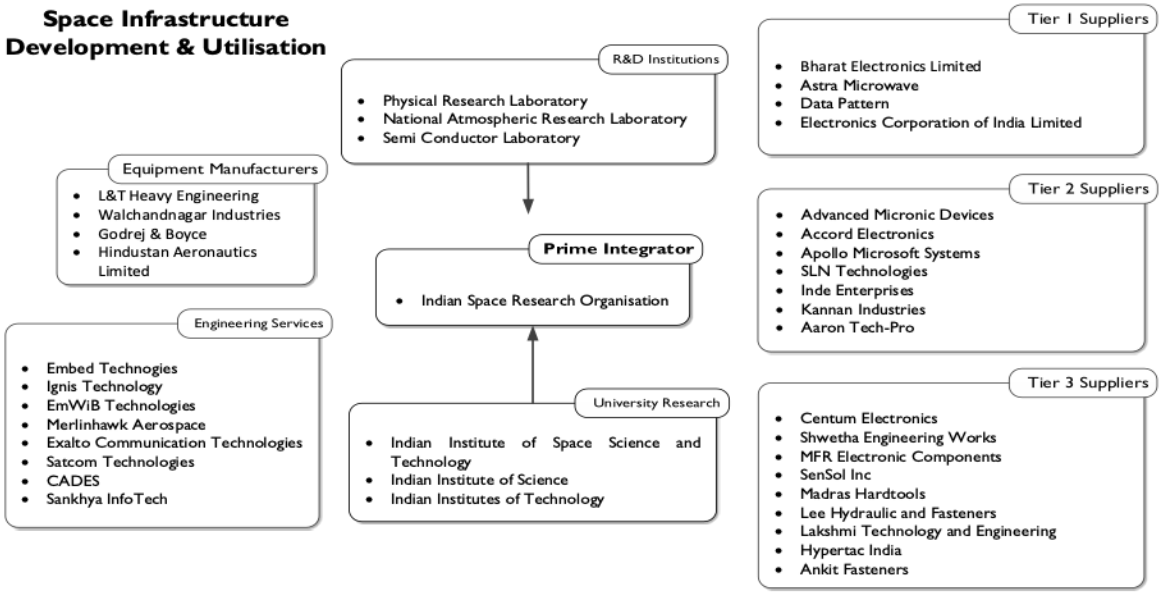


Figure 5-1: An illustration of India's supply chain for space infrastructure development

No specific change in procurement process or incentives has been implemented over the past five decades that allow risk taking, subsidy or incentivization for the private sector to create original IP with state-support, to enable the emergence of an Original Equipment Manufacturer (OEM) in the private sector in India. The conflict of interest with ISRO/Department of Space (DoS) being both the regulator and an operator has also not helped in this process.

More recently, the Government of India (GoI) announced a wave of reforms that include establishing the Indian National Space Promotion and Authorisation Centre (IN-SPACe), an "autonomous nodal agency under the Department of Space" that will provide the necessary support for the private space industry to conduct its activities.[130] IN-SPACe is said to have its own independent directorates for technical, legal, safety and security, and monitoring activities, as well as an "activities promotion unit" to assess private players' requirements and coordinate activities. IN-SPACe's outlook for now appears to be that of a 'regulator', functioning as an independent body under the DoS.[131]

5.2 Shifting dynamics in the space industry

[129] "ISRO Chairman K Sivan asserts that space sector reforms are not aimed at privatising the agency," Business Insider. https://www.businessinsider.in/science/space/news/space-sector-reforms-not-aimed-at-privatising-isro-chairman-k-sivan/articleshow/77653759.cms (accessed Sep. 26, 2020).
[130] A. Sinha, "IN-SPACe explained: what it means to the future of space exploration," The Indian Express, Jun. 28, 2020. https://indianexpress.com/article/explained/in-space-india-space-missions-private-participation-isro-6476532/ (accessed Sep. 26, 2020).
[131] "IN-SPACe to be new space industry regulator, says ISRO chief Sivan," The Hindu, Bengaluru, Jun. 25, 2020.

Space activities are generally driven by the mandate of the federal government in India; regional/state governments are mostly end-users of space-based services established by ISRO. State governments have the ability to come up with requirements that shall use space-based assets within the bounds of their own jurisdiction. These requirements are often presented to ISRO which then uses its satellites to provide those solutions to the States.

For example, the Bihar government (a state in India) requested technical support for real-time assessment and monitoring of natural calamities like flood, drought-like situations or earthquakes. The agreement is with the state's disaster management authorities and with ISRO.[132]Some of the states have established exclusive Regional Remote Sensing Service Centres (RRSSCs) to support various remote sensing tasks specific to their jurisdiction. They support areas that pertain to natural resources, like agriculture and soils, water resources, forestry, oceanography, geology, environment and urban planning.[133]

These regional initiatives are mostly centered around Earth Observation (EO) and very little is based around communications. Initiatives around the Indian regional navigation satellite system (NAVIC) are developing slowly, with states like Tamil Nadu working with ISRO to provide fishermen with satellite-enabled communication devices. In 2018, there were reports of 80 fishing boat groups fitted with 200 ISRO-developed, NAVIC-enabled messaging devices by the Tamil Nadu government, that will provide them real-time alerts on cyclones and weather updates.[134]

The most recent notable initiative of regional governments taking interest in space is SpacePark Kerala, an initiative of the Government of Kerala to create a New Space economic hub in India for space-based activities. Under this initiative, the Kerala government will set up the country's first state-of-the-art space systems park in Thiruvananthapuram, to attract global startups working in the space sector and also serve as a major manufacturing hub for space-related technology, applications, research and development. The government transferred 20.01 acres as lease to Kerala State Information Technology Infrastructure Ltd (KSITIL) to develop the space park.[135]

One of the major developments in the recent past has been the interest from international suppliers to partner with local Indian entities to be able to enter the Indian market. There are two main notable announcements for satellite manufacturing so far. They are:

- Azista - BST Joint Venture: Berlin Space Technologies, small satellite manufacturer based in Germany has teamed up with Azista Industries (India) to build a factory to mass manufacture small satellites in the range of 50-150 kg in India. The joint venture is currently building a pioneer facility that has an annual production capability of up to 250 satellites. The factory is located in Ahmedabad close to ISRO's Space Application Centre (SAC) and offers 50,000 square feet floor space.[136]
- Ananth Technologies: Ananth Technologies claims that a satellites Assembly, Integration and Test (AIT) facility is being readied for a start of operations in 2020. Located at the Aerospace Park in Devanahalli, Bangalore, this facility will cater to satellites up to 2,000 kg. It intends to support up to 450 kg class satellite with environmental testing and 2,000 kg class for complete assembly and integration. Ananth Technologies recently announced a partnership with Lithuania based

[132] R. K. Thakur, "'Bihar to launch Health Emergency Operating Center in collaboration with ISRO,'" The New Indian Express. https://www.newindianexpress.com/nation/2020/apr/25/bihar-to-launch-health-emergency-operating-center-in-collaboration-with-isro-2135336.html (accessed Sep. 26, 2020).
[133] H. Vardhan, "Regional remote sensing centres in India and their locations," Geospatial World, Mar. 04, 2017. https://www.geospatialworld.net/blogs/regional-remote-sensing-centres-india/ (accessed Sep. 26, 2020).
[134] "Tamil Nadu Fishermen Get ISRO-Made Gadgets For Real-Time Weather Alerts," NDTV.com. https://www.ndtv.com/tamil-nadu-news/tamil-nadu-fishermen-get-isro-made-gadgets-for-real-time-weather-alerts-1964008 (accessed Sep. 26, 2020).
[135] "India's first Space Park to come up in Kerala," Deccan Chronicle, Jul. 20, 2019. https://www.deccanchronicle.com/nation/current-affairs/200719/indias-first-space-park-to-come-up-in-kerala.html (accessed Sep. 26, 2020).
[136] T. Segert and S. Attara, "Mass Manufacturing of Small Satellites, Gearing up for the Henry Ford Moment," Small Satellite Conference, Aug. 2019, [Online]. Available: https://digitalcommons.usu.edu/smallsat/2019/all2019/265.

nanosatellite manufacturer NanoAvionics to potentially produce satellites and vertically integrate to launch them on Indian rockets.[137]

5.2.1 New Space start-ups

The most prominent development in the Indian space sector is the emergence of several New Space startups over the past 10 years. Today there are about 50 new startups that have emerged that span both the upstream and the downstream segment of the space industry value chain. Figure 5-2 provides a brief overview of the most notable and prominent Indian startups, while a more detailed overview of the breakdown by sector of these companies is provided in Figure 5-3.

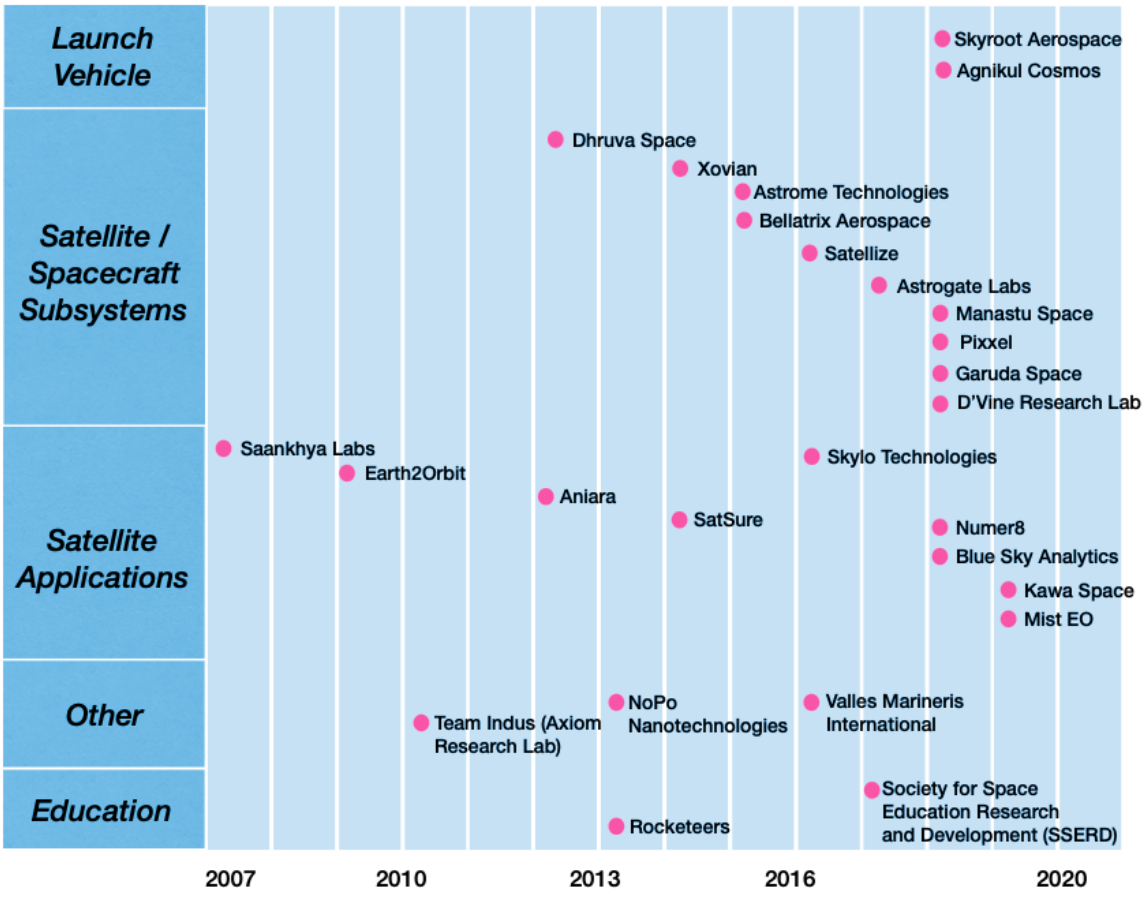


Figure 5-2: Landscape of New Space start-ups in India

New Space startups in India are leveraging local conditions in India which can make it a great place for building a space business as a startup. India has experienced space scientists who have been nurtured in an ecosystem that has 60 years of space mission experiences. India has perhaps one of the youngest groups of entrepreneurs among space startup hubs around the world, who are envisioning solving problems that are based on developing original IP for space-based products/services. They are looking to leverage the established small and medium enterprises landscape, currently catering to ISRO's supply chain of manufacturing and testing of satellites and rockets. The startups also have good access to

[137] "NanoAvionics Enters Indian Space Market With Ananth Technologies Partnership," Via Satellite, Sep. 17, 2020. https://www.satellitetoday.com/business/2020/09/17/nanoavionics-enters-indian-space-market-with-ananth-technologies-partnership/ (accessed Sep. 26, 2020).

academic institutions and can employ world-class human resources produced by dedicated space-focused universities such as the Indian Institute of Space Science and Technology (IIST).

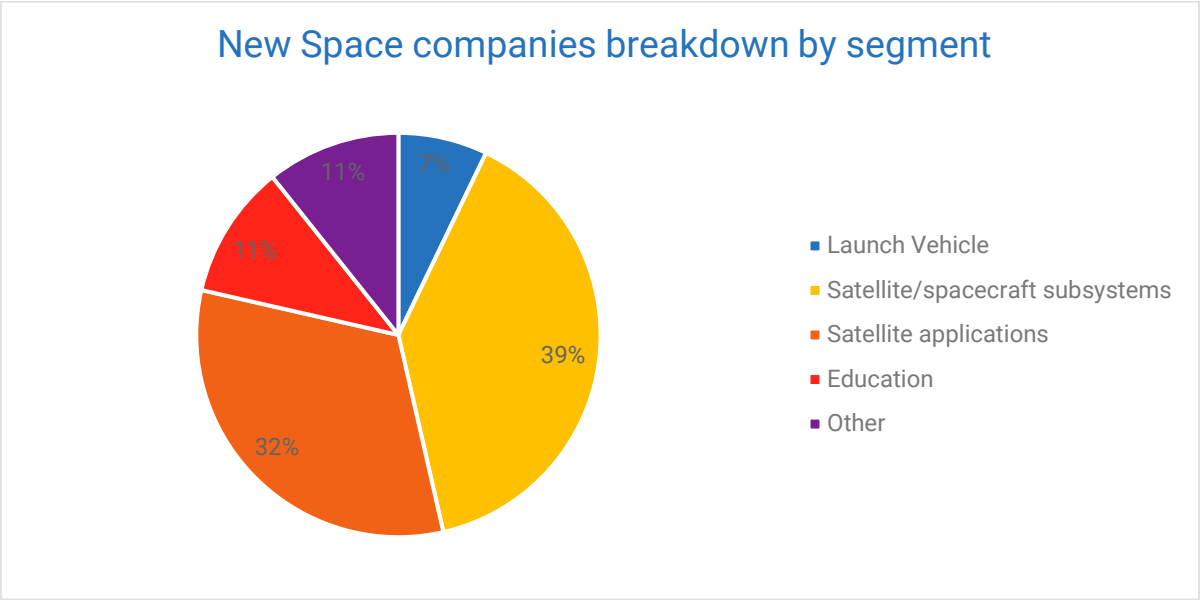


Figure 5-3: India´s New Space companies breakdown by segment

5.2.2 Key features of New Space startups from India

There is a healthy mix of startups across the value chain addressing different issues across the space industry that the New Space startups in India are addressing. One of the key features of the some of New Space startups in India are their ability to understand the gaps in the local market that can be filled by them with either inventing their own products or services. Here are some examples based on the work on some of the startups.

- Bellatrix Aerospace – Indian satellites have traditionally featured chemical propulsion as their core means of delivering satellites to the right GEO and also for orbit maintenance. Bellatrix Aerospace identified the gap in the development of electric propulsion systems in India and addressed this by venturing itself in the development of Hall Effect thrusters. They also found support from ISRO for taking such an approach and were supported by giving them a contract to deliver their thrusters.[138]
- Blue Sky Analytics - One of the core challenges of several cities in India is the massive decrease in air quality leading to severe health problems to citizens. Blue Sky Analytics is addressing this problem alongside other challenges in addressing climate change by creating datasets that can act as standards for climate-based decision making across industries.[139]
- Skylo Technologies - Founded in Palo Aalto in the US by Indian founders, Skylo has invested in creating a major development center in Bangalore, India where it is addressing several core problems for farmers, fishermen, railways, trucking, etc., using satellite-based IoT. Skylo has recently rolled out its satellite-based solution that continuously collects environmental and machine metrics, letting Indian farmers to take immediate action when there is a problem and maximize productivity and yield of high-quality crops and livestock.[140]

[138] "This startup working with ISRO on satellite propulsion raises funding from IDFC-Parampara, Deepika Padukone, others," The Financial Express, Jun. 23, 2019. https://www.financialexpress.com/industry/sme/this-startup-helping-isro-reduce-satellite-launch-cost-raises-funding-from-idfc-parampara-deepika-padukone-others/1616340/ (accessed Nov. 22, 2020).
[139] S. Sangwan, "[Funding alert] Gurugram-based startup Blue Sky Analytics raises $1.2M led by BEENEXT," YourStory.com, Jul. 08, 2020. https://yourstory.com/2020/07/startup-funding-blue-sky-analytics-seed-round-beenext (accessed Nov. 22, 2020).
[140] Skylo Technologies, Skylo Helps Farmers Make Better Decisions. 2020.

One of the interesting aspects of the problems especially that the downstream companies are addressing is their ability to take the solutions to other developing world countries in South East Asia, Africa or Latin America where the challenges may be very similar to India. This can be a key aspect of scalability for New Space startups from India and also a critical differentiator against some of the startups that are emerging from Europe, US or Japan. Their understanding of the local problems and the price points at which they can deliver the solutions necessary may provide them a strong moot against competition from New Space startups from geographies such as Europe, US, Australia or Japan.

5.2.3 Challenges for investment in the private industry

Table 5-1 provides a brief overview of some of the most notable and prominent startups with estimated funding raised by each of them according to internet sources such as Crunchbase and news reports.

The majority of the investments so far for the New Space startups from India have come from local high net worth individuals or small venture capital funds.

Company	Offering	Incorporated	Funding ($m)
Skyroot Aerospace	Small satellite launch vehicle development	2018, Hyderabad	4.2
Agnikul Cosmos	Small satellite launch vehicle development	2017, Chennai	3.58
Dhruva Space	Development of small satellite platforms with a focus on AIT	2012, Bangalore	0.69
Bellatrix Aerospace	Satellite electric propulsion systems	2015, Bangalore	3.01
Astrome Technologies	Satellite constellation-based Internet connectivity	2015, Bangalore	3.0
Pixxel	Nanosatellite constellation for imagery and data analysis tools	2018, Bangalore	5.7
Skylo Technologies	Satellite-based IOT applications for farmers, fishermen, trucking, etc.	2017, Bangalore	$133
Kawa Space	CubeSat based satellites services	2019, Mumbai	0.6
Blue Sky Analytics	Air Pollution	2018, Gurgoan	1.2
Team Indus (Axiom Research Labs)	Lunar lander; Indian contender for Google Lunar X-Prize	2010, Bangalore	18.01

Table 5-1: Funding for Indian New Space companies

One of the challenges for several of the startups in the coming years will be the ability to raise $10m+ from funding sources. The only sources of such capital (given the perceived risk in the sector) can be from large corporates such as TATA, Mahindra, Reliance, etc., in India. It may be unlikely that VC funds that are local may invest such big investments in the upstream of the ecosystem and even if they do, their investment might be preferred in the downstream. The downstream will find preference in investment due to a mix of the opportunity size in terms of the market being very large (addressable markets are large), lower barrier to entry and regulation, lower risk of conflict of interest with ISRO.

In 2017, Hughes India was willing to invest $500 million in satellite systems to provide satellite-based connectivity in India. However, there was no progress in granting them permission.[141] There seems to be a positive sentiment more recently about Foreign Direct Investment (FDI) in space with ISRO welcoming it. [142]However, it may be likely that FDI in Indian startups may be easier to be cleared than global giants like Hughes, Lockheed, Airbus, etc., trying to invest in their own Indian subsidiaries for the space sector. This may be due to the fact that it might threaten ISRO's own position as a system integrator for launch vehicles, satellites and as a space-based service enabler. It is more likely that large players will choose to act as local service providers in India. For example, Airtel has recently announced that it will start providing broadband services in India using the OneWeb satellites by June 2022.[143] This route might be preferred by large players since they will only address the gaps in the downstream market and not have large conflict of interest with ISRO as satellite integrators. The mechanism to clear FDI through IN-SPACe still needs to be spelt out for providing clarity to global investors which areas will be qualified automatic clearance against which will have to undergo reviews within the space industry value chain.

5.3 Factors to mature space industry

It is currently not clear what the contributions of India's space efforts are to India's economy. IN-SPACe could consider formally instituting a division within itself involving social scientists, economists and space technologists to create a framework to map and monitor the contribution of space activities to the economy, through investments by the government as well as the private sector. This will bear fruits in the long run, if only policymakers will be able to make data-driven decisions. A rolling framework will also allow a yearly public review of activities, which will encourage transparent assessments and accountability. The framework could also determine the number of jobs supported by space activities, keep track of competitiveness on the global stage, and set a roadmap with clear goals to meet the country's governmental, scientific, and commercial needs.

ISRO has recently announced a new program for space startups called Space Enterprise Encouragement and Development (SEED) and intends to release a list of space technology products and services for the private sector to develop. These are encouraging developments. However, a comprehensive outlook at all aspects that affect the success of New Space actors has to be addressed for emerging activities to gain commercial traction. This also affects long term sustainability and scalability of commercial space activities in India. Based on the joint deliberations with several New Space startups in India through a new space industry association called SpaceFed.[144]

[141] "Hughes India open to $500 million investment in satellite systems," The Economic Times.
[142] "Govt to encourage FDI in space sector, allow overseas companies to make, launch satellites." https://www.timesnownews.com/business-economy/economy/article/govt-to-encourage-fdi-in-space-sector-allow-overseas-companies-to-make-launch-satellites/672371 (accessed Nov. 22, 2020).
[143] "OneWeb plans to offer broadband services in India by June 2022: Sunil Mittal," The Economic Times. https://economictimes.indiatimes.com/industry/telecom/telecom-news/oneweb-plans-to-offer-broadband-services-in-india-by-june-2022-sunil-mittal/articleshow/79329402.cms (accessed Nov. 22, 2020).
[144] K. Reddy, "How Space Federation of India is bringing private Indian space industry to the forefront," YourStory.com, Feb. 21, 2020. https://yourstory.com/2020/02/space-federation-of-india-spacetech-startups-private-isro (accessed Sep. 27, 2020).

Based on several stakeholders' meetings, the following issues have been identified as core issues that need immediate addressing by the government for the success of New Space activity in India.

- Stakeholder Representation
  - Active Start-up/SME participation in government policy and decision-making bodies.
  - Start-up/SME composition of IN-SPACe board and evaluation committee.
  - Co-development and co-funding of high stakes projects between SMEs and IN-SPACe.
  - Add a representation of the industry to the Space Commission
- Facility Utilization
  - Simplified usage of ISRO facilities with an online portal for requisitioning, booking and approval.
  - Start-ups to be charged minimally/actual cost basis on consumables and minimum insurance fee where there is concern on usage of expensive equipment.
  - IN-SPACe should work with industry in establishing clear guidelines to enable minimal premium for insuring Private Space activities from testing to operations and shall fix an upper cap in advance.
  - Open up ISRO infrastructure/facilities or establish separate rocket test zones to conduct model, amateur and experimental rocketry events, activities and competitions.
- White Paper on IN-SPACe to be released explaining
  - Role and function of IN-SPACe, approach to legal/regulatory, procedural and managerial elements; composition of IN-SPACe Board and Evaluation Committee.
  - Eligibility criteria and process for evaluation and acceptance/rejection of applications.
  - Goods and services that private sector will be authorized/permitted to integrate into the international supply.
  - Develop a long-term Policy Vision along with the Implementation Roadmap
- Regulatory Clearances & Licensing
  - Establishing clear licensing guidelines and provide single window clearance for all licensing requirements including, but not limited to launch, spectrum, operations of satellites/ground stations, etc.
  - Clearly defined timelines for responses on clearance/next steps via a portal.
  - Communication system providers should also be allowed to set up ground stations in India in a seamless manner for enabling more robust in-space testing.
- Data Access
  - EO data should be openly available and easily accessible to Indian companies for free to provide a world-class playing field to Indian operators.
  - There should be a licensing, audit and traceability mechanism built for facilitating the purchase of EO imagery directly from satellite operators or resellers.
  - High resolution EO data purchase threshold should be reduced to 50 cm from the current 1 m, as there are a lot of civilian applications.
- Funding and Market Creation
  - Constitution of a Space fund by the GoI to invest in emerging space start-ups on either equity basis or grant basis (Ministry of Agriculture recently did the same by allocating funds to support 112 agri-tech start-ups in India).

- Allow start-ups/MSMEs to directly take part in the RESPOND program, Announcement of Opportunities (AOs) and Expression of Interests (EoIs). These are currently only for academic institutions or have revenue prerequisites.
- Request for removal of Goods and Services Tax (GST) for launch of satellites manufactured in India by Indian launch vehicles in similar lines as foreign satellites launching from India. This would increase the competitiveness of Indian satellite manufacturers in the global marketplace.
- Create a dedicated program to strategically fund and support homegrown solutions which can replace current imports and enable development of new critical technologies or materials.

- Outreach & Capacity Building
  - Need for improved outreach by the Indian space program, to create a highly skilled human resource pool and enable students, enthusiasts and professionals to be able to closely participate in and view the Indian space program.
  - Individual ISRO centres should have a focused incubation centre on campus which would allow for better dissemination of knowledge.
  - Create a Comprehensive & Structured Space Education Program which can cater to students at various levels and enable them to become industry-ready. This will go hand in hand with the National Education Policy (NEP) 2020 and create a strong workforce for the space industry.
  - Opportunities for start-up/MSME participation in national and international space exhibitions and events
  - Create a knowledge repository covering the major aspects of space technologies for building satellites and subsystems, launch vehicles, ground segment equipment etc.
  - IN-SPACe could consider formally instituting a division within itself involving social scientists, economists and space technologists to create a framework to map and monitor space activities' contribution to the economy. This can help policy makers make data-driven decisions and keep track of competitiveness in global scale.

5.4 Conclusion

With over six decades of investments in the space sector, the ISRO has created tremendous capacity, which now acts as a foundation for New Space entrepreneurs to sprout in India. The recent reform announcement of the Government of India to support the rise of the private sector in the space industry is signalling that policymakers are keen to see the Indian private companies capture a share of the global space market. Entrepreneurs will take advantage of incentives wherever they are available for them. In the present setting, space entrepreneurs in India may just want to leverage the operating cost, the infrastructure and human resources available locally, and have local entities just to manage them. However, to solve some of the significant hurdles mentioned above, they will look to or have already created entities abroad. Ultimately, the government is set to lose out any tax revenue that is generated by them. It is very important that the proposed board for the promotion of space industry in India work closely with emerging startups to put in place reforms and incentives that allow them to operate locally for the country to benefit from their success.

6 Public policies to support commercial space in India

By Ashok G.V, Partner, Factum Law; Attorney, High Court of Karnataka, India

6.1 Introduction

The Indian Space Program was traditionally driven by the Indian Space Research Organisation. A state organisation falling under the direct supervision and aegis of the Department of Space and the Prime Minister's office, its ethos and vision remained the pursuit of sciences tempered by the desire to impact national interests. As India entered into the realm of globalisation and economic liberalisation, the Indian Government notified the Policy framework for satellite communication in India followed by the norms, guidelines and procedures for implementation of the policy framework for satellite communications in India. Thereafter, the Government of India notified the Remote Sensing Policy, 2011. Though the foundations of these policies were entrenched in the desire to open the market for space activities to commercial entities, the policies lacked the level of clarity that would render it as "predictable" for foreign investments. The domestic regulatory uncertainties coupled with the demanding nature of coordinating within the International Telecommunication Union for clearances for satellite missions resulted in negligible foreign direct investment in the satellite communication sector in spite of the government providing for up to 100% FDI.

In the year 2020, the present Government of India felt the need to tap into this market potential and announced the formulation of new policies designed to attract investments and unleash the involvement of the private sector. Accordingly. the Indian Government recently released the draft of the Spacecom Policy, 2020 and Space-Based Remote Sensing Policy of India, 2020 ("RS Policy") (both policies shall hereinafter be collectively referred to as "Domestic Space Policies"). The objectives of both policies are to enhance and enable the private sector to access markets for Satellite Communication ("Commercial satcom missions") and Remote Sensing products and services ("RS Missions") (both of which are collectively referred to as "SATCOM and RS products and services"). The Domestic Space Policies have inspired considerable excitement considering the political narrative around them have emphasised on achieving the economic potential that the Indian market represents for Satcom and RS products and services. However, India's track record with satellite communications investments has not been smooth sailing to say the least. In this paper, we review the history of India's policy shortcomings while dealing with investments in satellite communications and telecommunications industries and review whether or not the new domestic space policies can avoid the mistakes of the past, mitigate legal risks and promote investments in the space sector.

6.2 The Schemes of the Policies

6.2.1 The Spacecom Policy, 2020

The Spacecom Policy, 2020 is primarily intended to regulate the process of authorisation of satellite missions and services designed to deliver satellite-based communication services. It primarily contemplates three principal forms of SATCOM businesses viz., missions leveraging geo-stationary orbit, missions leveraging low earth orbit and finally earth stations.

The common theme of the regulations for all three businesses is that only Indian entities are allowed to apply for and seek authorisations[145]. Considering that India currently enables and allows foreign direct investments in the SATCOM sector subject to approval of the government, foreign businesses are not precluded from seeking authorisations, but they will be required to set up an Indian entity for the said purposes. Given that the latest foreign direct investment policy of India allows for up to 100% foreign direct investment, such a rule requiring the setting up of a local entity could very well be consistent with India's obligations under the Trade Related Investment Measures under the WTO regime. However, with the policy explicitly envisioning a responsive and timely regulatory atmosphere, there is cause to celebrate the progressive thinking of the Indian government in its approach to SATCOM[146], although the policy does not, within itself, elaborate on what this means.

Curiously, geo-stationary based missions are eligible for authorisations only if they leverage Indian orbital resources comprising of an orbital slot and frequency that is under Indian administrative control[147]. If the mission seeks to leverage a foreign orbital resource, it is required to formulate a scheme for bringing the foreign orbital resource under Indian administrative control. So far as LEO based missions are concerned, the requirements of authorisations are far less onerous and do not contemplate orbital resources either being under Indian administrative control or having to be brought under Indian administrative control. This classification and dichotomy between LEO based commercial SATCOM missions and GSO based SATCOM missions will be analysed in detail in the later parts of this paper.

While the Spacecom Policy, 2020 distinguishes itself from its predecessor, the SATCOM Policy, 2000 in terms of how much more nuanced its approach to regulating satellite communications, it never the less stops short of providing a single window clearance by requiring applicants to secure separate operational licenses from either the Ministry of Information and Broadcasting and the Department of Telecommunications as the case may be[148]. India having traditionally positioned itself as a responsible space actor has practiced a scrupulous policy of compliance with the letter and spirit of the Outer Space Treaty.

The Spacecom Policy does stipulate that one of the considerations for adjudicating applications for authorisations is the Applicant's proposal for addressing the subject of liability[149]. However, the policy fails to prescribe the standards of expected conduct towards liability avoidance. One could argue that this approach only provides a deterrent but not the means to enable beneficiaries of the authorisations to engage in best practices that promote the sustainable uses of outer space. A more pro-active approach would have been to either define expectations for de-orbiting and debris avoidance or at the very least specify a consideration of space sustainability factors as the basis for adjudicating applications for authorisations. In the absence of consideration of space sustainability as a mandate, any rejection of applications for authorisations citing unsatisfactory space sustainability plans could attract litigation on the grounds that the adjudicating authority transgressed the scope of the powers granted to it under the policy leading to infringement of the right of equal protection under the law envisaged as part of the right to equality under Article 14 of the Constitution of India.

[145] See Section 4.1 of the Spacecom Policy, 2020 ISRO, "*Norms, Guidelines And Procedures For Implementation Of Space Based Communication Policy Of India- 2020 (Spacecom NGP- 2020)*" section 4.1 at pg 8 (PDF file), downloaded from www.isro.gov.in, [https://www.isro.gov.in/sites/default/files/draft_spacecom_policy_2020.pdf], accessed December 12, 2020.
[146] Ibid., section 8, at pg 14. See Section 8 of 1 ibid.
[147] Ibid., section 4.1B, at pg 9. See Section 4.1B of 1 ibid.
[148] Ibid., section 4.3.6, at pg 12. See Section 4.3.6 of 1 ibid
[149] Ibid., section 4.1 A (d), at pg 8. For example, please refer to section 4.1 A (d) of 1 ibid

6.2.2 RS Policy

The RS policy reflects to a large extent, the expectations that the space industry had consistently expressed. The RS policy classifies data into two categories, sensitive data and non-sensitive data based on a threshold resolution of 50 centimetres. While data with resolution better than 50 centimeters invites a more stringent set of regulations owing to the national security implications, non-sensitive earth observation data can be distributed by an Indian entity only through a process of authorisation subject to applying for registering the source of the data. Contrary to the previous Remote Sensing Data Policy of 2011 which concentrated the powers of sourcing and distribution of remote sensing data into the hands of the National Remote Sensing Center and the High Resolution Image Committee, the new RS policy contemplates a liberal market based approach for sourcing and distributing remote sensing data allowing private sector enterprises to not only set up and operate remote sensing satellite missions but also act as distributors for the data from remote sensing assets.

6.2.3 International Law and the Domestic Policies

The inherent feature of the Space and Telecommunications industry is their transborder nature and potential. It is therefore natural to expect a robust interplay between domestic policies and International law, both international space law and international trade law. Being a signatory to a significant number of Bilateral Investment Treaties, the General Agreement for Trade and Tariffs, The Trade Related Investment Measures and the General Agreement for Trade in Services, India has exercised significant sovereign discretion and leveraged its market size, skilled labour, geo-political location among other advantages to negotiate, execute and participate in trade agreements and international trade institutions. The benefits of these agreements and institutions were enabled by a policy of liberalisation and globalisation initiated in the early 1990s which gained momentum under successive governments, leading to India becoming a hub for Information Technology and a variety of other industries.

For the purposes of the present discussion, it is useful to recollect on some of the obligations that accrues to India, as it does to the countless other signatories to these bilateral and multi-lateral trade agreements and instruments. Firstly, common to international trade agreements, is the underlining belief that free movement of goods and services across borders and greater international trade and commerce is beneficial for the world and any disruption to the same is counter-productive to the stability and prosperity of the world. Secondly, as signatories to these agreements, India is required to refrain from *de-jure* or *de-facto* discrimination[150] between products and services originating domestically vis-à-vis similar products and services originating from a foreign source[151]. As a corollary to this, India's actions vis-à-vis foreign direct investments into its market is required to be non-arbitrary and reasonable.

While India's status as a developing country and emerging economy has allowed it some leeway to encourage domestic sources of products and services[152], for the most part, India remains true to its obligations leveraging significant dividends for its economy in the process. No doubt, there remains domestic discord against increased globalisation citing the lack of dividends for India's underprivileged

[150] "The Legality of Local Content Measures under WTO Law" by Holger P.Hestermeyer & Laura Nielsen, Article in Journal of World Trade · June 2014: Hestermeyer, Holger P. and Nielsen, Laura, "The Legality of Local Content Measures under WTO Law", Journal of World Trade 48(3) (2014) 572. Also See, e.g., Canada – Certain Measures Affecting the Automotive Industry Appellate Body Report, WT/DS139/AB/R, WT/DS142/AB/R (31 May 2000) [hereinafter Canada – Autos Appellate Body Report], para. 150. In Canada – Autos the Appellate Body cited to an early GATT case from 1958, see Italian Discrimination Against Imported Agricultural Machinery Panel Report, L/833 BISD 7S/60 (adopted 23 Oct. 1958) (GATT) [hereinafter Italy – Agricultural Machinery Panel Report] para. 12, which does not mention de facto discrimination explicitly. See also by now classic contribution on de facto discrimination in Lothar Ehring, De Facto Discrimination in World Trade Law: National and Most-Favoured-Nation Treatment – or Equal Treatment? 36 J.World Trade 921–977 (2002).

[151] See Article II (1) (a) of the General Agreement for Trade and Tariffs, the substance of which is also a recurring feature in Bilateral Investment Treaties between nations.

[152]

sections including its farmer populations[153], but one could argue that better equity can be achieved through domestic interventions rather than blaming economic globalisation. However, merits or the lack of it notwithstanding, the capitalist model of globalisation of trade and commerce is inevitable and India, to its credit, has aggressively encouraged Foreign Direct Investment.

6.3 Investments in Space and Telecommunications- The Outlier

India's track record with Foreign Direct Investment specifically and compliance of International Trade Law obligations is best exemplified by the fact that between the months of April 2000 and March 2020 India received investments aggregating to approximately USD 44.91 billion dollars in the Information Technology sector alone [154]. However, the history of foreign direct investment in space and telecommunications has seen its fair share of turbulence. In this section, two specific case studies are discussed: the arbitral award in the Antrix-Devas dispute involving Bilateral Investment Treaty between India and Mauritius and the judgement of the Indian Supreme Court cancelling the grant of 2G spectrum licenses to various telecom operators.

6.3.1 The Antrix-Devas Dispute[155]

Devas Multimedia Pvt. Ltd., ("Devas") for short had executed an agreement with Antrix Corporation Ltd. ("Antrix") in the year 2005 as per which, Antrix was required to build and launch satellites that would carry transponders with S-Band capabilities, which Devas intended to leverage for providing communication services within the Indian market. Following the execution of the said agreement with Antrix, Devas proceeded to obtain an "Internet Service Provider" license from the Department of Telecommunications the nodal agency for implementing the provisions of the Indian Telegraph Act, 1885. In addition, it also proceeded to invest significantly, in setting up local offices, procure equipment and undertake steps to set up the infrastructure necessary to leverage its agreement with Devas.

However, not long after the execution of the initial agreement between Devas and Antrix, there were media reports as well as opinions with the subsequent administration at the ISRO that the allotment of critical S-Band capacity to Devas was not transparent and failed to consider the demand for S-Band frequency by the Indian armed forces. In the face of such public scrutiny of the deal between Devas and Antrix, the Agreement was sought to be terminated. Curiously enough, between the then Additional Solicitor General of India, Dr. S Radhakrishnan, the chairman of Antrix and the Department of Space, the reasons for seeking to terminate varied widely from grounds of S-Band being required for India's national security, to the agreement being counter-intuitive for societal and strategic needs of India to reasons of force majeure. When Antrix finally terminated the agreement, for reasons that were not entirely clear, Devas promptly invoked the India-Marutius Bilateral Investment Treaty and raised a claim against India before the Permanent Court of Arbitration and ultimately succeeded in securing an award for damages, the execution of which, continues to be a contested litigation before the Indian judiciary[156].

[153] B.M.Vyas, and Manu Kaushik, "How India was Stripped of Its Atmanirbharta in the Edible Oil Industry," The Wire, November 4, 2020, https://thewire.in/political-economy/india-edible-oil-self-sufficiency, accessed December 2020. https://thewire.in/political-economy/india-edible-oil-self-sufficiency

[154] India Brand Equity Foundation, "IT & BPM Industry in India", www.ibef.org, October 2020. https://www.ibef.org/industry/information-technology-india.aspx, accessed December 2020 https://www.ibef.org/industry/information-technology-india.aspx

[155] Devas Multimedia Private Limited v. Antrix Corporation Limited, CC Case No. 18051/CYK (ICC Award)

[156] "Antrix-Devas Case: SC Stays US Court Order Asking Antrix to Pay Compensation" November 5, 2020, Science the Wire, https://science.thewire.in/spaceflight/antrix-devas-case-isro-supreme-court/ , accessed December 2020. https://science.thewire.in/spaceflight/antrix-devas-case-isro-supreme-court/

While the termination of the contract between Antrix and Devas was sought to be justified on the grounds of national security and India's societal-strategic needs, the chronology of events leading to it strongly suggests that intense media scrutiny precipitated the dispute, if not outright provoke it. In hindsight, the lack of established standard operating procedures for issuing contracts to private parties to undertake space activities had caused questions to be raised about the integrity of the agreement awarded to Devas by Antrix, although, till date, no official of Antrix has been convicted for corrupt practices or bribery[157]. Lastly, whether or not the termination of the contract with Devas was legally justifiable, it revealed the lack of consensus within the different ministries and departments of the Government of India on the manner in which the contract was initially awarded and later terminated raising legitimate concerns about the predictability of investments in the Indian sub-continent.

6.3.2 The Cancellation of 2G spectrum licenses

One of the most significant developments for the telecommunications industry remained the judgement of the Hon'ble Supreme Court in the case concerning the grant of 2G spectrum licenses. In its iconic judgement in Writ Petition No. 423/2010, in the case of *Dr. Subramaniam Swamy v. Union of India & Ors.*, the Hon'ble Supreme Court came down heavily on the Ministry of Communications and Information Technology for adopting the first come first serve method to award licenses for 2G telecom service providers and ultimately cancelled the licenses granted on or after the 10th of October, 2008. The Court's reasoning was premised on the fact that the cut-off date for submission of applications seeking 2G spectrum licenses were determined in an arbitrary manner and defied the advice of the Ministry of Law and Justice and The Prime Minister's Office that had repeatedly called upon the Ministry of Information Technology to follow principles of reasonableness and fairness. The Court further concluded that spectrum being a natural resource was covered by the public trust doctrine and therefore its allocation and utilisation had to conform to the principles of non-arbitrariness in administrative actions, envisaged under the Right of Equality, a fundamental right under Article 14 of the Constitution of India.

The decision in the case concerning the grant of 2G spectrum licenses is thematically similar to the Antrix-Devas dispute. To begin with, the intra-governmental lack of consensus and clarity which ultimately affected Devas, remained true even in the case of the cancellation of 2G spectrum licenses as was evident in the difference of opinion of the Ministry of Communications and Information Technology on one hand and the Ministry of Law and Justice and the Prime Minister's Office on the other hand. Furthermore, the Supreme Court's decision to cancel the 2G spectrum licenses already granted, which was premised on the need to uphold reasonableness and non-arbitrariness in the exploitation of natural resources, resulted in allegations of arbitrary and unreasonable treatment of investments under the India-Mauritius Bilateral Investment Treaty, in as much as Khaitan Holdings, one of the parties aggrieved by the cancellation of 2G spectrum licenses has initiated arbitration proceedings against India for BIT violations[158].

While the arbitration proceedings are yet to be concluded, there remains the obvious albeit unfortunate conclusion, that what is reasonable and non-arbitrary under the Indian Constitution need not be reasonable and non-arbitrary for the purposes of international investment obligations. While the Court was guided by the noble principle of upholding propriety in allocation and utilisation of national natural resources, it may have been oblivious to the possibility of its judgement, intended to address

[157] While charges have been brought against certain former officials of ISRO and Antrix, none have been convicted thus far, "https://www.business-standard.com/article/current-affairs/antrix-devas-deal-ex-isro-chief-officials-chargesheeted-116081101512_1.html"
"Antrix-Devas deal: Ex-Isro chief, officials chargesheeted", Business Standard, August 12, 2016, https://www.business-standard.com/article/current-affairs/antrix-devas-deal-ex-isro-chief-officials-chargesheeted-116081101512_1.html, accessed December 2020.
[158] Wto.org. 2020. *WTO | Dispute Settlement - The Disputes - DS139*. [online] Available at: <https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds139_e.htm> [Accessed 12 December 2020].
See https://pca-cpa.org/en/cases/206/

discrimination and arbitrariness, could itself attract allegations of arbitrariness and discrimination under India's international obligations. That, the Minister of Communications and Information Technology who was at the centre of the grant of 2G spectrum licenses, was absolved of the wrong-doing that had caused the court to cancel the 2G spectrum licenses in the first place, only makes the cancellation of the said licenses all the more indefensible in the potential case lodged by Khaitan Holdings[159].

6.4 Has the legal context changed?

With the case studies discussed so far, one would wonder if the situation or the context for international investments in space and communications changed? And how much do the new Domestic Space Policies reflect the change? In this section, we map some of the developments in the jurisprudence in India that is relevant to this question of whether or not India's legal landscape is in harmony with India's international obligations and what, if any, are the changes since the Antrix-Devas dispute and the cancellation of 2G spectrum licenses?

So far as the Spacecom Policy is concerned, by specifically requiring applicants seeking authorisation to seek separate operational authorisations from the Ministry of Communications and Information Technology, the potential for the intra-governmental lack of consensus and conflict, the foundational problem that ultimately led to the Antrix-Devas dispute and the 2G spectrum cancellation, continues to remain. In practice, the authority constituted for the purposes of implementing the Spacecom Policy, IN-Space can very well take the lead to develop a proper flow chart outlining the specific roles and responsibilities of the Department of Telecom and the Department of Space in adjudicating applications to provide Spacecom Services to address this issue. Alternatively. the composition of IN-Space could potentially have representation from different ministries and departments in order to ensure intra-governmental uniformity of approach and decision making. This would make the process of dealing with multiple ministries predictable. However it is undeniable that the most ideal regulatory approach would be to integrate the processes of the Department of Space and the Department of Telecommunications to ensure that any friction between the two departments would not affect investments in this sector. Never the less by providing explicitly, the specific application forms for seeking authorisations and the considerations for adjudicating such applications, the policies have conveyed exactly the nature of the regulatory expectations from applicants, which, if complied with, indicates that the results will be as positive as they would be predictable.

Another area of potential concern remains the requirement of having to bring foreign Geostationary orbital resource involved in providing services in India, under Indian administrative control as a condition to quality for grant of authorisations under the Spacecom Policy. Prima facie, such a requirement does not, per se, exclude foreign entities from entering into the Indian market for spacecom services. However, as the transfer of administrative control of the Geostationary orbital resource to India, would be counter intuitive to the country in which the foreign entity is domiciled, this requirement acts as a significant deterrent for foreign satellite operators who wish to enter the Indian market, while correspondingly giving Indian satellite operators a competitive advantage.

[159] Nirnimesh Kumar "A. Raja, Kanimozhi, others acquitted in 2G spectrum allocation case, The Hindu, December 21, 2017, https://www.thehindu.com/news/cities/Delhi/a-raja-kanimozhi-others-acquitted-in-2g-spectrum-scam-case/article22121626.ece, accessed December 2020. https://www.thehindu.com/news/cities/Delhi/a-raja-kanimozhi-others-acquitted-in-2g-spectrum-scam-case/article22121626.ece

The World Trade Organisation's dispute resolution panel in the case of "India – Certain Measures Relating To Solar Cells And Solar Modules"[160] had concluded that the policy requiring solar power producers to source certain components only from Indian entities to qualify for power purchase agreements was contrary to Article 2.1 of the Trade Related Investment Measures. Accordingly, India will have to justify how the requirement of the foreign geostationary orbital resource having to be transferred to Indian Administrative Control, does not qualify as a discriminatory measure or a form of local content requirements prohibited under the Trade Related Investment Measures.

Even independent of international dispute resolution forums such as the WTO, India must be mindful of its own judiciary that remains robustly independent and famous for its integrity of approach towards upholding the constitutional principles of equality while adjudicating the propriety of licenses granted to private entities involving national resources like spectrum. In the case of *The State of Jharkand v. Brahmputra Metallics* Civil Appeals No. 3860-3862/2020, the Supreme Court held as follows,

> *"The state must discard the colonial notion that it is a sovereign handing out doles at its will. Its policies give rise to legitimate expectations that the state will act according to what it puts forth in the public realm. In all its actions, the State is bound to act fairly, in a transparent manner. This is an elementary requirement of the guarantee against arbitrary state action which Article 14 of the Constitution adopts. A deprivation of the entitlement of private citizens and private business must be proportional to a requirement grounded in public interest"*

The judgement of the Supreme Court cited supra imposes upon the Indian state, a greater obligation to ensure that contracts and benefits once granted to private entities are not arbitrarily rescinded or terminated. Therefore, it would be useful for the domestic policies to be revamped and further strengthened in order to ensure that the authorities enforcing it do not unwittingly violate the jurisprudence laid down by the Supreme Court while dealing with contracts between the state and private entities. It also reflects the new thinking of the Indian judiciary that upholding the rule of law would also be synonymous with obligating the sovereign state to honour its commitments. A significant step towards inspiring confidence in the Indian regulatory atmosphere is to ensure such finer and progressive thinking of the Indian judiciary translates to meaningful practices while adjudicating applications for authorisations of space activities.

In order to avoid a repetition of what transpired in the cancellation of 2G spectrum licenses, the Indian Government must aggressively formulate a legislation, rather than leaving it to executive policies such as the domestic space policies that governs the subject of authorisation of commercial space activities. As opposed to executive action, legislations enjoy a presumption of constitutionality and the Indian judiciary has always been circumspect in striking down legislations as unconstitutional owing to its discipline against judicial activism. Additionally, the regulators tasked with regulating commercial space activities would be empowered to take actions when they have a legislative policy mandate to fall back on rather than having to depending upon their own policies to withstand any legal challenge in a court of law. After all, executive policies and actions are not as immune and therefore more prone to judicial review for grounds ranging from arbitrariness to failure to consider relevant factors. In addition, whether or not the full range of legal considerations including those under the Indian Constitution and under India's international trade obligations, have been considered while formulating the domestic policies remains unanswered.

[160] Report of the Panel of the World Trade Organisation, "India-Certain Relating to Solar Cells and Solar Modules" (PDF file), downloaded from World Trade Organisation website, [https://www.wto.org/english/tratop_e/dispu_e/456r_e.pdf], accessed December 2020.
See report of the Panel of the World Trade Organisation in Case No. WT/DS456/R in the case concerning "India-Certain Relating to Solar Cells and Solar Modules"

Investors would also be heartened to note that the Indian judiciary has also increasingly leaned in favour of upholding and honouring India's international trade and investment obligations, reflecting a significant change from the days when the 2G spectrum licenses were cancelled at the hands of the judiciary. The Division Bench of the Hon'ble Delhi High Court in the case of *Director of Income Tax v. New Skies Satellite BV*[161], held that foreign satellite service providers providing services in India would be exempted from payment of income taxes in India as the Direct Tax Avoidance Agreement would prevail over the Indian Income Tax Act, 1961 and observed as follows.

> *"This Court is of the view that no amendment to the Act, whether retrospective or prospective can be read in a manner so as to extend in operation to the terms of an international treaty. In other words, a clarificatory or declaratory amendment, much less one which may seek to overcome an unwelcome judicial interpretation of law, cannot be allowed to have the same retroactive effect on an international instrument effected between two sovereign states prior to such amendment. In the context of international law, while not every attempt to subvert the obligations under the treaty is a breach, it is nevertheless a failure to give effect to the intended trajectory of the treaty. Employing interpretive amendments in domestic law as a means to imply contoured effects in the enforcement of treaties is one such attempt, which falls just short of a breach, but is nevertheless, in the opinion of this Court, indefensible."*

Furthermore, the Union of India's efforts to secure an interim anti-arbitration injunction was not entertained in the case of *Union of India v Khaitan Holdings & Ors.*[162], in which the Delhi High Court leaned in favour of having the challenge to the arbitration proceedings under the Indo-Mauritius Bilateral Investment Treaty, be decided by the Arbitral Tribunal itself rather than by the Indian judiciary. Vodafone secured a historic verdict in which, the court struck down the demand for nearly Rs. 12,000/- crore on the ground that Vodafone's transactions would be exempt from India's taxing jurisdiction under the relevant tax treaty[163].

Where the investments sought to be authorised under the Domestic Policies are significant, the Government should consider applying for an advisory opinion of the Hon'ble Supreme Court under Article 143 of the Constitution of India so as to pre-empt any constitutional law violations in the process of grant of the authorisations. Though the advisory jurisdiction of the Supreme Court remains a part of the basic structure of the Constitution of India, it has hitherto been underutilised to avoid illegalities of the nature that was the subject matter of the case concerning the grant of 2G spectrum licenses. There remains every reason for the Indian Government to exercise this option in order to ensure that its handling of investments of significant size and scale and importance is also endorsed by the judiciary through this approach.

Additionally, for the first time the domestic space policies have a separate section that contemplates and defines the need for a timely and responsive regulatory atmosphere, although the form and substance of what this timely and responsive regulatory atmosphere means is yet to be defined. IN-Space, the authority which is designated to carry the mandate of increasing private sector participation in this sector forward

[161] *Director of Income Tax v. New Skies Satellite BV* [2016] (The Hon'ble Delhi High Court), ITA 473/2012. Judgement of the Hon'ble Delhi High Court in ITA 473/2012

[162] *Union of India v. Khaitan Holdings & Ors* [2019] (The Hon'ble Delhi High Court), CS (OS) 46/2019. See judgement of Delhi High Court in CS (OS) 46/2019

[163] *Vodafone International Holdings v. Union of India* [2012] (The Hon'ble Supreme Court of India), Civil Appeal No. 733/2012. See judgement of the Hon'ble Supreme Court in the case of *Vodafone International Holdings v. Union of India,* in Civil Appeal No. 733/2012

is expected to address conventional concerns regarding the Department of Space's potential conflict of interest, as both the regulator of commercial space activities as well as a competitor. The RS Policy has significantly liberalised the regulation of remote sensing data with non-sensitive data being made freely available. Unlike the Spacecom Policy, the RS policy has no stipulation requiring applicants to seek operational clearances from different ministries thus representing what could potentially be a single window approach to authorisations. In all, the new policies have adopted a far more realistic, pragmatic and investment friendly approach compared to their predecessor policies and any gaps that could bring back memories of the Antrix-Devas dispute, is now addressed through a forward thinking jurisprudence that does not see India's domestic interests and international treaty obligations as mutually exclusive.

6.5 Conclusion

As can be seen from the discussion, the new policies by themselves, perhaps fall short of the expectations of the commercial space industry in India. However, when read together with the collateral developments in India's constitutional jurisprudence and commercial legal developments, India has made a big leap forward as a destination for investments in general. From the day and age of the Antrix-Devas dispute to the present day where the ISRO Chairperson and the Finance Minister themselves announced predictability of investments as the factor influencing the changing of policies, the time is now ripe for the commercial space industry to see the Indian regulatory context, not as a challenge, but as a partner in accessing the significant market that India represents.

NEW SPACE IN OTHER SELECTED ASIAN COUNTRIES

7 New Space in South Korea

By Sangwoo Shin, Senior Researcher, Korea Aerospace Research Institute,

7.1 Introduction

Defined by OECD as the "full range of activities and the use of resources that create value and benefits to human beings in the course of exploring, researching, understanding, managing, and utilizing space", the space economy is increasingly disrupting the way we live. Today, the continuous development of space infrastructures enables the creation of new services that have an increasingly positive impact on economic growth and society. Sectors such as meteorology, energy, telecommunications, insurance, transport, maritime, aviation and urban development have all been positively affected by the emergence of space-based applications, evidencing the nature of the sector as vital enabler of growth in other fields and industries.[164]

South Korea (subsequently, Korea) is clearly no stranger to these activities, having emerged as a very active spacefaring nation. Despite its substantial achievements, the country's space activities remain largely unknown to outsiders.

Korea began the development of its space programme in 1989 and achieved rapid growth through a successful mid entry strategy which resulted in the development of low-Earth orbit satellites and the first launches of its KSR family of sounding rockets. Its growth was, however, delayed compared to that of more technologically advanced countries especially as a result of the limited participation of industrial actors in the development of space technologies. The preponderant role of public actors in the sector temporarily halted the creation of a solid industrial base centred on the activity of large aerospace companies, instead favouring the growth of a limited ecosystem focused on the activity of small and medium sized companies.

In order to analyse the evolution of Korea's space ecosystem, this paper will address the following research questions: What are the emerging trends in Korea's space ecosystem? What are the challenges to advancing the ecosystem? What policies have driven the growth of the ecosystem and what policies are needed in the future?

In order to provide an answer to answer these questions, we will hereby present the results of a broad review of the relevant literature as well as of a series of interviews made to experts that enable to establish a clear overview of the political, economic and demographic factors that have influenced South Korea's innovation policy relative to other countries.

[164] OECD Handbook on Measuring the Space Economy 2012

In an effort to review the evolution of Korean space ecosystem, we will examine the strategic approaches applied by the government in order to enhance the country's capabilities in space. In order to do so, we will divide the chapter into three parts: We will firstly analyse the concepts of systems of innovation and highlight how it can be used within the context of the space sector as there are no previous cases of such application. We will then provide a brief historical evaluation of innovation within the Korean space sector, underlining each of its components. Finally, some of the implications of these results will be outlined.

7.2 Korea's ascent to becoming a space faring state

The concept of systems of innovation is essential to understanding the evolution of South Korea's path to technological development in all sectors of innovation, including in space. Since the 2000s, this concept has played a role in informing the policy background of Korea's public investment in research and development. The concept has emerged as an analytical concept since the late 1980s (Freeman, 1987; Dosi et al., 1988; Lundvall, 1992; Nelson, 1993). According to Lundvall (1992:12), such systems include 'all parts and aspects of the economic structure and the institutional set-up (of a country) affecting learning as well as searching and exploring'. In concrete, he identifies the internal organization of firms, inter-firm relationships, the role of the public sector, the institutional set-up of the financial sector, R&D intensity and R&D organization as its basic elements. His definitions indicate that the concept of systems of innovation rests on two basic notions: firstly, that the comprehension of national and internal dynamics are an essential factor when measuring/assessing technological competitiveness and performance and secondly that these are determined not by a single factor, but by the interaction between a wide range of institutional actors. In other words, Lundvall suggests that a systemic approach is necessary to understand and analyse the technological performance and competitiveness of countries. The systems of innovation approach, however, does not imply, that the national level is necessarily the most important level applicable for such a systemic analysis, nor that it is the only dimension that should be considered when doing so.

Detailed frameworks have been developed through the collaboration of different actors in order to elaborate the concept of system innovation (e.g., OECD, 1999). A detailed analysis of the systems of innovation which embraces all these factors would exceed the scope of this chapter. Instead, we will base the analysis of the space sector in Korea on a simpler framework following analytical approaches established in previous studies. Prior research on national innovation systems has almost invariably considered (1) the activities of the business sector, (2) the government and the public research sector and (3) the interaction between these three sectors which materializes in flows of capital, human resources and knowledge, in addition to generating innovation outputs such as scientific papers, patents, and new products and processes. Following a brief historical sketch and an overview of aggregated indicators of innovation-related input and output, the subsequent analysis will be therefore be based on this analytical framework.

Korea's space development began in the early 1990s, almost 40 years following that of western economies. The Korea Aerospace Research Institute (KARI), a government-funded research institute specializing in space development projects, was established in 1989 only.

The country has historically focused on satellite development, while more recently it has been expanding into space launch vehicles. Korea's first satellite, KITSAT-1, was developed in cooperation with the University of Surrey in the United Kingdom and launched in August 1992 in a European Ariane-4 satellite launch vehicle. A replica of the KITSAT-1, accordingly named KITSAT-2, was then launched the following year. Since the early 1990s, South Korea has promoted cooperation between the government, the Korea Aerospace Research Institute (KARI), universities and the private sector to assist the growth of its domestic satellite and space applications industry. The Satellite Technology Research Center (SaTReC)

at the Korea Advanced Institute of Science and Technology (KAIST) is the main research and development centre for satellite technology.

In the area of space launch vehicles, Korea started developing sounding rockets in the early 1990s. It developed the KSR-1, 2 and 3 and then began developing orbital rockets in 2002. After 10 years of cooperation and development with Russia, it successfully launched the Naro rocket in 2013. Significant progress has been made through the Naro, but because of the introduction of the first stage rocket from Russia, complete independence for the core technologies composing space launch vehicles, such as medium and large engines, could not be achieved. Accordingly, after the Naro project the development of a Korean launch vehicle capable of putting a 1.5-ton satellite into low-orbit orbit around the earth has being carried out independently.

To this end, private firms have collaborated with state-run research institutes such as the KARI and the KAIST Satellite Research. The institute has been in charge of the functions of system synthesis and quality management, while the development of individual components has been carried out by private space companies. In the future, the government aims to drastically reform the national space development system and gradually shift from the system development method applied under the auspices of the Korea Aerospace Research Institute, which was mainly centred on securing technology, to a system under the supervision of the industry.

7.3 Current status of space ecosystem

In order to provide an overview of Korea's space ecosystem, we will analyse the results contained in the Korea Space Industry Survey. The survey was conducted for the first time in 2005 and was designated as a national approval statistic in 2015 after improvements were made relating to definition and classification.[165] With regards to the term "space industry", the survey defines it as "all industries related to the production and operation of space devices, such as launch vehicle and satellites, development of products and services utilizing related information, and supply".

7.3.1 Key characteristics of Korea´s space industry

The Korean space industry, which employs over 6000 people, has developed capabilities in most space industry segments, including space vehicle and equipment manufacturing, satellite launch, satellite operations and downstream applications.

Over the past 10 years, the overall scale of the industry has grown. According to the data collected in the Korea Space Survey of 2019, the number of players active in the sector has increased from 93 to 449 over the past decade. Especially noteworthy is the increase in the number of private firms which rose from 61 to 342 in 2018, with a 5Y CAGR of 8.4% (see Figure 7-1).

[165] The survey targets are a list of related companies, research institutes, and universities that the Korea Aerospace Research Institute has secured since 2005, and a list of space-related companies identified by related agencies such as the Ministry of Science and ICT, the Korea Space Technology Promotion Association, the Ministry of SMEs and Venture Business, and the Korea Chamber of Commerce and Industry. The survey will be conducted through a questionnaire to the organizations identified as having related activities.

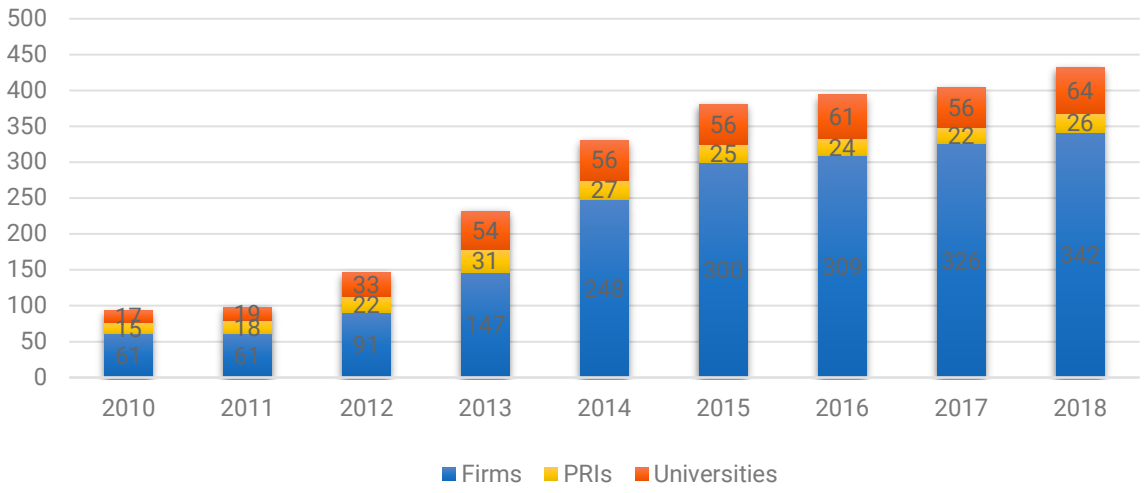


Figure 7-1: Number of actors in space sector (source: Korea Space Survey - Kostat.go.kr)

In terms of sectorial involvement, the number of satellite service companies was the highest with 152 companies, followed by 81 ground equipment, 68 launch vehicle manufactures, and 58 satellite manufactures (see Figure 7-2).

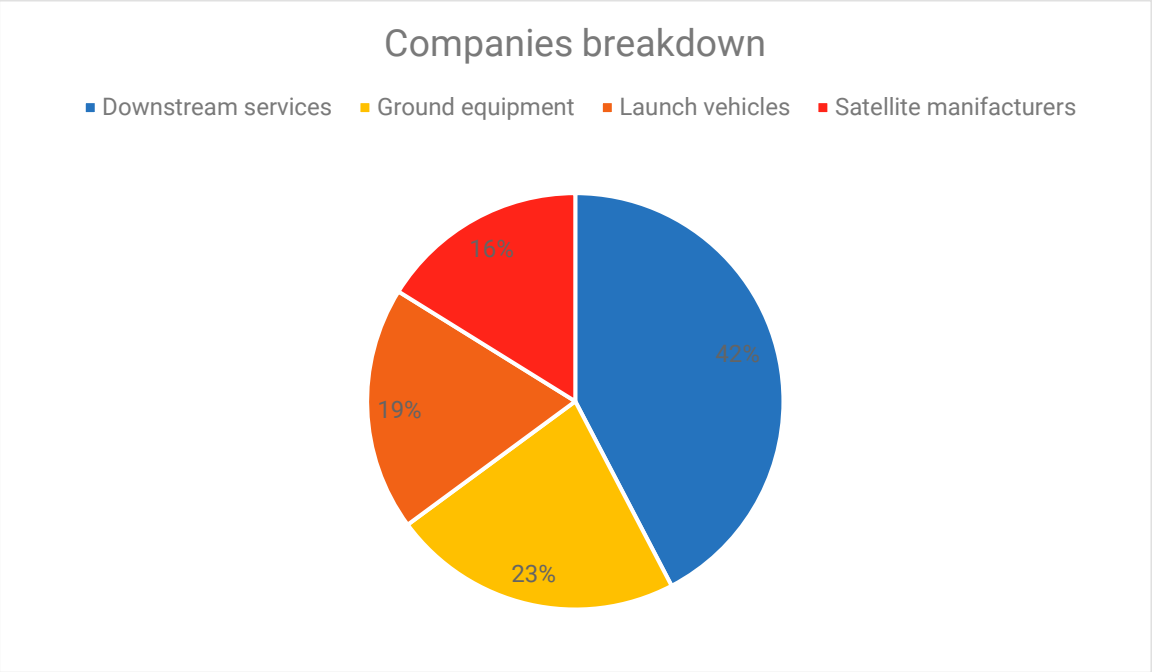


Figure 7-2: Private companies' breakdown by segment of activities (source: 2019 Korea Space Survey)

Geographically, more than half of firms are located in the Seoul metropolitan area (185 firms), while 76 and 67 are present in Chungcheong and Gyeongsang provinces, respectively. Finally, 11 companies are present in the Jeolla region and two in Jeju Island. Research centres are instead generally to be found in Daejeon, where KARI is based.

In terms of revenues, the Korean space industry generated a revenue of around KRW 3290.8 billion (USD 2.9 billion) in 2018 with a 5Y CAGR of 7.4% (see Table 7-1).

Year		2014	2015	2016	2017	2018	5Y CAGR
Number of Firms		248	300	309	326	342	8.4%
Total Sales (A+B)		2,477,839	2,487,685	2,779,256	3,393,099	3,290,795	7.4%
Sales/GDP		0.17%	0.16%	0.17%	0.20%	0.18%	1.4%
Satellite manufacturing		49,023	53,839	78,827	108,446	144,359	31.0%
Launch vehicle manufacturing		40,544	74,598	99,481	122,738	122,395	31.8%
Ground system	Ground station	15,987	27,128	41,528	52,919	39,032	25.0%
	Launch pad	101,951	118,604	118,909	70,316	63,936	-11.0%
Insurance		22,161	14,381	12,186	25,452	21,247	-1.0%
Manufacture (A)		229,665	288,549	350,931	379,870	390,969	14.2%
Space application services	remote sensing	31,492	54,787	64,935	65,767	74,617	24.1%
	satellite telecommunication	1,880,146	1,816,506	2,016,685	2,614,612	2,491,752	7.3%
	navigation	332,274	322,882	343,830	325,083	331,224	-0.1%
Science research		2,468	5,307	3,061	2,424	1,759	-8.1%
space exploration		-	-	85	4,353	474	136.1%
Applications (B)		2,248,175	2,199,136	2,428,325	3,013,229	2,899,826	6.6%

Table 7-1 Sales in space industry in Korea 2014-2018 (source: 2019 Korea Space Survey)

The survey shows that combined sales of 342 companies fell 3.0 percent on-year to 3.29 trillion won. This is mainly due to a decline in the volume of sales within the satellite broadcasting and telecommunications sector. Moreover, the survey indicated that total sales for companies in 2018 accounted for 0.18 percent of gross domestic product, down 0.02 percent from the previous year's share.

The Korean space ecosystem can be divided into upstream and downstream sectors. While thehe upstream segment encompasses the provision of technology such as space contractor, contract R&D, space component supplier, space subsystem and insurance, the downstream covers the exploitation of technology such as satellite broadcast services, Earth observation, satellite communications, science and space exploration. According to the 2018 sales figures, the space utilization sector was estimated at 2.9 trillion won (88.1%) and the space equipment manufacturing sector at 391 billion won (11.0%). However, whereas space equipment manufacturing has been on the rise every year, space utilization has declined. This is due to the decrease in sales of set-top boxes/cable boxes in the satellite communication sector.

Two attributes have to be emphasized in order to understand the main characteristics of Korea's space industry.

Firstly, the budget of the space sector is highly dependent on the government, which often leads to high volatility. In particular, this is due to the frequent changes in space development strategies and the inaccurate predictions of public demand, which has discouraged private investments thus leading to a condition of overreliance, on government investments. Moreover, the establishment of the space development plan is not centralised as it is determined under the leadership of the Ministry of the Science and ICT and the KARI, thus impacting the long term viability of the budget procurement plan and leading to its highly volatile nature.

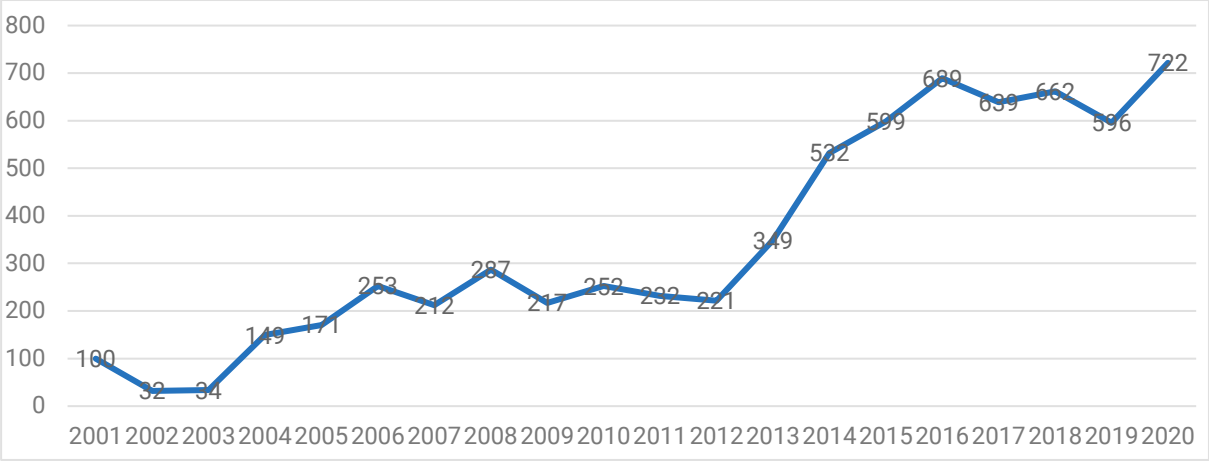


Figure 7-3: Government space funding by year (2000-2020) (source: Euroconsult, 2020)

Secondly, the lack of a long-term space development plan at the national level adds to the disagreements over the appropriate size of the space development budget. The full scale of Korea's space budget remains lower than that of other major space faring nations. Despite the recent increase in space budgets due to and the development of launchers and lunar exploration missions, stable future space budgets remain cumbersome for the financial authorities. The space budget for 2020 is expected to rise from 221 million USD in 2012 to 722 million USD as a sharp increase in the budget is required for the early development of Korean launch vehicles and for participation in the full-scale research phase of other major in the future. It remains challenging to reconcile the need to maintain the momentum of expanding space budgets at a time when restructuring expenditures to secure welfare budgets is a policy priority, and inter-ministry issues of national consensus on equity remain unresolved.

7.3.2 Identification of industrial stakeholders involved in space activities

KAI

KAI (Korea Aerospace Industries) is a listed company in the stock market, leading the domestic aerospace sector. It plays a key role in both aviation and space and participates in the field of space launch vehicles and satellites in relation to the space industry. Korea Aerospace Industries participated in the entire development process of the satellite body from the Arirang 1, a one-ton utility satellite, to the second, third, third, third and fifth. Recently, the company has signed a contract for the development of the 7th multi-purpose satellite and is playing a leading role in the development next-generation of medium-sized satellite (500kg) for the Korea Aerospace Research Institute. In the case of launch vehicles, they are responsible for the overall assembly of the Korean launcher system and the development of the first stage propellant tank.

Hanwha system

Hanwha System is a listed company in the securities market and has been operating in the defence sector since its designation as a defence company in 1978, basing its business model on the manufacture of precision electronic components, focusing on the information and communication technology sector.. It carried out the research and development and design and assembly of the infrared camera system mounted on the country's first multipurpose satellite, the Arirang 3A. Hanwha System is participating in the Data Link Construction Project and the Military Satellite Communication System-II Project, and also has R&D performance and development and production experience of network control, modem and terminal in the satellite payloads such as digital repeaters and Dae-electronic repeaters. Hanwha Systems has formed a joint design team with the Korea Aerospace Research Institute to carry out the development of the payload, and is participating in the joint development of the payload design, fabrication, assembly test, launch and initial operation. In addition, it is leading the development of high-performance image radar (SAR) sensors and data link systems by participating in the production of the 425 project satellite payload, a reconnaissance satellite development project organized by the Agency for Defense Development.

LIG Nex1

LIG Nex1 is a listed company in the securities market and is a comprehensive defence company that researches, develops and mass-produces advanced weapons systems in various fields such as precision guided weapons, surveillance and reconnaissance, command and control/communication, and aviation electronics/electronic warfare. It is currently developing a high-performance image radar (SAR) that will be used for the multipurpose satellite Arirang 6, and is participating in the development of the next military satellite communication system-II, which will replace the military satellite communication system-I (ANASIS) using the existing Mugunghwa satellite 5. In addition, it is developing a radio jamming system, a device that normalizes the operation of the GNSS/GPS receiver by removing the jamming signal entered into the GNSS/GPS receiver, and is participating in a core development project for core technologies to establish a military-only precision-calculated satellite navigation system to ensure high GPS location accuracy throughout the Korean Peninsula.

Doowon Heavy industry

Founded in 1979 as a company specializing in the manufacture of industrial products and ship engines for the defence sector, Duwon Heavy Industries is developing and building satellite structures and propellant tanks as well as satellite thermal control systems for the space sector. In the field of launch vehicles, the company was responsible for the KSR No.1, No.2 and No.3 projects led by the Korea Aerospace Research Institute, and the development of the upper part of the KSLV-I, and is currently carrying out the research and development project for the propellant storage tank of KSLV-II, a Korean launch vehicle. In addition, the company has been in charge of satellite thermal control systems since the early stages of development of satellites, including the multipurpose satellite Arirang Satellite No. 1, which began in 1994. It also participated in the development of thermal control systems for the Arirang-3, Arirang-5 and Arirang 3Asatellites. Currently, the company is carrying out research and development projects for thermal control systems for multipurpose satellites (6 and 7), geostationary combined satellites (2A and 2B), heat pipes (Heat Pipe), multi-layer thin film insulation (MLI), and secondary surface mirror (SSR) panels.

AP Satellite

AP Satellite is a KOSDAQ-listed company that develops and manufactures satellites as well as satellite communication terminals and other satellite components. It was established as Asia-Pacific Satellite Industry in 2000 and mainly developed mass-produced satellite communication terminals. After

absorbing and merging AP Space Aviation in 2016, it has been focused on is participation in the development and manufacturing of satellites. AP satellite possesses data link system technology capable of encrypting satellite observation data to prevent damage caused by potential hacking attacks, and is developing Electronic Ground Support Equipment (EGSE) for the multi3purpose satellite Arirang 6's payload data link system and satellite electronics that support ground testing. In addition, AP satellite has been awarded a project for the development of the next-generation medium-sized standard satellite-mounted computer (OBC) No. 1 and No. 2, and is currently participating in the design and development of high-speed data processing devices for the multi-purpose satellite Arirang No. 7 as well as for the electrical equipment for the main body of the orbiter for lunar exploration.

Satrec Initiative

Setrec Initiative is a KOSDAQ-listed company that was established around the team responsible for the development of Korea's first satellite, the Woori Star 1, and is present throughout the production line for technologies/components related to the satellite industry such as satellite body, payload, ground body, and satellite service. However, it lacks production capabilities for launch vehicles. It develops and manufactures payloads and components of small and medium-sized satellites directly, and provides EO satellite image sales and analysis services through its affiliates. It has supplied space-based sensors and satellite image reception systems by developing a flight model for space-based payloads of the geostationary complex satellite Chollian 2A, and signed a ground body supply contract for the 425-satellite project, which is a military reconnaissance satellite launch project by the Ministry of National Defense. Meanwhile, Setrekai is the country's only exporter of satellite systems and has supplied electronic optical payloads for the United Arab Emirates' KalifaSat-3 launched in October 2018, optical system, satellite image reception system and Singapore's TeLEOS-1 satellite. On 12 January 2021, Satrec Initiative announced the signature of a contract with Hanwha Aerospace to attract investments worth 108 billion won. When the investment will be completed, Hanwha will become the largest single shareholder of Sactrec Initiative. It is expected to hold about 30 percent of the shares.

7.3.3 Emerging commercial ecosystem

Investment in the aerospace industry continues as demand for telecommunication networks increases around the world. Leading venture capitalists (VC) in Korea are engaged in a heated competition, focusing on the development of rocket launchers for small satellites, an unexplored market.

Examples include that of South Korean micro launcher start-up Perigee Aerospace, which was recently awarded a Series B funding worth 10 billion KRW from investors including new investors such as the Korea Development Bank as well as established VCs such as LB Investment, Samsung Venture Investment, Stick Ventures, and Mirae Asset Venture Investment.

Hybrid rocket propulsion start-up Inno Space also received 8 billion KRW worth of Series A investment from Company K Partners, Intervest, Kolon Investment, and Hana Ventures.

In the scope of investment programmes, the TIPS (Tech Incubator Program for Startup) is also of note. TIPS is a private Investment-driven Technology Startup Support program that focuses on nurturing start-up teams with technology items that will lead the global market. In order to provide opportunities to promising innovative and technological start-ups, private venture incubators such as Angel Investment Company, venture capital specializing in early companies, and technology conglomerates will be designated as 'TIPS Operators' to support R&D funds along with investment and childcare. TIPS, which has been operating since 2013, has established itself as a technology start-up development program that supports successful commercialization through various support activities such as attracting seeding and follow-up investment from operators. In 2017 and 2018, the three start-ups received 500 million won in start-up funds through the TIPS program along with several other space start-ups.

Although the industry is still in it is in its early days, space start-ups are starting to developing their own business models, through the development of differentiated satellite manufacture strategies and the development of a variety of business models for launch, operation, and service phases. Each sector able to form a value chain has seen increased demand for specific services in the specific sector due to decreasing/ low costs, mass production, and increased use of commercial parts. A brief look at the business model of the start-ups by sector is as follows.

Firms	Foundation year	Upstream			Downstream		
		Satellite	Launch vehicle	Ground system	Application	Science	Space data
UZURO Tech	2018	◎	○		○		
SI Analytics	2018				○	○	◎
NARA Space Technology	2015	◎			○	○	
Perigee Aerospace	2018		◎	○			○
Ironwalks	2019					◎	
Dream Space World	2010	◎				○	○
Inno Space	2017		◎	○		○	
Contec	2015			◎	○		◎

◎ (main field) ○ (sub field)

Table 7-2: Key Start-ups in Korea

UZURO tech

The company is studying new form of space propulsion technology with the aim of providing a servicec to solve the question of sustainable disposal of micro-satellites in-orbit. Uzuro tech is a university-based start-up company that is developing a technology to enable the disposal of micro satellites at the end of their life cycle in order to mitigate the increase in space debris. Their monopropellant propulsion system is designed so as to not interfere with the planned life cycle of the satellite it is attached to. The company based their model on the rapid growth of the micro-satellite market and the increasing need for orbital debris mitigation procedures, as identified by the international community. In order to do so, Uzuro tech has established a series of partnerships with small satellite manufacturers in South Korea.

SI Analytics

SI Analytics (SIA) is subsidiary of Satrec Initiative established in 2018. The company has built up expertise in artificial intelligence, deep learning, and Earth observation image analysis specifically for defense and intelligence applications. Whereas most players focus GIS, SIA was moved to the field of AI, providing a platform that enables continuous learning through the constant analysis of satellite imagery data.

Under its "Human-Machine GeoInt Platform", SI Analytics has been essentially training machines to learn all abilities of humans to analyse the satellite/aerial imagery. The company has developed this general-purpose platform by making use of different AI-specific models that result in three changes: object analysis, area analysis, and video at different points of time.

The company´s services include training courses for satellite imagery analysis/understanding using deep learning and deep learning education for utilizing satellite imagery. As for its software products, these include imagery interpretation, inference label search, review and management and insight of analytics.

Demand for these services is mainly anchored to public institutions and public markets: major SIA customers include the Agency for Defense Development, the Korea Aerospace Research Institute and the National Disaster Management Research Institute. As a subsidiary of Satrec Initiative, SI Analytics is supported manages to maintain a strategic competitive advantage through Satrec´s global network.

NARA Space technology

There are three key start-ups in satellite and launch vehicle manufacturing. Nara Space is South Korea's first company that provides a comprehensive solution for small satellites. Based on its know-how in developing nano satellites, it is currently developing nano-class (less than 50kg) satellites that have a ground resolution precision capacity of 1m. Their aim is to develop the smallest satellite possible capable of maintain the same degree of performance. The company also aims to develop the most efficient satellite in each subsystem and system unit. In particular, it intends to secure global competitiveness by specialising in marine data collection and the production of satellite analysis software services specialised in the collection of ocean data.

Nara Space's marine nanostatellite development project accelerated as it became connected to Busan City. Busan, Korea's representative maritime city and global port city, needs systematic management of marine space, monitoring ships entering and leaving, and managing huge port facilities located on the coast. In response, the city participated in the development of nano-class satellites for collecting marine information through cooperation with various related organizations, including the Korea Marine Science and Technology Institute, located in Dongsam Innovation District in Yeongdo-gu. To this end, the city organised the 2019 Balanced National Development Committee's pilot project of regional development investment agreement in Busan and Nara Space was selected as a participating company by promoting a marine nanostatellite development project.

Perigee Aerospace

Perigee Aerospace is a microlauncher start-up company founded in 2018. The development of microlaunchers has seen an increase in interest in the industry as the necessity for frequent launches of small satellites constellation capable of delivering data with low latency intensified. The company is set to become the first South Korean company to launch the microlauncher, the “Blue Whale 1”.

The company received a seed funding in August 2018, was awarded a Seed (raising 1.3 billion won from Blue Point Partners, KAIST Foundation, and Setrek Eye) and won Series A round (Samsung Venture Investment, LB Investment, etc.) in May 2019. In particular, it is estimated that Samsung Venture Investment has invested more than 14 billion won without disclosing the exact amount of investment. Since attracting investment, it has been reported in the U.S. space aviation magazine Space News, drawing attention from the U.S. and Australia beyond Korea. Although it has already succeeded in securing enough funds to operate the company steadily and solidly without revealing the company in stealth mode, it is necessary to secure external funds through IPO for commercial launch and technical listing after Blue Whale test launch.

Ironwalks

Ironwalks' four-legged walking robot's walking method is operated by a field-oriented, low-cost, high-efficiency walking algorithm. Related technologies are leading the industry, and continuous technology development and product improvement are being made with the aim of carrying out work in rural areas and remote areas where manpower is difficult to supply, as well as industrial sites where labor is scarce. In particular, in the case of missing person rescue solutions, walking algorithms using dynamic models are being developed considering the input of disaster sites. Ironwalks also derive improvements by accepting feedback for differentiation between ground walking algorithms and space walking algorithms. It has a walking algorithm that allows free movement and work on behalf of humans and allows stable trajectory generation in real time with fewer sensors. It can walk only with the touch of the robot's toes, has developed and verified hardware and software, and is about to be applied to industries. Since then, the goal is to upgrade technology so that it can be used for space exploration.

Dreamspace World

Dreamspace World is a leading company in future space industry by utilizing satellite and science and technology satellite technology, and aims to meet the needs of various customers by commercializing micro satellites.

The main products are sensors, actuators, and computer control systems for postural control systems. In addition, they want to lighten high-performance and multi-purpose ultra-small satellites such as cluster satellites, space junk cleaning satellites, and provide beneficial space services to mankind.

It developed a small satellite-class posture control system, a super-small satellite system, a cube satellite system, a major bus module for cubes and super-small satellites, and a space exploration payload for micro satellites. It is seeking to commercialize the space education experience program for gifted/scientific high schools and middle schools using Cube satellites, and is planning to secure price competitiveness by mass production of products for postural control systems by completing verification through the Cube satellite launch performance test in 2021.

Inno Space

InnoSpace is a venture company specializing in the development of small satellite launchers using hybrid rockets and satellite launch services. It is planning to provide satellite launch services by developing micro launchers designed for 50kg nanosatellite, 150kg microsatellite, and 500kg mini-satellite. It has stability, affordability, thrust control, and short-term hybrid rocket technology. It plans to test-fire a hybrid rocket that can reach an altitude of 450 kilometers in 2021. Small satellites are rapidly increasing in demand in line with the expansion of the telecommunication industry and the global observation industry. Small cluster satellites are pushing away from previous large satellites. A total of 8,500 small satellites are expected to be launched by 2028, and InnoSpace has completed 11 flight tests, developing science rockets that can reach an altitude of 20 kilometers with up to a ton of thrust.

Solid rockets are difficult to control due to their complex thrust dynamics and are used as weapons, limiting private development, and liquid rockets have the disadvantage of having high production costs. InnoSpace uses hybrid rockets that take advantage of both types of rockets to have both safety and economic thrust control capabilities. In addition, it aims to gradually develop nanosatellite, micro-satellite and micro launchers to provide satellite launch services and provide nanosatellite projectiles for 2 billion won. Hybrid rockets are likely to be used for small satellite projectiles, given that they have differences using existing solidor liquid types of boosters. InnoSpace aims to lower the existing high launch unit price and provide 2 billion won for a 50kg launch and 5 billion won for a 150kg launch for a micro satellite launch. There are only about 10 launch companies around the world, and companies have to take a long production period because they launch using large projectiles and have to bear the burden of failure to

launch. InnoSpace will dominate the market as a small satellite projectile company in Korea with the safety and economic technology of hybrid rockets.

Contec

Contec provides space data reception and transmission services that customers need through space ground stations. It has a facility that receives and controls data produced from satellites and satellite projectiles, and is a platform that provides easy access to web-based operating systems and receives desired space data with a single click.

Contec's ground station network supports VHF, UHF, and S-Band for TT&C and X-Band frequencies through high-performance receivers for high-speed data reception. It has a software development technology that performs a quality assessment of the registration and location accuracy of data generated by the Korea Multi-purpose Satellite Series (KOMPSAT-3, KOMPSAT-3A) operated by the Korea Aerospace Research Institute (KARI). CAL/VAL quality evaluation software uses satellite data generated from image processing systems to establish radioactive, spatial, and geometric quality evaluation criteria and evaluate image quality. Based on the above information, satellite CAL / VAL technology and data quality improvement are expected. The improvements will be applied to the upcoming KOMPSAT-7 and CAS-500 satellites.

Contec is currently providing related services by purchasing video from a satellite-owned company for satellite video utilization services. There is a plan to have Context's own Earth observation satellite in the future. At Space Tech Expo 2019, which was recently held in Bremen, Germany, it signed a memorandum of understanding (MOU) to develop joint satellites to secure satellite images in cooperation with satellite manufacturers. It is also planning a launch mission service to support launch missions for small projectile companies that launch CubeSat (square-shaped satellites) by establishing contact's own commercial launch sites in Korea (or overseas). As the demand for cube sets increases, companies that make small launch services (Rocket Lab, Vector, Skyrora, Firefly, etc.) also increase worldwide, with few commercial launch sites. Therefore, it is also planning to build its own small commercial launch site in the near future, which can support commercial launch missions through experience in supporting overseas launch operations.

7.4 Policy direction to response new space era

The Korean government, while continuing to promote applied research in high tech and emerging technologies, since the 1990s has sought to put more attention on space technology. The Korean space policy is based on the Short, Middle and Long-Term National Space Development Basic Plan. The Basic Plan laid in 1995 was revised in the years 2000, 2013 and 2018. It aims to strengthen international cooperation and R&D in fundamental technologies. This revision of the objectives of the Space Basic Plan was a reflection of changes in the national and international environment as well as of the possibility of implementing space technology development. The recent revision of the National Basic Plan was passed in 2018.

Because the basic plan contained the overall contents of space development, detailed plans for industrial policy were needed. Therefore, the government created a space industry strategy. "Space Industry Strategy" plans to expand the size of the space industry from 2.7 trillion won (2016) to 3.7 trillion won in 2021 by expanding the private-led space industry market, creating new industries to grow the space market, strengthening global competitiveness of space companies.

It supports challenges to new satellite-based services, new IT convergence industries, and niche device markets for growth and innovation in the space market by creating new industries. To this end, it is also seeking to provide satellite information that will be applied to IT technologies such as artificial intelligence

(AI) and big data and ease security regulations for satellite images that are tied up with 4m resolution. In order to expand the foundation for innovative growth in the space industry, the government will revise legal systems such as the Space Development Promotion Act and the Space Damage Compensation Act by next year to promote commercial space activities by the private sector, and re-establish KARI's role.

The challenge of future space policies is whether they can gather the requirements of new companies. The direction of implementing space policies led by the government and led by the private sector has been set, but specific methods and timing of the transition is still in need of discussion. In particular, New Space startups do not want to partially participate in existing technology transfers or government research and development projects. They are calling for market development, public procurement and financial support to expand their businesses. These challenges are policy measures that are not considered in existing industrial policies.

Support policies that can enhance global technology and price competitiveness of leading domestic companies that mainly participate in government projects are also needed. It is necessary to support companies participating in the satellite and projectile business, which is currently being developed by the government, to secure technology and price competitiveness in New Space startups and global markets. For example, hiring non-space components for small and medium-sized satellite businesses for public demand purposes, securing price competitiveness through the introduction of a separate quality certification system, and setting up missions based on business models. Small satellites have a higher proportion of commercial components than space components, so it is urgent to establish an appropriate system for performance and testing as they need to verify parts.

7.5 Conclusion

The space industry, which has been historically dominated by space agencies and a few defence space companies from the most technologically advanced countries, is currently expanding its global value chain through increased commercial use of satellite data, increased technology exchanges among countries, and the resulting increase in the number of countries investing in space. In each sector that makes up the value chain, low cost, mass production, and increased use of commercial parts, companies providing specific services in detailed fields are emerging, which can serve as an opportunity for domestic companies.

Korea's space industry ecosystem has achieved quantitative growth through government-led development projects. However, the industry is bound to be affected by the continuity of government development projects. Furthermore, with the recent emergence of New Space companies, a new ecosystem is emerging. Private investment is occurring, and large companies invest in the space sector or mergers and acquisitions may occur. In other words, Korea is also believed to have entered a new phase where the space industry can grow.

Korea's space industry and related policies are expected to be as follow. First, the role of the government is expected to be transformed into a business area of private capital investment and commercial technology unrelated to the government's space development program. The government has played a crucial role in the growth of space companies, and the role will become more important in the future. If the direction and development goals of technology development proposed by the government have been carried out through service contracts, the government will only present requirements for technology development and conduct step-by-step inspections to achieve the goals. It is expected to promote technological innovation among the private sector by promoting such a public-private partnership method.

Second, New space is expected to drive greater changes in existing space industry ecosystems such as launchers and satellite systems. Space companies are actively responding to changes by using new

technologies such as virtual reality and 3D printing in their processes to streamline production and introducing mass production lines that use commercial components to quickly produce satellites of various sizes at low cost. As a result, the existing space industry will become more important to incorporate into the global value chain as competition in the space parts supply market intensifies. This means that opportunities for domestic parts and materials suppliers, which have been stuck in the limit of the domestic market, to enter the space industries will increase.

Finally, the participation of large companies, such as Samsung Electronics, is expected to accelerate. One of the important features recently found in the domestic market is the way the business expands to integrate different value chains or sectors. Unlike in the past, when there was a clear market division such as satellite component manufacturing, satellite system manufacturing, services, and terminals, more and more companies are integrating final utilization services as well as manufacturing through active mergers and acquisitions.

8 New Space in Malaysia

By Norilmi Amilia Ismail, School of Aerospace Engineering, Universiti Sains Malaysia, Shahrizal Ide Moslin, Space Technology & Engineering Complex, Malaysia Space Agency, and Sholehah Ismail, Corporate Planning and Communication Division, Malaysia Space Agency.

8.1 Introduction

The landscape of the space industry has dramatically changed since the beginning of the 21st century. More private players have been established and new government policies have been enacted to provide the right ecosystem for the commercial space sector to grow. Malaysia has engaged in commercial space activities since the launch of a communication and broadcasting satellite by MEASAT in 1996. Despite the success of MEASAT, the Malaysian space sector was still mainly driven by governmental strategies and public funding. Malaysia has launched its first domestic satellite, TiungSat, in 2000 and carried out an astronaut program, Angkasawan, resulting in Sheikh Muszaphar Shukor becoming the first Malaysian in space in 2007. Nearly a decade after the first satellite launch, in 2009, RazakSat-1 was launched to validate technologies for near-equatorial low Earth orbit remote sensing satellite systems. The TiungSat and RazakSat-1 programs were funded by the government and the satellite development managed by domestic company Astronautic Technologies Sdn Bhd (ATSB).

Since the launch of RazakSat-1, domestic space activities, especially in the upstream sector, were at a slow pace and did not record any significant space development milestone. However, in 2018, Universiti Teknologi MARA(UiTM) was involved in the BIRDS-2 program, developing and launching a 1U CubeSat from International Space Station (ISS). The program is still funded by the university and the government of Malaysia. The commercial space sector in Malaysia is more active in the downstream segment. The utilization of satellite images from remote sensing satellites, navigation satellite applications and satellite communications become the core business of local space-related companies and non-space companies.

In 2020, Malaysia's space landscape is about to change, with more private companies getting involved in the space business. Currently, the global space economy has grown over USD 400 billion,[166] and Malaysia can tap into this space industrial market with the emergence of new private companies in this sector. These new private companies are also involved in new space businesses such as launchers, small satellite manufacturing and space tourism. The Space Bill waiting to be approved by the Malaysian Parliament will also support private space companies' activities and attract more international investors to Malaysia. Aiming to "be one of the aerospace nations by 2030", Malaysia plans to have a satellite manufacturing and servicing industry to boost the economy and create jobs. Partnerships with the private sector will be key in the execution of this plan.[167] Malaysia also benefits from being close to the equator, providing cheap and efficient access to space. Therefore, launching vehicles and a spaceport can be a potential business for the private sector to involve in.

This chapter presents the space sector's ecosystem in Malaysia and discusses the government's initiatives and roles in improving the ecosystem to support the new space industry.

[166] Approximately 330 billion EUR.
[167] M. Obe, "Philippines, Malaysia and Indonesia bet on space as growth engine," *Nikkei Asia*, 2019.

8.2 The Malaysian space ecosystem

The aerospace industry has been identified as a strategic industry by the Malaysian government that catalyses industrialization and technological development programs in Malaysia. The space industry is under the flagship of the aerospace sector in Malaysia. Malaysia's aerospace industry has taken off with the launch of the National Aerospace Blueprint in 1997 which has charted the development plan to transform Malaysia's aerospace industry into a dynamic regional and international aerospace player by 2015. In 2015 the new Malaysian Aerospace Industry Blueprint 2030 was launched with the following vision: "*By 2030, Malaysia will be the number one aerospace nation in South East Asia and be an integral part of the global market*".[168] The blueprint has five focus areas, as shown in Figure 8-1, and the space-related industry is under the 'system integration' focus area.

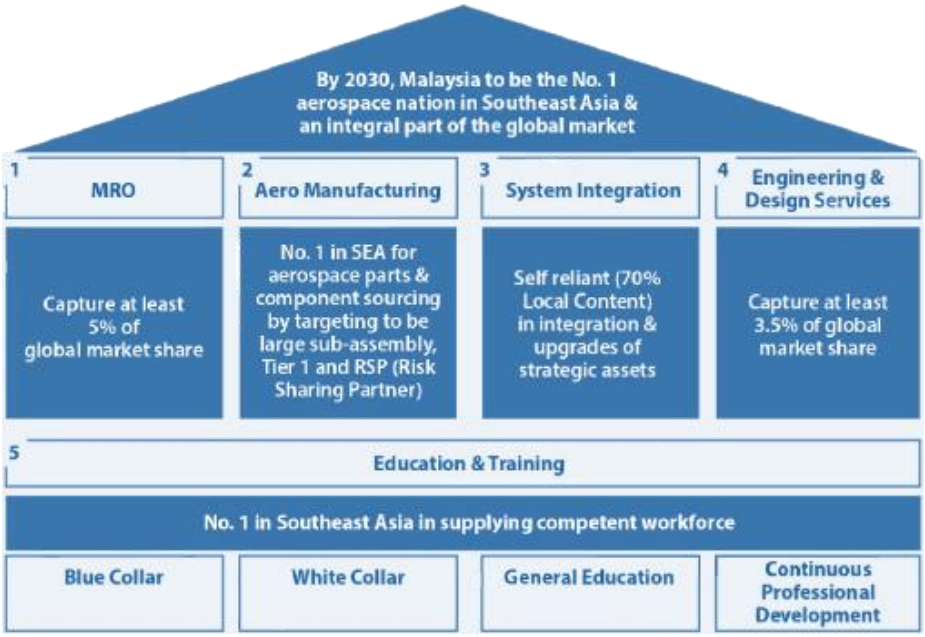


Figure 8-1: Malaysian Aerospace Industry Blueprint 2030[169]

8.2.1 Overview of the ecosystem

The blueprint presented an ecosystem comprised of regulators, government agencies, industries based on the focus areas, research and technology, and training and education. The Malaysian Space Agency (MYSA) is one of the regulators. ATSB Sdn Bhd is part of the System Integration focus area and currently the only company listed in the spacecraft segment.[170] The blueprint did not include the industries related to satellite systems applications such as satellite communication, Earth observation, and satellite navigation. Nevertheless, the industries listed in the ecosystem of the blueprint mostly focus on Aero-manufacturing and Maintenance, Repair and Overhaul (MRO), where both sectors contribute for, respectively, 48% and 46% of the 14.4 billion revenue of the aerospace industry in 2018.[171]

The ecosystem in the blueprint also includes government agencies to support the aerospace industry. The agencies are the National Aerospace Industry Coordinating Office (NAICO), the Malaysian Investment

[168] A. R. A. Talib, *Malaysian Aerospace Industry Blueprint 2030*, May 2015.
[169] Ibid.
[170] National Aerospace Industry Coordinating Office, "Malaysian Aerospace Industry Report 2019," 2019.
[171] S. J. Syahirah, "Malaysian Aerospace Industry to Generate RM16b in 2019," *The Edge Market*, 2019. [Online]. Available: https://www.theedgemarkets.com/article/malaysian-aerospace-industry-generate-rm16b-2019.

Development Authority (MIDA), the Malaysia External Trade Development Corporation (MATRADE), the Malaysia Productivity Corporation (MPC), the SME Corporation Malaysia, the Selangor Darul Ehsan Aerospace Industry Coordination Office (S-DAICO) and the Department of Skills Development. NAICO is a unit established under the Ministry of International Trade and Industry to oversee the implementation of the blueprint's strategies and initiatives. On the education, training and research side, a number of institutions are part of the ecosystem supporting the development of human capital for the industries, public and private higher education institutions, technical and vocational education and training (TVET) organisations, and private training centres.

The ecosystem outlined in the Malaysian Aerospace Industry Blueprint 2030 may not capture the real ecosystem in the space sector as the industry is small. In the framework of Malaysian space activities, space industries can be divided into three segments. The three segments are the civil, commercial and defence sectors. The government sponsors the civil and defence sectors, and the commercial sector area is self-sponsored but heavily backed by the government. In the civil sector, MYSA, as a government agency, plays a significant role in developing the nation's capabilities in a comprehensive and coordinated manner and in implementing the national space policy. The coordination of international collaborations and partnerships is another function of MYSA to further pave the way for beneficial technology exchange among space agencies. MYSA will become one of the regulators of the space industry once the Space Act is implemented. Although MYSA is leading the space development in Malaysia, the defence sector is solely under the jurisdiction of the Ministry of Defence.[172] Figure 8-2 shows the overview of the Malaysian space ecosystem.

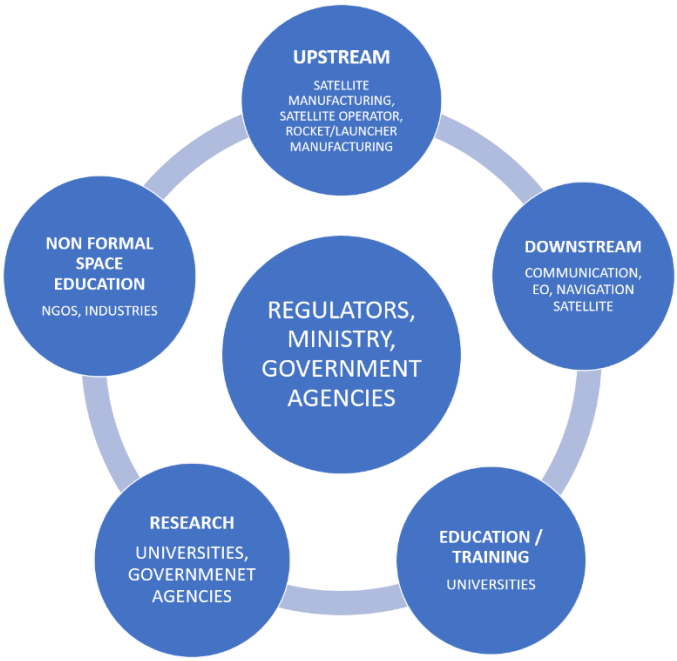


Figure 8-2: The Malaysian space ecosystem

8.2.2 The Malaysian commercial space sector

The commercial space sector is divided into the downstream and upstream segments.

[172] SIRIM Berhad, "Space Industry In Malaysia: A Strategic Development 2008," 2008.

Upstream segment

The upstream segment includes industries in satellite manufacturing, satellite operations and rocket manufacturing. The involvement of the local industry in this segment is limited: only ATSB and MEASAT are satellite manufacturing and operations players. ATSB was established in 1995 and wholly owned by the Ministry of Finance under the Malaysian Ministry of Science, Technology and Innovation. The main objective of ATSB was to be the premier satellite manufacturer in Malaysia. Unfortunately, at the time of this article's publication, ATSB Sdn Bhd is no longer in operation. MEASAT is a satellite operator company and currently own five operational geostationary communication satellites. MEASAT plans to launch MEASAT-3d in 2021 to serve the growth of 4G and 5G mobile networks in Malaysia and additional distribution capacity for video in HD, 4K, and ultimately 8K in the Asia-Pacific region.[173]

Rocket manufacturing is an emerging industry with the involvement of a few active players. Currently, Marine Technology Sdn Bhd (MTC) has started developing rockets for military training and STEM education, based on cloud seeding rocket research of their defence division. Their investment for this rocket project is approximately USD 250,000[174].[175] In December 2020, MTC collaborated with Equatorial Space System (ESS) to launch the Low Altitude Demonstrator rocket, for the first commercial rocket testing in Southeast Asia.[176] Independence-X Aerospace (IDXA), known as one of the finalists in Google Lunar-X prize, is also a launcher manufacturing company. It is building a small satellite launcher called DNLV (Dedicated Nano Launch Vehicle) that will be commercially ready by 2023. The DNLV can provide dedicated launch services to small satellites and CubeSat owners for insertion into their intended orbit.

Other new players in this upstream sector are Mapri Sdn Bhd and SpaceIn Sdn Bhd. Mapri is owned by UZMA Berhad, a publicly listed company in the oil and gas business and venturing into satellite manufacturing for remote sensing and monitoring services. SpaceIn is a spin-off company of Universiti Sains Malaysia focusing on small satellite development. They are now developing a PocketQube satellite with the size of 5 x 5 x 5 cm and planned to be launched in Q4 2021. SpaceIn also develops a High-Altitude Balloon system and provides services such as space photography, communication testing and scientific experiments. The other new company in this upstream sector is Orbital Space Sdn Bhd and Skye technology Berhad (SKYE). Orbital Space's business focuses on value engineering, lean satellite development, project management with end-users and stakeholders, and commercialization. SKYE has a few programs to be operated in their company, namely: the unmanned orbital laboratory, the Airborne Vehicle Ecosystem and the Hypersonic Intercontinental Flight Ecosystem.

Downstream segment

In contrast to the upstream segment, the downstream segment has many industries involved in using communications, Earth observation (EO) and navigation satellites technologies for their business. The largest segment in the downstream market is communication, where the local telecommunication and broadcasting sectors account for, respectively, USD 8.87 billion and USD 1.58 billion[177] of revenue in 2018.[178] MEASAT, as satellite operator, also provides services for transponder leasing, broadcasting and telecommunication. MEASAT has sealed a USD 350-million-agreement[179] with Astro Malaysia Holding for transponder service on the coming satellite MEASAT 3-d. The other main players are Maxis (sister

[173] C. Henry, "Measat buying single replacement for two satellites," *SpaceNews*, 2019. [Online]. Available: https://spacenews.com/measat-buying-single-replacement-for-two-satellites/.
[174] Approximately 206,000 EUR.
[175] Rosli, "Cloud Seeding Rockets More Cost- Friendly and Effective," *Ipoh Echo*, 2020. [Online]. Available: https://www.ipohecho.com.my/2020/09/23/cloud-seeding-rockets-more-cost-friendly-and-effective/.
[176] S. T. Asia, "Singapore ' s Equatorial Space Systems concludes first test flight," *Space Tech Asia*, 2020. [Online]. Available: https://www.spacetechasia.com/singapores-equatorial-space-systems-concludes-first-test-flight/.
[177] Approximately, respectively, 7.30 billion and 1.30 billion EUR.
[178] MCMC, "Shaping the digital landscape - Annual Report 2018," 2018.
[179] Approximately 288 million EUR.

company to MEASAT), Digi and Celcom with revenue in 2018 of, respectively, USD 2 billion, USD 1.61 billion, and USD 1.65 billion.[180]

EO services are an important segment in Malaysia. The government has allocated a budget of nearly USD 1.9 million in 2018 and USD 15 million[181] in 2019 to develop remote sensing activities at MYSA. MYSA is also servicing the government and private companies for satellite image data. Some of the private companies involved in EO activities are Sky-Shine Corp (M) Sdn Bhd, Jurupro Sdn Bhd, Juruukur Perunding Sdn Bhd, Espatial Resources Sdn Bhd and many more. MYSA will implement a National Earth Observation Satellite Development program to reduce the reliance on foreign satellite imagery through a Public-Private Partnership (PPP) initiative. This program will develop a remote sensing satellite with a cost of about USD 27 million.[182] Malaysia is currently spending USD 5 million[183] per year to subscribe to foreign satellite image and data services.

Other than EO, business applications of navigation satellite data are also rapidly growing in Malaysia. Many small to medium enterprises (SME) are focusing on navigation and positioning applications for commercial and private vehicles. There are more players in this segment thanks to the enhanced accuracy of the Global Positioning System (GPS) after the selective availability was lifted in 2000 and the introduction of small, accurate and affordable navigation receivers. This event was further elevated with the introduction of Google Maps in 2005. Additionally, the government introduced funding and grants to spark further interest in setting up space-based application companies. Katsana, Starfish, Netstar Advanced Systems, Favoriot, Stopanik and IntectX Creation are some of the well-known non-space companies in this segment.

8.2.3 Human capital development

The human capital to feed the space industry is also essential in the ecosystem. Education, training and research in the space sector are mostly provided by public universities. Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM) and the International Islamic University of Malaysia (IIUM) offer aerospace engineering programs including space-related courses. Other than being a coordinator for the space sector, MYSA also involves in space research. Other research centres include USM's Space System Laboratory (USSL), UPM's Space System Laboratory, and Universiti Kebangsaan Malaysia (UKM)'s Space Science Centre. Universiti Teknologi MARA(UiTM) established the Centre for Satellite Communication and launched its first satellite, UiTMSat-1, in 2018 and is now developing the next satellite called ASEANSAT, a collaboration work with international institutions from Japan, Thailand and the Philippines, and Orbital Space Sdn Bhd. Universiti Teknologi Malaysia (UTM), IIUM, UPM and UiTM are, through MTC-Hemrell Lab, among universities that are actively conducting rocket research.

The space education segment also witnesses the participation of NGOs and companies. Their common objectives are to enhance awareness and the importance of space technology in improving daily life quality. Hence, this will spur the next generation's interest to pursue a career in science, technology and mathematics (STEM). Malaysia Space Initiative (MiSI), SpaceVio, AstroX, Falak Online are among active NGOs in space education. Generasi Marikh, Space.S and Apadilangit are space education companies that conducted various activities for children from kindergarten to secondary schools. Space.S has popularized solid rockets for STEM in schools to provide an alternative to traditional water rocket programs. Apadilangit has conducted various astronomy and space STEM camps for kids. They have

[180] Approximately, respectively, 1.65 billion, 1.33 billion and 1.36 billion EUR.
[181] Approximately, respectively, 1.56 million and 12.35 million EUR.
[182] Approximately 22 million EUR.
[183] Approximately 4 million EUR.

integrated astronomy and the tourism industry to create a new business model to boost astronomical awareness and the local economy by promoting the Dark Sky agenda.[184]

8.3 Governmental policy and initiatives

Malaysia plans to launch a homegrown satellite under the National Remote Sensing Satellite Development Programme by 2025 and become the main player in the region to distribute geospatial-related data or images and services. Malaysia also aims to be a regional hub in providing one-stop centre testing and measurement services for both government actors and commercial industries through assembly, integration and testing (AIT) facilities at MYSA. To strengthen the national space ecosystem, Malaysia plans to create a platform for growth-seeking companies to lift them off to international markets by 2030. These plans are part of the Malaysia Space Exploration 2030 program, established by the Malaysian government in October 2020.[185] Two targets of this program are for Malaysia to rank in the top 3 in Southeast Asia and become 50% self-sufficient in space technology. By 2030, this program's economic spin-off is projected to contribute to an increase of at least 0.3% of the country's gross domestic product, create 5000 'Knowledge Workers' (K-Workers) and generate around RM40 million[186] a year from satellite operations and data business. This program will focus on strengthening the upstream segment by having a national satellite program and a launcher program. Malaysia Space Exploration Program 2030 will also focus on the space economy and one of the plans is to establish a space industry strategic plan. The space economy roadmap includes a plan to set up at least ten space business incubators in 2024 and to commercialise a minimum of five products by 2025 to achieve the objective to become 50% self-reliant in space technology.

The Malaysia Space Exploration 2030 program aligns with the strategic objectives and principles of the National Space Policy 2030 and the Malaysian Aerospace Industry Blueprint 2030. The National Space Policy 2030 has been approved by the Malaysian government in 2017. This policy is an important milestone in carving Malaysia's niche in the space sector. This policy aims to safeguard the country's interests by recognizing the importance of the access to space capabilities to improve the services needed by the people and national security. This policy is a reference to determine the directions of space sector development in Malaysia, to align the priorities and commitment of the sector strategically and place the appropriate resources to achieves the country's objectives in the space sector.[187] The National Space Policy 2030 will help Malaysia to coordinate space issues domestically and internationally and also assure the access to space capabilities by implementing its five 'thrusts' as listed below:

i. Reinforcing governance in optimizing the country's access to space capabilities;

ii. Focusing on space technology, infrastructure and applications significant to the nation;

iii. Driving the development of space science and technology as well as building expertise;

iv. Contributing to the economy and wellbeing of the country; and

v. Improving and strengthening international cooperation and network.

The Ministry of Science, Technology and Innovation (MOSTI) and MYSA have prepared the Space Bill to regulate national space activities, which is waiting to be approved by Malaysia's Parliament.[188] This bill

[184] For more information on the activities of the International Dark-Sky Associations, see https://www.darksky.org/
[185] A. Zambry, "MYSA Sasar Jadi Pembangun Teknologi Angkasa," *Wilayahku*, 2020. [Online]. Available: https://www.wilayahku.com.my/manfaatkan-teknologi-angkasa-manfaatkan-teknologi-angkasa-dalam-kehidupan/#.X50PyC2Q2u4.
[186] Approximately 8.2 million EUR.
[187] Malaysia Space Agency, *National Space Policy*. 2017.
[188] Bernama, "Malaysian Space Board Bill tabled in Parliament," *The Edge Market*, 2020.

aims to strengthen the national space sector's governance in line with Thrust 1 of the National Space Policy 2030 by establishing the regulations and guidelines for safe space activities. The bill will assure that the implementation of national space sector development is to be done in a highly responsible manner, complying with international space-related obligations.

8.4 Discussion, summary and conclusions

The Malaysian space ecosystem has changed significantly with the growth of upstream companies. More private players are venturing into the space industry and bring new technologies and approaches. One of the reasons underpinning the growth of upstream companies and the emergence of new ventures is financial backing. Companies with strong capital positions, such as publicly listed companies, have demonstrated a willingness to support upstream research and commercialisation. In the case of university spin-off companies, such as SpaceIn, this is a welcome source of funding which supplements university funding. In addition to financial support, these strong financial backers also offer equipment and facilities, giving the nascent space industry considerable in-kind assistance.

The collaboration between universities and the private sector as in the ASEANSAT project is also a good approach and makes the ecosystem more sustainable. However, the ecosystem can be improved with additional governmental initiatives to attract more venture capital investment to fund space start-ups at an accelerating rate. In terms of space awareness, NGOs and space education companies have played a good role in educating Malaysians. Still, they need to have more penetration outside the circle of space enthusiasts to get more people to support Malaysia's space program.

The establishment of Malaysia Space Exploration 2030, the National Space Policy 2030 and the Space Bill, gives a clear direction to Malaysia's space agenda. This shows the willingness of Malaysia to be part of this new space economy. The Space bill gives certainty of legality to the space players. However, the government should also oversee the bureaucracy and procedures that may become a factor in the industry not being involved or slowing down their space activities.

Previously, space technology in Malaysia was implemented as a one-off program and done by government agencies. There was no continuity, and it was separated from societal and national development objectives. This situation also causes space technology not to be considered an important element in the national development agenda. There is also no clear programme to incite the local industry to be involved in the space sector. Some existing industries are too dependent on government programs and allocations, making it difficult for them to sustain risk-taking in the space sector and survive. To enhance space development in Malaysia, a strong framework for the coordination of various ministry, agencies, industries, and universities is sought to be critical to ensure the successful implementation of the National Space Policy.

Overall, Malaysia has a good location, ecosystem and policy in support to the growth of a new space economy. The government still plays a major role in creating the right ecosystem for the private industry to grow. The coordination between the government, the industry and universities is important to ensure the sustainability of the ecosystem and the success of the space program.

9 New Space in Thailand

By Ekachai Phakdurong, Senior Vice President and Head of Regulatory Affairs, Thaicom Public Company Limited; and Onanong Sa-nguantongalya, Manager in the Regulatory Affairs Department, Thaicom Public Company Limited

9.1 Introduction

This paper provides an overview of the Thai space economy by compiling up to date information on Thailand's domestic satellite development history, on other national space-related projects and finally on the 20-year national space strategy for the development and utilization of space, based on domestic technology, innovation, knowledge and manpower, for the benefit of the Thai people. In view of the space economy in Thailand, space applications have become increasingly part of the assistance provided by the government to the people. New space development and investment in Thailand is mostly driven by the civil government and the military. However, the current trend seeing more participation from private commercial companies, research organizations, academia and citizens is a great help to promote and drive the space economy fast forward, providing both communication and information infrastructures for present and future uses by the country, such as telecommunications, internet of things, transportation, climate, agriculture, fishery, ship routing, mining, etc.

9.2 Thai domestic satellite development history

The Thai domestic satellite program started in 1991 with the main goal of using geosynchronous communication satellites to provide broadcasting services to people living in remote areas in Thailand and the region, through the Thai satellite series Thaicom.

After starting from advanced commercial communication, the satellite development roadmap in Thailand progressively integrated science, academic and security missions, namely the THEOS, THAI-PAHT and NAPA satellite systems.

9.2.1 The Thaicom satellite series

In 1991, King Bhumibol Adulyadej (Rama IX) graciously named the national communication satellite program "Thaicom". Thaicom stands for "Thai Communications", as a symbol of the linkage between Thailand and modern communications technology. Thaicom Public Company Limited (formerly named Shin Satellite), founded on 7 November 1991 as part of Intouch Holdings Public Company Limited, was granted a 30-year communication satellite operating license by the Ministry of Transport and Communications. This section provides a brief overview of all satellites of the Thaicom series.[189]

Thaicom 1, the first Thai commercial communication satellite, successfully launched in 1993, carries 12 C-band transponders covering Southeast and East Asia, serving the region's broadcast industry from its 78.5° East orbital position.

One year later, Thaicom 2 was successfully launched to its 78.5° East orbital position. The satellite provides broadcast services over Southeast Asia, Korea, Japan and the East coast of China via its 12 C-band and 3 Ku-band transponders. On the same year, Thaicom became the first operator in Asia to offer

[189] For more details on Thaicom's history and current services, see https://www.thaicom.net/history/

Ku-band, Direct-to-Home (DTH) broadcasting, and the world's first operator to employ MPEG-2 DVB compression standard.

In 1997, Thaicom 3 was launched and co-located with Thaicom 1 and 2. Together they establish the company's prime video channel neighborhood at 78.5° East to provide Hotspot Platform over South Asia.

IPSTAR (Thaicom 4), the world's first high throughput satellite (HTS) was successfully launched in 2005. Since then, IPSTAR has connected hundreds of thousands of users in underserved and unserved areas across Asia-Pacific to broadband internet. IPSTAR provides backhaul for mobile phone and Internet services in emergency shelters, schools and community centers. Cellular backhaul over broadband satellite proved to be effective in the aftermath of the Great East Japan Earthquake and Tsunami of 2011. The same year, a Thaicom subsidiary, IPSTAR Australia Pty Ltd (IPA), signed a contract with NBN Company Limited (NBN Co) for Australia's National Broadband Network's Interim Satellite Service. This contract represented a major breakthrough for the IPSTAR broadband satellite system - IPA is going to provide cost-effective broadband connectivity to unserved and underserved areas in Australia.

Later, in 2006, Thaicom 5 was launched into orbit at the same 78.5° East orbital position for operational service to replace Thaicom 3. The regional beams of Thaicom 5, with high-powered Ku-band and C-band payloads, provide broadcast and media services over Southeast Asia. Global beam coverage on Thaicom 5 spans over four continents and can service users in South Asia, Europe, Australia and Africa.

At the beginning of 2014, Thaicom successfully launched Thaicom 6 to its orbital position at 78.5° East. The satellite's high-powered C-band and Ku-band payloads provide broadcast and data services over Southeast Asia and Sub-Saharan Africa. The satellite's African payload is marketed under Africom-1.

Later on the same year of 2014, Thaicom 7 was placed on its orbital slot at 120° East. It provides a full range of media and data services tailored to the communication needs of the entertainment industry and telecommunication operators in Asia.

In 2016, Thaicom 8 was successfully inserted into orbit on a Falcon 9 rocket by SpaceX from Cape Canaveral, Florida, USA. The satellite's goal is to enlarge the company's footprint over high growth Asia markets where it will strengthen Thaicom's video channel neighborhood at the 78.5° East position.

Up to now, Thaicom has launched eight geosynchronous communication satellites mainly for communications, broadcasting and broadband missions. Thaicom has now become one of the Asian satellite leaders. Table 9-1 provides the list of Thaicom satellites, inclusive of their manufacturers, launch dates and current operational status.

Satellite	Manufacturer	Launch Date (UTC)	Status
Thaicom 1	Hughes Space Aircraft	18 December 1993	Decommissioned
Thaicom 2	Hughes Space Aircraft	8 October 1994	Decommissioned
Thaicom 3	Aérospatiale, now Thales Alenia Space	16 April 1997	Decommissioned (Deorbited: 2 October 2006)
Thaicom 4 (IPSTAR)	Space Systems/Loral, USA	11 August 2005	In Service
Thaicom 5	Alcatel Alenia Space, France	27 May 2006	Decommissioned
Thaicom 6	Orbital Sciences Corporation	6 January 2014	In Service

Thaicom 7 (AsiaSat 6)	Space Systems/Loral, USA	7 September 2014	In Service
Thaicom 8	Orbital ATK	27 May 2016	In Service

Table 9-1: List of Thaicom satellites

9.2.2 An early academic initiative: THAI-PAHT

In 1996, Mahanakorn University of Technology has designed a micro-satellite system, working at the Surrey Space Centre of the University of Surrey, UK. The first Thai micro-satellite, THAI-PAHT, was successfully launched into orbit in July 1997. THAI-PAHT was the first satellite designed and built by Thai people. This satellite was used primarily for education, with additional applications for weather forecast, mineral resources detection and communications.[190]

9.2.3 Government satellite programs: THEOS and NAPA

In 2000, the Geo-Informatics and Space Technology Development Agency (GISTDA) was founded. With centers in Bangkok and Chonburi, it serves as one of the core government agencies for space-related projects. THEOS-1, also known as Thaichote, is Thailand's first operational Earth observation satellite, owned and operated by GISTDA. It was developed at EADS Astrium SAS, Toulouse, France by a joint team included Thai engineers. It was launched in 2008. The THEOS-2 satellite is the second generation of GISTDA Earth observation systems, being the successor of the first generation THEOS-1 satellite. This satellite will provide very high-resolution geostrategic information, which will help improving science and technology infrastructure, increasing economic, social, and environmental capability to the country. It is currently under development in partnership with UK company Surrey Technology Satellite Limited (subsidiary of Airbus group). Apart from satellite development, it includes an ambitious capacity building program.[191]

In addition to the THEOS Earth observation satellite program, the Royal Thai Air Force (RTAF)'s first security satellite, NAPA-1, was successfully launched in 2020. The satellite and its ground segment were designed, built and developed by Dutch company ISISPACE in close coordination with the RTAF.[192] It will help the Air Force's operations in three domains – air, cyber and space – as part of its 20-year strategic plan and will also help support the country's disaster mitigation measures by providing pertinent data that can be used to prevent forest fires, flooding and drought.

9.3 Government initiatives to support space innovation

The Thai government outlooks that the New Space technologies are key tools to assist the country in many space-based services projects using big data analytics systems and would also help to drive the Thai space economy to a similar scale as other leading countries in the region. In the government's plans, the space sector is therefore encouraged to participate in government initiatives to foster innovation and develop space technologies and systems that can provide both communication and information

[190] For a complete overview of THAI-PAHT's development history and contribution to space education in Thailand, see Sujate Jantanrang, "THAI-PAHT the small satellite for education," *Proceedings of the Euro-Asia Space Week on Cooperation in Space – 'Where East and West Finally Meet'*, 23-27 November 1998, Singapore (ESA SP-430, February 1999).
[191] https://www.gistda.or.th/main/en/node/3126
[192] https://www.isispace.nl/news/packing-completed-napa-1-satellite-is-ready-for-launch/

infrastructures for present and future public and private utilization. In light of this, the Space Krenovation Park is one of the government initiatives to support space innovation and research.

9.3.1 GISTDA's Space Krenovation Park

The Space Krenovation Park (SKP) is a science park framework under the supervision of GISTDA with the goal of developing the area of the Thaichote satellite control and receiving station, Sri Racha District, Chonburi Province, to be GISTDA's main operational center. 'Krenovation' is a word formed by combining the words 'Knowledge', 'Creation' and 'Innovation'. SKP is a center to develop research and innovation on space and geospatial technology in order to create added value with small entrepreneurial products of medium and industrial scale. This will help promote Thailand to be a leader in the ASEAN in terms of business development based on science, technology and innovation.

SKP is an important foundation towards the development of the national and regional science and technology infrastructure and an innovation system of peers in order to support the economic and social development of the country, emphasizing the use of science and technology to enhance the competitiveness of entrepreneurs. Within this space innovation park, there will be a area for the private sector to research and develop space and geospatial information technology. Services will be provided to private entities to support transforming research into actual commercial products and increase business competitiveness. This project can help bringing science and technology to the help of the people and strengthen the country's sustainability.[193]

9.3.2 Royal Thai Air Force initiatives

Besides the aforementioned research, the RTAF is also developing space capabilities development and space security projects in terms of system fundamental structure, facilities and related support equipment in order to support capability enhancement in space operations with timeframe obligated budget for 2 years (2022-2023). RTAF is expecting these initiatives to enhance its abilities to support and conduct space activities in the areas of satellite development, manufacturing and testing on a basis of self-reliance, which allows RTAF to develop and sustain its own satellite technologies.[194]

9.3.3 Other projects

In addition to governmental projects, some universities and students are becoming active in research. For example, the Thai Space Research Group has launched a high-altitude balloon with sensors and tracking devices to study the higher atmosphere to further stimulate the interest of young Thai people in space.

9.4 Thai National Space Strategies

Today, space technologies in Thailand are utilized in a wide variety of areas. For this reason, Thailand needs to set plans, strategies for the development and utilization of space based on technology, innovation, knowledge and manpower for the country. The National Space Policy Committee, chaired by the Prime Minister, has approved a National Space Master Plan to clearly define the needs for the development of the country's space operations. The National Space Master Plan for 2017-2036 determines national space strategies, visions, missions and goals of a 20-year outlook for the

[193] For a detailed overview of innovation activities, projects and start-up companies present at SKP, see the park's official webpage: http://skp.gistda.or.th/txp/ (note: many resources are available only in Thai language).
[194] For an official overview of the RTAF's approach to space operations, see RTAF White Paper 2020, see https://www.mzv.cz/file/3896487/Thailand_RTAF_White_Paper_2020_ENG_complete_text.pdf

development of space industry and economy of the country with more commercial participation and innovation.

The goals given in the National Space Master Plan are to utilize space technologies for sustainable space management, driving economic value of the space industry of the country by promoting Thai space innovations for cost-effective use, establishing a national space academy that meets international standards to produce and develop personnel expertise in space and related fields.[195]

As a part of the Master Plan, creating innovations – space devices that belong to Thai people for cost-effective use with quality and standards recognized internationally, driving the Space Economy by enhancing communication satellite technologies, developing Earth observation remote sensing satellites with big data analytics systems, supporting participation in research, exploration and development of high-altitude platform manufacturing are at the core of the country's strategic plans for the 20 years ahead.

9.5 Summary

In Thailand, the satellite programs started from commercial uses, relying on foreign technologies. Nowadays, the government encourages the domestic space sector to create its own Thai innovations and develop technologies and systems that can provide both communication and information infrastructures for present and future uses by the country, such as telecommunications, internet of things, transportation, climate, agriculture, fishery, ship routing, mining, etc., as well as space-related Thai products being cost-effective and meeting international standards. The Thai government also plan to establish a space academy to prepare and build more expertise in this area.

New Space development and investment in Thailand are still mainly driven and led by the government. However, with the development of affordable space technologies and the enhancement of digital technologies, space-based applications in Thailand started shifting down to the private sector, which has developed many more applications for public and private uses. Therefore, space technologies are now getting much closer to the Thai people and also to the business sector. This requires an appropriate regulatory framework so that all stakeholders work together harmoniously.

[195] For an overview of the whole Master Plan, see Phee Choosri, "Leveraging Space Law Capability for new space actors in Asia Pacific Region". Presented at the UNCOPUOS on 25 September 2019. Available at https://www.unoosa.org/documents/pdf/spacelaw/activities/2019/T5-3-PC_Leveraging_Space_Law_Capability_for_new_space_actors_in_Asia_Pacific_Region.pdf

ANNEXES

Annex A – New Space companies in major Asian countries

List of New Space Companies in Japan

Start-up name	Foundation year	Segment
Institute for Q-shu Pioneers of Space	2005	Satellite Infrastructure
PD Aerospace	2007	Access to Space, Space Tourism
Axelspace	2008	Satellite Infrastructure, Satellite Data Use
Space Shift	2009	Satellite Data Use
ispace	2010	Space Exploration
ALE	2011	Satellite Data Use, In-Orbit Servicing
Space Bio Laboratories	2011	Satellite Data Use
Interstellar Technologies	2013	Access to Space
Meltin MMI	2013	Space Exploration
Club Tourism Space Tours	2014	Space Tourism
Astroscale	2015	In-Orbit Servicing
Integriculture	2015	Space Tourism
Dynamic Map Platform	2016	Satellite Data Use
infostellar	2016	Satellite Infrastructure
Umitron	2016	Satellite Data Use
Ridge-i	2016	Satellite Data Use
WARPSPACE	2016	Satellite Infrastructure
GITAI	2017	Space Exploration
SpaceBD	2017	Access to Space, In-Orbit Servicing
Telexistence	2017	Space Exploration
SPACE WALKER	2017	Access to Space, Space Tourism
GREE	2017	Satellite Data Use
Global Positioning Augmentation Service	2017	Satellite Data Use
mercariR4D	2017	Satellite Data Use
Polar Star Space	2017	Satellite Data Use
OUTSENSE	2018	Space Tourism
Synspective	2018	Satellite Data Use
SpaceOne	2018	Access to Space
AstroOcean	2018	Access to Space
Sagri	2018	Satellite Data Use
SIGNATE	2018	Satellite Data Use
Yspace	2018	Space Tourism

SAKURA internet	2018	Satellite Data Use
SE4	2018	Space Exploration
ONE TABLE	2019	Space Tourism
euglena	2019	Space Tourism
TENCHIJIN	2019	Satellite Data Use
Astroflash	2019	Satellite Data Use
Bascule	2019	Satellite Data Use
DATAFLUCT	2019	Satellite Data Use
Space Basil	2019	Satellite Data Use
amulapo	2020	Satellite Data Use
Skygate Technologies	2020	Satellite Data Use
avatar-in	2020	Space Exploration

List of New Space Companies in China

Company Name	Foundation year	Segment
LandSpace	2015	Access to space
One Space	2015	Access to space
LinkSpace	2014	Access to space
iSpace	2016	Access to space
Galactic Energy	2018	Access to space
Expace	2016	Access to space
Chinarocket	1998	Access to space
Space Transportation	2012	Access to space
Space Trek	2015	Access to space
Jiuzhou Yunjian	2017	Access to space (engines)
Deep Blue Aerospace	2016	Access to space
Tianbing Aerospace	2015	Access to space
S-Motor	2017	Access to space (engines)
Aerospace Propulsion	2018	Access to space (engines)
Ningbo Tianqing	2018	Access to space (engines)
AAEngine	2016	Access to space (engines)
Jilin Enter Space	2018	Access to space
Changguang Satellite	2014	Satellite manufacturing, satellite operator
Galaxy Space	2016	Satellite manufacturing, satellite operator
Deep Blue Space	2016	Access to space
Space Vision	2012	Satellite Data Use
MacroNet Communications Company Limited		Satellite operator
Zhuhai Orbita	2000	Satellite operator, satellite data use
SpaceTY	2016	
MinoSpace	2017	Satellite manufacturing

HEAD	2007	Satellite operator
ZeroG Lab	2017	Satellite manufacturing, satellite operator
LaserFleet	2017	Satellite operator
Space Engineering Development Company Limited	2017	Access to space
LEOBit Technologoes	2017	Satellite manufacturing
PIESat	2008	Satellite operator
Qiansheng Exploration	2017	
Hangsheng Satellite	2015	Access to space, satellite manufacturing
ADA Space	2018	Satellite manufacturing, satellite operator
GeeSpace	2018	Access to space, satellite manufacturing, satellite operator
Commsat	2015	Access to space
21AT	1992	Satellite manufacturing, satellite operator
SatelliteHerd	2016	Ground segment equipment
Space Wisdom	2015	Satellite data use
AstroCruise	2017	Access to space
OK-Space	2014	Access to space, satellite manufacturing
Caton	2010	Satellite manufacturing
StarTime	2015	Satellite manufacturing
Kuang-Chi Science	2013	Satellite operators
Huaxun	2007	Satellite manufacturing, satellite operator
Shanghai ASES		Satellite manufacturing, satellite operator
Synertone	2001	Satellite manufacturing
Guodian Gaoke	2015	Satellite manufacturing
Origin Space	2017	Satellite manufacturing
TWR Engine	2018	Access to space (engines)
Smart Satellite	2018	Access to space, satellite manufacturing
VSatTech		Satellite operator
Linksure	2013	Satellite operator
Centispace	2017	Satellite data use
Beijing Sixiang		
Hong Kong ATG	2019	Access to space, satellite manufacturing, satellite operator

List of New Space Companies in India

Company	Foundation year	Segment
Skyroot Aerospace	2018, Hyderabad	Access to space - Small satellite launch vehicles
Agnikul Cosmos	2017, Chennai	Access to space - Small satellite launch vehicles
Dhruva Space	2012, Bangalore	Satellite/Spacecraft Subsystems - Development of small satellite platforms with a focus on AIT
Xovian	2014, Kanpur	Satellite/Spacecraft Subsystems - Low-cost, sustainable satellite fabrication solutions, sounding rockets & HAPS
Bellatrix Aerospace	2015, Bangalore	Satellite/Spacecraft Subsystems - Satellite electric propulsion systems
Astrome Technologies	2015, Bangalore	Satellite/Spacecraft Subsystems - Satellite constellation-based Internet connectivity
Satellize	2016, Bangalore	Satellite/Spacecraft Subsystems - CubeSats and satellite services
Astrogate Labs	2017, Bangalore	Satellite/Spacecraft Subsystems - Optical communications
Manastu Space	2018, Mumbai	Satellite/Spacecraft Subsystems - Green propellant thruster
Pixxel	2018, Bangalore	Satellite/Spacecraft Subsystems - Nanosatellite constellation for imagery and data analysis tools
Garuda Space	2018, Bangalore	Satellite/Spacecraft Subsystems - EO data processing on satellites
D'Vine Research Lab	2018, Bangalore	Satellite/Spacecraft Subsystems - Monitoring of Aircraft and Ship using Small Satellite
Azista Aerospace		Satellite/Spacecraft Subsystems - Development of small satellite platforms with a focus on AIT
Saankhya Labs	2007, Bangalore	Satellite Applications - Software Defined Radio (SDR)
Skylo Technologies	2017, Bangalore	Satellite Applications - Satellite-based IOT applications for farmers, fishermen, trucking, etc.
Earth2Orbit	2009, Mumbai	Satellite Applications - Provision-of remote sensing value-added products, Technology consulting
SatSure	2014, Bangalore	Satellite Applications - Crop yield risk assessment for Insurance companies and banks

Numer8	2018, Mumbai	Satellite Applications - Geo-Big Data Exploration and Analytics
Aniara Space	2012, Bangalore	Satellite Applications - Satellite services (VSAT connectivity, capacity leasing, IoT, etc.)
Kawa Space	2019, Mumbai	Satellite Applications - CubeSat based satellites services
Blue Sky Analytics	2018, Gurgoan	Satellite Applications - Air Pollution
Mist EO	2019	Satellite Applications - Weather
Team Indus (Axiom Research Labs)	2010, Bangalore	Exploration - Lunar lander; Indian contender for Google Lunar X-Prize
Valles Marineris International	2016, Nagpur	Exploration - Lunar Rover- Synergy Moon (Google Lunar X-prize-Finalist), Cubesats, Pressurized Space Station Modules
NoPo Nanotechnologies	2013, Bangalore	Manufacturing - Carbon nanotubes for space use
Rocketeers	2013, Bangalore	Education - Model rocketry and human resource development
Society for Space Education Research and Development (SSERD)	2017, Thrissur	Education - Space Curriculum, Astro Space Camp, Space Workshops and Space Labs.

List of New Space Companies in South Korea

Company	Foundation year	Segment
UZURO Tech	2018	Satellite manufacturing, launch vehicle manufacturing, applications
SI Analytics	2018	Space data and applications
NARA Space Technology	2015	Satellite manufacturing, applications
Perigee Aerospace	2018	Launch vehicle manufacturing, ground systems
Ironwalks	2019	Science and space applications
Dream Space World	2010	Satellite manufacturing, space data and applications
Inno Space	2017	Launch vehicle manufacturing, ground systems
Contec	2015	ground systems, space data and applications

Annex B – Provincial support to New Space

Provincial support to commercial space industry development in China

Province	City	District / Project	Relevant space companies	Relevant policies - remarks
Jiangsu	Nantong	Nantong Economic and Technology Development Zone (NETDA)	Galaxy Space, Nantong Tongyi Aerospace S&T Company Limited	New infrastructure satellite internet Galaxy Space intends to build a satellite "super factory" in the NETDA. In July 2020, Galaxy Space CEO Xu Ming, the Mayor of Nantong and the Nantong Party Secretary, supervised the signature ceremony for a framework agreement.
Sichuan/ Chongqing	Chengdu-Chongqing		ADA Space, Star Time, various CETC subsidiaries including University of Electronic Science and Technology of China	New infrastructure satellite internet, Artificial Intelligence, "Chengdu New Infrastructure Development Action Plan" ADA Space announced in summer 2020 plans to build a "Chengdu-Chongqing Satellite Production Science and Technology Research Centre".
Chongqing	Chongqing	Liangjiang New Area Aerospace Comprehensive Industry Development City	Hongyan, One Space	5G, Intelligent Manufacturing, new infrastructure/satellite internet The Chongqing Liangjiang New District is a State-Level New Area, and as such has significant support from the Central Government comparable to Pudong (Shanghai) or Binhai (Tianjin). Liangjiang New Area has several key industries related to aerospace, internet technology, and IoT/Cloud. In December 2019, Hongyan operating company Macronet announced the commencement of operations in Liangjiang, with the company at the time being called a joint effort between Liangjiang and CASC. Separately, One Space has set up its global HQ in Chongqing.

Zhejiang	Hangzhou, Taizhou	National Satellite Manufacturing Base / Modern Digital City	Geely, CASC, CASIC, Starfast	New infrastructure satellite internet, cloud-related services due to Alibaba being Hangzhou-based Hangzhou government published a plan in 2018 for the city's comprehensive 2018-2022 plan to create a modern digital city. Within the plan, they mentioned an aspiration to become home to a national-level satellite manufacturing base.
Shanghai	Shanghai	New Infrastructure 2020-2022 Plan	SAST, VSATTech, Shanghai VSAT, Shanghai Hugong, LinkSure, CAS SECM, Gesi Space	New infrastructure policy related to 5G and satellite internet In April 2020 it was announced that Shanghai would create China's first "5G + Satellite" communication integration innovation laboratory in the Hongkou district. The laboratory is a cooperation between VSATTech, China Mobile Shanghai, and others. Shanghai's 2020-2022 city-level new infrastructure development plan mentions satellite internet as a priority, while also mentioning LinkSure as a local company working on satellite internet. Shanghai has also created the Zhangjiang Science City in Pudong, and the Lingang Satellite Research Base, which hopes to be able to produce 30-50 tonne-class satellites, and 600 microsatellites per year.
Jilin	Changchun	Jilin Province Aerospace Information Industry Park, a part of the larger Changchun New Area, which was established in 2016	Charming Globe, Jilin Enter Space, Changguang Aerospace Composites, Chinese Academy of Sciences	Made in China 2025, BRI, remote sensing, revitalizing the Northeast of China, "Jilin Province Opinions on Supporting EO" The Jilin Province Aerospace Information Industry Park is hosting Charming Globe's satellite manufacturing facility with an expected capacity of 30 satellites and 200 UAVs per year. The park is linked with the "Optoelectronics and Intelligent Equipment Industrial Park" in the neighbourhood.

Hubei	Wuhan	Wuhan National Aerospace Industrial Base	CASIC, Expace	National High-Tech Industry Base Civil-Military Integration In 2015, CASIC signed with Wuhan's municipal administration the Investment Framework Agreement for the 3rd National New Comprehensive Development Base of Space Industry in Wuhan. (The first two Development Bases of the Space Industry are in Beijing and Shanghai.) The Wuhan base, located in the Xinzhou District, includes the 1st national commercial space hub in China, called the National Aerospace Industrial Base. In 2016, the National Development and Reform Commission approved declaring the Wuhan aerospace base as a national high-tech industrial base. In September the same year, during the 2nd China Commercial Aerospace Forum (CCAF), CASIC, the Hubei provincial administration, and the Wuhan municipal government signed a cooperation agreement and officially marked the starting point of the industrial base. In April 2017, a public-private partnership between China Fortune Land Development and the Xinzhou District of Wuhan City was agreed. It is expected that at least 100 space-related enterprises will join the Wuhan commercial base by 2020/21, while the overall construction period will last for 10 years.
Shandong	Haiyang/ Yantai	Haiyang Eastern Coastal Space Port / Yantai Economic and Technological Development Area	CALT, China Rocket	Civil-Military Integration In 2019, the provincial and Yantai governments agreed with CASC on cooperation for a space industry park. It will become a base for sea-launch activities and a provincial hub for space-related industries. The park will host a 800-hectare manufacturing complex for production of 20 solid-propellant rockets annually: CALT's Long March 11 and for the Smart Dragon (Jielong) of CALT's subsidiary ChinaRocket. Also included will be satellite production and testing facilities.

Beijing	Beijing, Haidan	Beijing Tech Hub with Mega Aerospace Cluster	Zhongguancun Science City (China's Silicon Valley) in Beijing's North is the traditional centre of China's aerospace industry, scientific research institutes and related enterprises, forming a complete industrial chain for satellite design and manufacturing, for ground support and terminal equipment, satellite telemetry, tracking and control, and operations. In September 2020, the Haidian municipal administration announced plans to build a 100 billion-RMB (U.S.$ 14.8 billion) aerospace industry cluster in Zhongguancun Science City. Within an area of 1 million m2, the project will comprise three functional zones that focus on satellite internet innovation, Beidou satellite navigation, and space information services, as well as scenario applications. The Haidian administration will provide policy support, investments funds and subsidies for enterprises to settle in the cluster.
Jiangsu	Nanjing, Luhe District		18 billion RMB (about U.S.$2.7 billion) will be invested in a science and technology innovation centre for the aerospace industry, a national science education base and an international innovation zone. Attached to that will be a space-themed lunar exploration and aviation entertainment park, to open to the public in 2022.

Acknowledgment

ESPI would like to express its gratitude to everyone who supported and participated in this research project.

The Institute and the editors of this report are immensely grateful to the authors for their invaluable contribution and insights on New Space trends in their respective countries and domains of expertise.

We would also like to extend our thanks to everyone who supported this project in their professional or personal capacity including in particular Mrs. Jacqueline Myrrhe.

This research project was conducted under the supervision of Jean-Jacques Tortora, ESPI Director and managed by Sebastien Moranta, ESPI Coordinator of Studies.

About the Authors

Editors

Marco Aliberti works as Senior Research Fellow at the European Space Policy Institute (ESPI) in Vienna, Austria, where he has carried out and published a number of research projects covering governance and space security issues, access to space and exploration, and Asia's space programmes, particularly those of China, Japan and India. Prior to joining ESPI in October 2012, he held positions consistent with his academic background in East Asian Studies.

Quentin Verspieren is an Associate Research Fellow at the European Space Policy Institute (ESPI) and researcher at the Science, Technology, and Innovation Governance (STIG) program of the University of Tokyo. He primarily works on space policymaking and technology development in developing countries and on the role of the military in space safety and sustainability. Dr Verspieren has two master's degrees in aerospace engineering (ISAE-SUPAERO and The University of Tokyo) and a Ph.D. in public policy. He is a fellow at the Japan Space Forum in Tokyo and holds consultancy positions with the Japanese government and Japanese space ventures.

Authors

Masayasu Ishida is co-founder, chairman and CEO of the SPACETIDE Foundation, a Tokyo-based non-profit organization focusing on the development and expansion of the space industry. He is also a Principal at the global management consulting firm A.T. Kearney and has over 15 years of consulting experience, focusing on the aerospace and automotive sectors. As an acting member of the Japanese government's Committee on National Space Policy, he has supported the Cabinet Office and other governmental agencies, especially in the context of fostering commercial space businesses. He holds a degree in Mechanical Engineering from the University of Tokyo.

Kazuto Suzuki is Professor of Science and Technology Policy at the Graduate School of Public Policy, The University of Tokyo, Japan. He graduated from the Department of International Relations, Ritsumeikan University, and received a Ph.D. from the Sussex European Institute, University of Sussex, England. He has worked at the *Fondation pour la recherche stratégique* in Paris, France as assistant researcher, Associate Professor at the University of Tsukuba from 2000 to 2008 and served as Professor of International Politics at Hokkaido University until 2020. He also spent one year at the School of Public and International Affairs of Princeton University from 2012 to 2013 as visiting researcher. He served as an expert

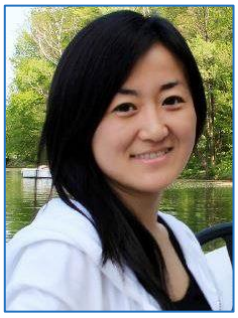
in the Panel of Experts for the Iranian Sanction Committee under the United Nations Security Council from 2013 to July 2015. He has been the President of Japan Association of International Security and Trade. His research focuses on the conjunction of science/technology and international relations; subjects including space policy, non-proliferation, export control and sanctions.

Chen Lan studied at the Tongij University of Shanghai. He worked as civil engineer before he joined the IT business in 1996. Since the 1990s, Chen Lan has been observing and analysing Chinese space activities. He published the web page "Go Taikonaut!" dedicated to Chinese efforts in space – the first English language online source on this matter. This website found international recognition and for a long time it became the most cited source on Chinese space endeavours. In May 1998 Chen Lan together with a Malaysian space enthusiast to introduce the word "taikonaut" for a space flight participant of Chinese nationality. This term experienced a common acceptance and is now used world-wide by media and space enthusiasts alike. Next to managing his IT company in Shanghai, Chen Lan is involved as an independent space analyst and free-lance author.

Blaine Curcio is a consultant and analyst specializing in the space and aerospace industries, particularly in regard to China. Blaine is the Founder of Hong Kong-based Orbital Gateway Consulting and is Affiliate Senior Consultant for Euroconsult. Blaine is a contributor to GoTaikonauts!, as well as the co-founder of the Dongfang Hour, a podcast focused on the Chinese space and aerospace industries. Blaine holds an MBA degree from the Hong Kong University of Science and Technology, and a BSc from Illinois State University.

Jean Deville is a China aviation and space observer, founder of the website China Aerospace Blog and co-founder of the Dongfang Hour space podcast. He has spent many years in the Chinese-speaking world, including the cities of Beijing, Shenzhen and Taipei. Jean currently works in the Chinese aviation business and is based between Shanghai and Paris. He holds an aerospace engineering degree from ISAE (Institut Supérieur de l'Aéronautique et de l'Espace). In his spare time, Jean enjoys astrophotography and hiking.

Zhuoyan Lu is a global adjunct faculty at the international space university. She was the co-lead for Commercial Space Project Group of the Space Generation Advisory Council and the deputy manager of the 3rd Asia-Pacific Workshop at the Council. Previously, she interned at the United Nations Office for Outer Space Affairs in Vienna and the United Nations Office of Legal Affairs in New York. Her specialized area is aerospace law, telecommunication law and cyber security law."



Narayan Prasad is a cofounder at satsearch, a global marketplace for space supported and incubated by the European Space Agency. He is also an Associate Research Fellow at the European Space Policy Institute where he is leading a study on Europe – India cooperation in space. An awardee of Emerging Space Leaders by the International Astronautical Federation, he has been supported by the German Academic Exchange Service to pursue doctoral research at the intersection of space industry and supply chain management. Narayan is supporting the development of a New Space industry ecosystem in India by working with startups such as Bellatrix Aerospace, SatSure alongside the Government of Kerala's initiative to create a home for New Space in India. He has authored over 50 articles in various national and international publications and has previously studied in India, Germany, Sweden and France. He can be reached by email on narayan@satsearch.co or @cosmosguru on Twitter.

Ashok G.V. is an attorney who practices before the High Court of Karnataka, India and a partner with Factum Law, Bengaluru. Ashok leverages his background experience as a commercial disputes lawyer with his interest in aerospace and space law to advise and assist a variety of businesses in the aerospace and space industry on domestic and international legal compliance, intellectual property management, contractual requirements and investment transactions. In addition to authoring papers and articles, he has spoken extensively on the inter play between trade and investment law, human rights and space law.

Norilmi Amilia Ismail is a senior lecturer at Universiti Sains Malaysia (USM) and President and co-founder of Malaysia Space Initiative, a non-profit organisation with a mission to help to advance the Malaysian space industry. She holds a master's degree in Space Mission Analysis and Design and PhD in Mechanical engineering from University of Glasgow, United Kingdom. She is also leading a research group in USM developing a Nano-Satellite and High Altitude Platform System. She founded SpaceIn, a spin-off company of USM focusing on small satellite system.

Shahrizal Ide Moslin works as a Senior Researcher at the Malaysian Space Agency (MYSA). He is based in Space Technology Complex, Malaysia. He holds a master's degree from Delft University of Technology (TU Delft), the Netherlands in Space System Engineering. His interest is in the field of satellite navigation, space technology utilization and space industry development.

Sangwoo Shin is a senior researcher of the Korea Aerospace Research Institute, Korea. He has experience in multilateral space diplomacy and space policy formulation. His research gravitates around the innovation policy. His contributions include fresh evidence on the allocation of public support to ecosystems, and the impact of public policy on innovation in different countries over time. He hold a PhD from the Science Policy Research Unit (SPRU) at University of Sussex. In the past, he worked for the Gyeonggi Research Institute (GRI).

Sholehah binti Ismail works as Research Officer under Corporate Planning and Communication Division at Malaysian Space Agency (MYSA) in Kuala Lumpur, Malaysia. She primarily works on space policy and legislation development in Malaysia. She has a Bachelor of Science with Honours in Physics and Master of Science in Applied Physics from Malaysian National University (UKM), Malaysia. She is one of the key persons who are developed the Malaysian National Space Policy 2030 that has been approved by the Government of Malaysia in December 2017.

Onanong Sa-nguantongalya started her career as a lecturer at the Faculty of Science and Engineering, Kasetsart University Chalermphrakiat Sakon-Nakhon Campus in early 2000. Later in the same year, she joined Thaicom Public Company Limited as an Engineering Specialist in Frequency Regulations and Coordination Department, specializing in Spectrum Management, ITU Radio Regulations and Satellite Coordination. She is currently a Manager in Regulatory Affairs Department responsible for Regulatory and Spectrum Development. While working at Thaicom, she actively participated in ITU and regional regulatory and spectrum activities. She was an APT (Asia-Pacific Telecommunity) coordinator during the World Radiocommunication Conferences 2007 and 2015 on certain satellite issues. She chaired the Task Group: Modern Satellite Applications at APT Wireless Forum (AWF) (now called APT Wireless Group - AWG) from AWF-6 to AWF-9 meetings and she was also a Co-Chair of DG's WRC-15 Agenda Item 1.6 and as a candidate Chair of DG's WRC-23 Agenda Item 1.17 of the APT Conference Preparatory Group (APG) meetings. For her education, Ms. Onanong Sa-nguantongalya graduated with a master's degree in Engineering (Telecommunications) from King Mongkut's Institute of Technology Ladkrabang (KMITL) in January 2000.

Ekachai Phakdurong is Senior Vice President and Head of Regulatory Affairs at Thaicom Public Company Limited. He works in satellite & telecommunication industries for more than 20-year, covers wide portfolio of roles and responsibilities. He spent years on ITU's activities and government affairs, including acquisition of landing rights and licenses in Asia Pacific. He gained experiences in engineering as head of RF-engineering for satellite programs. He had been the head of Thaicom's operations and customer services. He was also running subsidiary companies in broadcasting & maritime businesses in Thailand and other countries.

About ESPI

Policy & Strategy

Economy & Business

Security & Defence

International & Legal

ESPI is the European think-tank for space. The Institute is a not-for-profit organization based in Vienna, World capital of space diplomacy, providing decision-makers with an informed view on mid to long-term issues relevant to Europe's space activities since 2003.

ESPI is supervised by a General Assembly of member organizations and supported by an Advisory Council of independent high-level experts.

ESPI fulfils its objectives through various multi-disciplinary research activities leading to the publication of books, reports, papers, articles, executive briefs, proceedings and position papers, and to the organisation of conferences and events including the annual ESPI Autumn Conference.

Who we are	What we do
Independent think-tank specialised in space policy	Research and analysis on major space policy issues
Multinational team with interdisciplinary expertise	Monitoring of global space trends and policy developments
Part of a network of European and international partners	Organization of thematic conferences and workshops

Download our reports, check our events and subscribe to our newsletter online

www.espi.or.at

Schwarzenbergplatz 6 | A-1030 Vienna, Austria | (Entrance: Zaunergasse 1)
Phone +43 1 718 11 18 - 0 | E-Mail: office@espi.or.at

www.espi.or.at