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Full Report

Emerging Spacefaring Nations

Review of selected countries and considerations for Europe

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1 About Emerging Spacefaring Nations

1.1 A more diverse international space community

Alongside the rapid growth of both uses and users of space, perhaps the most striking trend characterising the ongoing evolution of the space sector is the increase in the number of actors - both private and public, conducting space activities.

Recent years have seen an expansion of space activities by established space nations, as well as the entry of young space nations, an entry that has been usually accompanied by the establishment of new space agencies.[1] Over the past five years alone, more than ten countries have established their national space agencies (see Figure 1). The number of agencies or administrations dedicated to space has increased exponentially in the last decades.

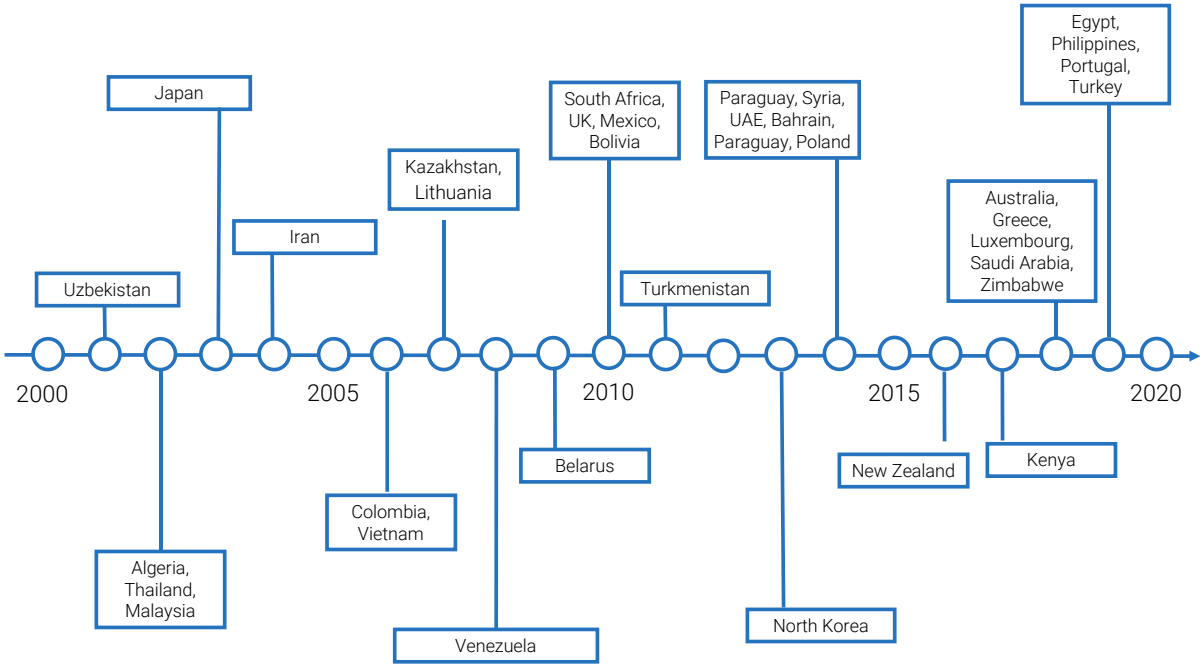

Figure 1: Creation of space agencies since 2000 (ESPI database)

Consistent with institutional developments, the once exclusive club of countries boasting national space infrastructures has also increased, and now includes a wider group of developed and developing countries with a diverse set of capabilities.[2] A clear indication of this is the growth in the number of countries with a satellite in orbit. These satellites are different in their specifications and may involve different levels of technical expertise, ranging from large telecommunication satellites purchased on the international market to very small CubeSats built by universities. As mentioned in OECD's report on the space economy, "the possibility to have one's satellite in orbit, registered with one's own national administration, has never been so affordable".[3]

[1] Tugnoli, Matteo and Wells. Leyton. "Evolution of the Role of Space Agencies", *ESPI Public Report* 70 (October 2019): 34, https://espi.or.at/publications/espi-public-reports.
[2] OECD, The Space Economy in Figures: How Space Contributes to the Global Economy (OECD Publishing, 2019).
[3] *Ibid.*

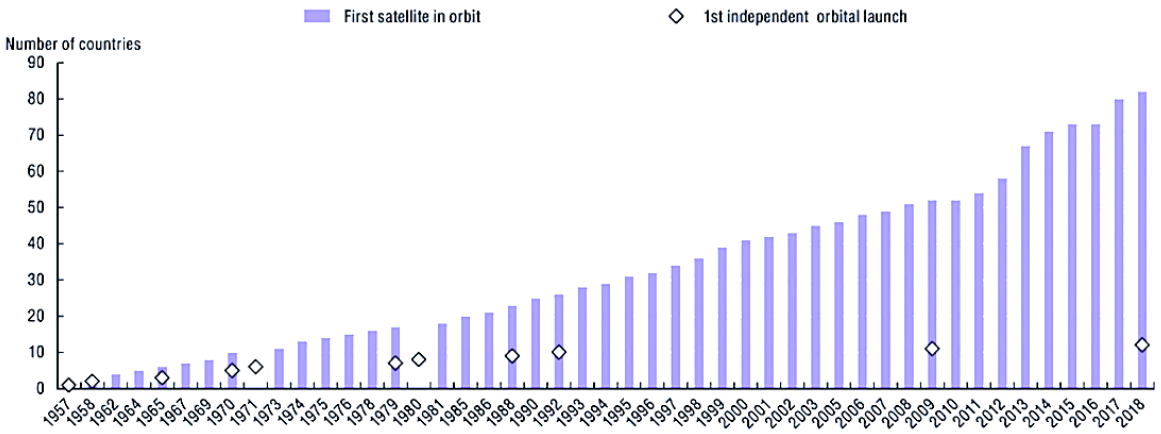

Figure 2: Number of countries with a spacecraft in orbit from 1957 to 2018 (OECD, 2019)

The result of these ongoing developments is a space arena populated by a diverse set of space actors pursuing space activities at different scales and with different ambitions. Alongside countries with a long history and heavy investment in the development of the full-spectrum of space capabilities, there are countries focusing on the provision of specific space-based services (e.g., applications for socio-economic purposes), and others seeking to acquire capabilities through private space initiatives. In between, an increasing number of countries are pursuing a tailored development of national capacities including launch and spacecraft manufacturing capacities, which are adapted to domestic objectives and resources.

Given these variations, a key question is how to categorize these actors and assess their relative positions within the international space arena. As there is no standardized taxonomy, it remains very challenging to draw the lines between an established space power, a spacefaring nation, and an emerging spacefaring nation.

1.2 Defining and mapping space actors

In order to better assess the relative position of the various actors in the space arena and better appraise their space power, a methodological framework was developed by ESPI in a previous study.[4] Within this study, ESPI classified space actors according to their relative ranking on the two key dimensions of space power: capacity and autonomy.

- "Capacity" refers to the ability of a country to implement space strategies to achieve its economic, political, or social goals in society. It includes:
    - Hard capacity: Ability to address the full spectrum of space activities.
    - Soft capacity: Ability to integrate space into national infrastructure, policies, and strategies.
- "Autonomy" refers to the country's ability to formulate space-related interests on its own, independent from or against the will of divergent political interests. It includes:
    - Technical autonomy: Ability to access and operate in space without relying on others.
    - Political autonomy: Ability to define space policies independently from others.

[4] ESPI (Aliberti et al.) *Measuring Space Power. A Theoretical and Empirical investigation on Europe*. Springer, 2019.

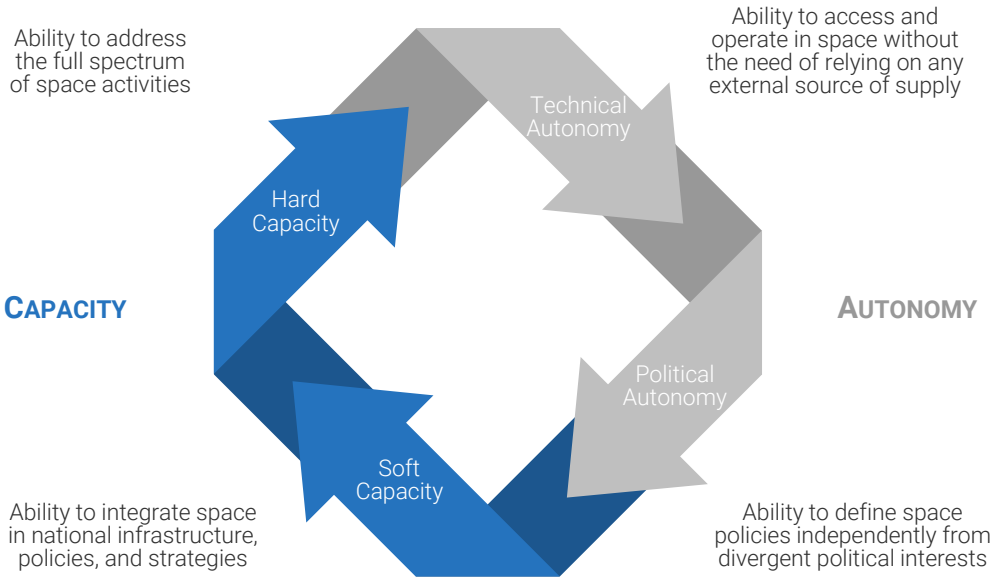

Figure 3: Space power requirements

The extent to which these conditions are met determines the relative status and overall position of countries on the global space scene. For instance, some countries may score high on both the capacity and autonomy dimensions, while others may not meet either of the two sets of conditions. In between, there are countries giving higher priority to one or the other. For example, some countries may focus on reaching a high degree of autonomy in a few domains, while others may rather seek to expand their capacities at the cost of dependence on other countries.

The scoring of countries according to their level of capacity and autonomy (low, medium, high) allows them to be positioned on a matrix as represented below:

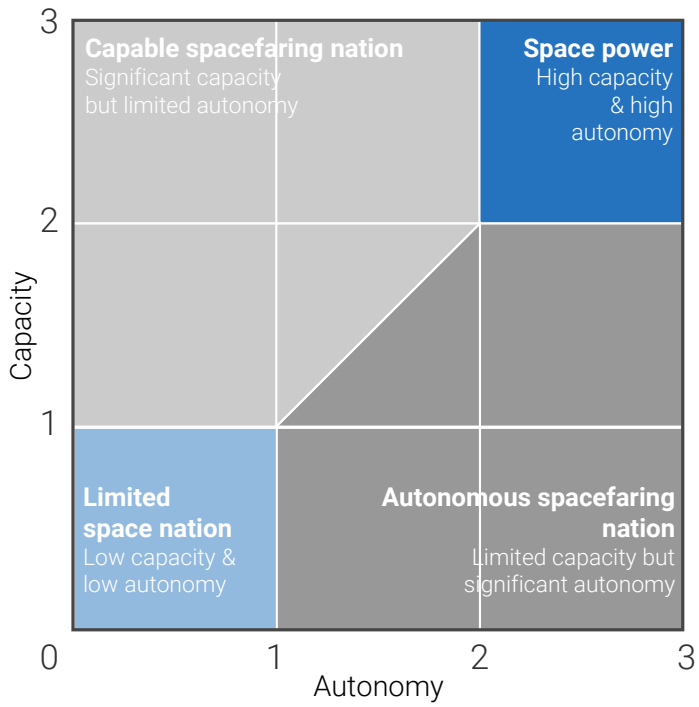

Figure 4: ESPI Space Power Matrix

In the upper-right quadrant, we can find states with a high level of both capacity and autonomy that fit the status of a **space power,** defined as a nation with the means to autonomously deploy, operate, and benefit from *any* space-related capability to support the achievement of national objectives.

In the opposite bottom-left quadrant, we find states with a comparatively low level of capacity and autonomy, which are considered as **limited space nations.**

Between these two poles, there are countries with more nuanced situations resulting from different combinations of capacity and autonomy, which are considered **spacefaring nations**. Within this group, two ideal types can be further identified:

- **A capable spacefaring nation**, which is characterised by more capacity than autonomy,
- **An autonomous spacefaring nation**, which is characterised by more autonomy than capacity.

For the purpose of the previous ESPI study on "Measuring Space Power", this methodological framework was applied to Europe and five selected countries (USA, China, Russia, Japan, India).[5]

For this study, a total of 68 indicators have been evaluated to measure the relative capacity and autonomy of these countries. The study concluded that, although Europe scores high with regards to capacity, its level of autonomy is not high enough to qualify it as a full-fledged space power.

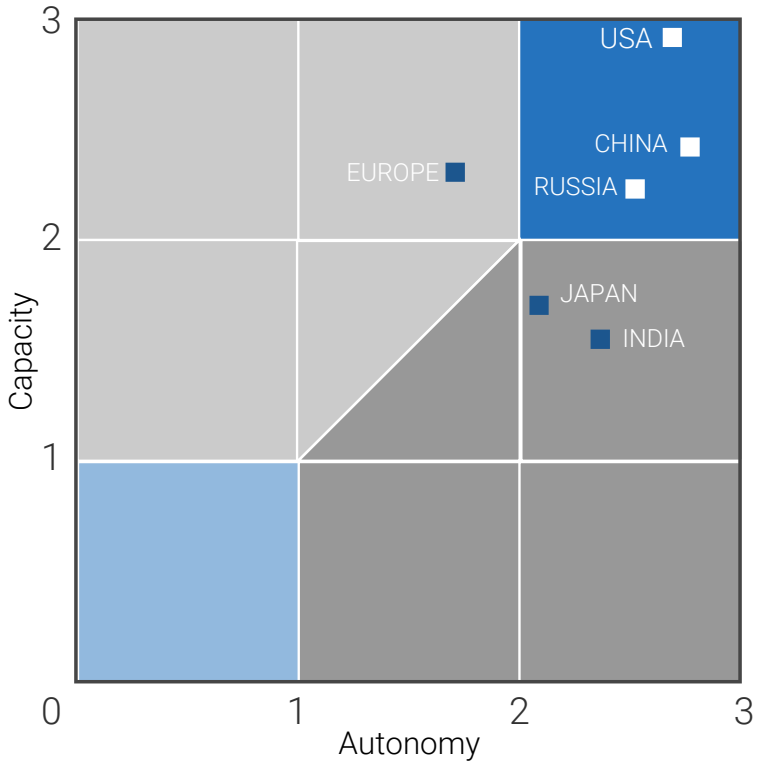

Figure 5: Selected nations on the ESPI Space Power Matrix

[5] ESPI (Aliberti et al.) *Measuring Space Power. A Theoretical and Empirical investigation on Europe*. Springer, 2019.

1.3 Emerging spacefaring nations: countries in transition

The position of countries on the matrix is not set and evolves as a result of a nation's development efforts, relative to the developments of other countries. China's rise from a spacefaring nation to full-fledged space power in the span of just two decades is a good example of such development. Other actors, including Europe, Japan, and India are making continuous efforts to further improve their level of capacity and autonomy with the objective of reaching the status of space power, while other actors like Russia may progressively lose their historic status of space power.

There are now an increasing number of countries shifting from the category of "limited space nation" and transitioning to the category of "spacefaring nations". Although these "emerging spacefaring nations" pursue different objectives and are developing their space capacity and autonomy at different paces and along different priorities, their transition is marked by important milestones, including for example:

- Adoption of a space policy/strategy, often in conjunction with a legal regime for space activities,
- Foundation of a national institution specifically in charge of space activities (e.g., space agency),
- Establishment of a national space programme with a dedicated budget and covering multiple projects,
- Acquisition of space capabilities from third countries for national purposes,
- Domestic industrial means for the development and/or operation of space systems,
- Development of systems and/or facilities for access to space (e.g., spaceport, launch system),
- Participation in international programmes and/or space diplomacy.

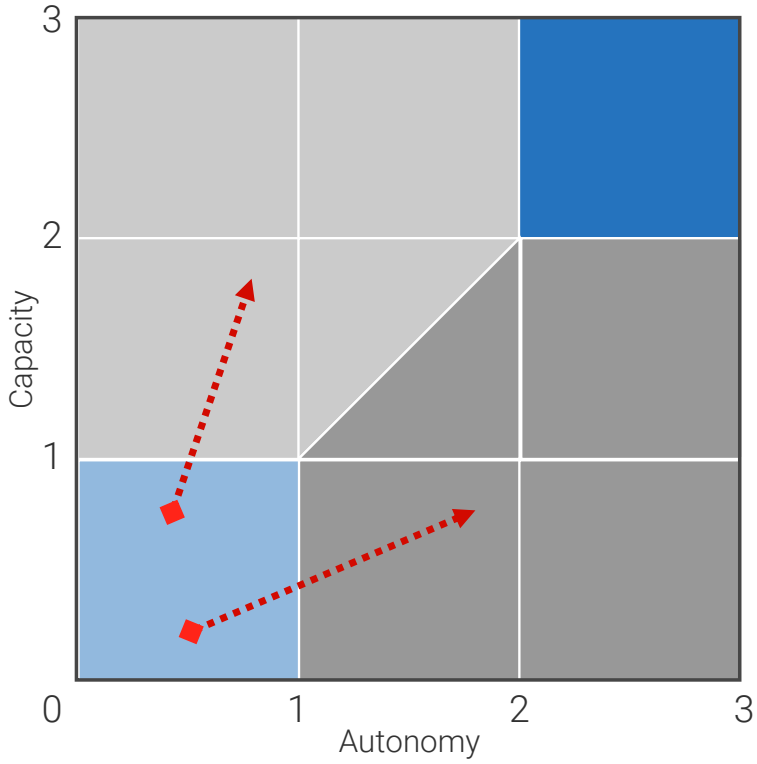

Figure 6: Emerging spacefaring nations are countries in transition

Emerging spacefaring nations can therefore be defined as countries that are increasing their efforts in the space domain, which are in the process of establishing broader autonomous capacities to access and operate in space and benefit from a variety of space activities.

Multiple countries meet this definition. As a matter of fact, the emergence of new spacefaring nations accelerated considerably over the last decade as many countries are raising their ambitions in the space domain and mobilising more resources for the sector. Notable examples of emerging spacefaring nations include Argentina, Brazil and Mexico in Latin America, South Africa, Egypt, Saudi Arabia, Iran, United Arab Emirates and Turkey in Africa and the Middle East as well as Australia, New Zealand, Indonesia, Vietnam, Malaysia, and South Korea in the Asia-Pacific region.

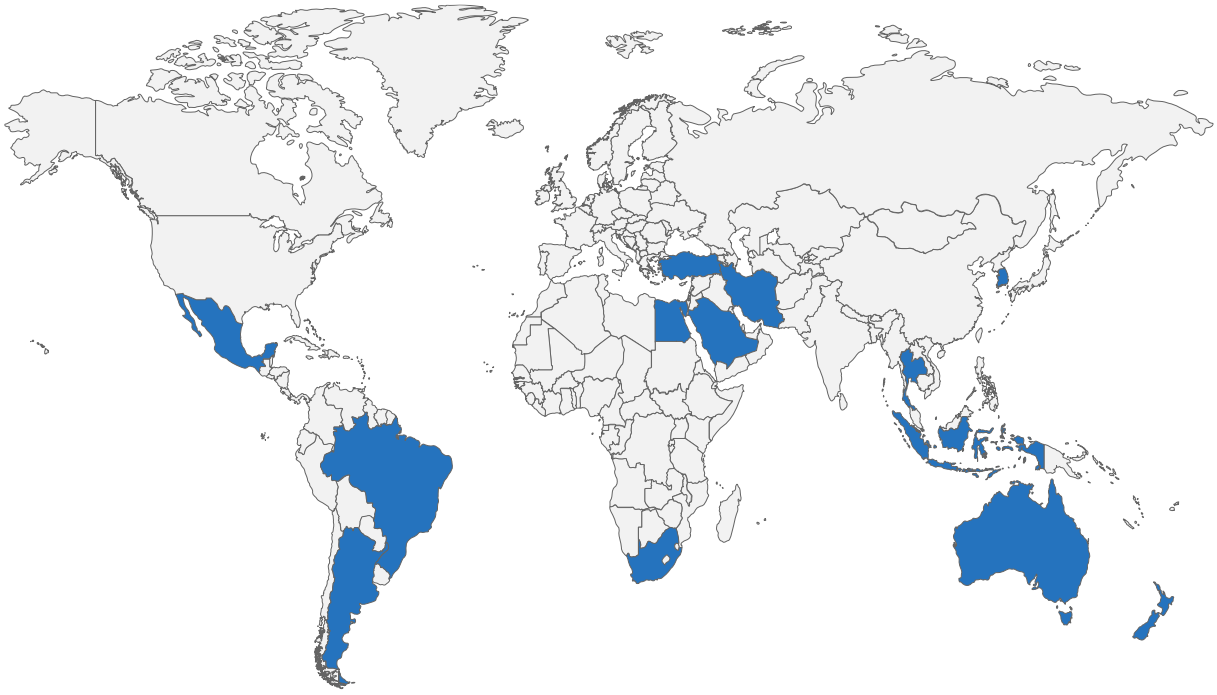

Figure 7: Selected emerging spacefaring nations

This list does not aim to be comprehensive, but rather to highlight the global dimension of the emergence of new spacefaring nations as well as the diversity of regions and countries concerned. With over 20 new national space agencies founded in just a decade and additional national developments, several other countries could also be considered emerging spacefaring nations.

1.4 Selected case studies

The emergence and development of new state actors has far-reaching implications for the future of the space sector and for the international space community, including Europe.

In this context, ESPI seeks to raise awareness among European decisionmakers about this developing international situation and about the opportunities and challenges associated with the emergence of new spacefaring nations in the global space arena.

With this objective, this report provides a review of space strategies, policies, programmes, and sectoral developments in selected emerging spacefaring nations and discusses implications of current and future developments in emerging spacefaring nations for Europe, in particular with regards to cooperation and international diplomacy.

ESPI selected four case studies to provide an illustrative overview of the variety of emerging spacefaring nations in terms of objectives and priorities, space programmes and history, and industrial developments, as well as political system, socio-economic development, or international diplomacy:

- The United Arab Emirates (UAE),
- Australia,
- Argentina,
- South Korea.

For each case study, the report provides information about their historical involvement, their domestic framework, the major policies, and programmes, as well as the objectives/drivers of the country's space strategy.

National space history

Major milestones and events

Space sector governance

Institutional framework
Space industry and economy
Research centres and academia

Policy and legal framework

Space policies and strategy
Legal and regulatory regime
International affairs

Programmes and infrastructure

Resources and infrastructure
Space programmes and activities

Key takeaways

Space ambitions
Key achievements in space

2 The United Arab Emirates

2.1 National space history

The Emirati journey into space started with the foundation of Thuraya Communication Company in 1997 and the subsequent launch of its first mobile communication satellite, Thuraya 1, in 2000. In 2007, Al Yahsat Satellite Communications joined the telecommunications market and performed its first launch in 2011 with Al Yah 1. The Emirates Institute for Advanced Science and Technology (EIAST) was established in 2006 for EO satellite design, manufacture, and operation.[6] Through EIAST, the country started developing national space capacities from a programme of knowledge and technology transfer with South Korea.[7] The objective of this programme was to send a number of Emirati engineers to South Korea to learn from the country's experience in Earth observation, to be used in the development of the DubaiSATs. Then, as next steps, they disseminated their newly acquired experience to progressively increase their involvement in the projects and become autonomous.[8]

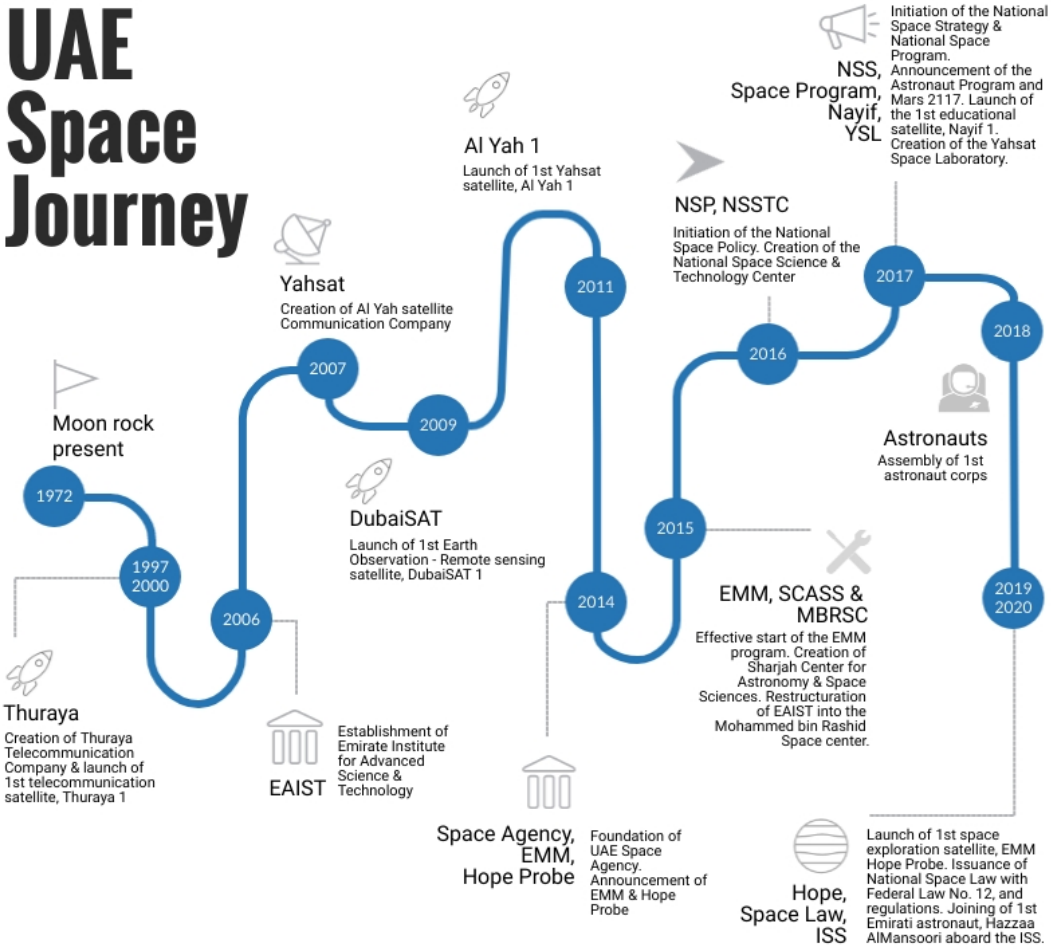

Figure 8: Timeline of UAE space journey

[6] Federal Competitiveness and Statistics Authority, *Policy in Action: Mission to Mars* (2019). Available at: https://fcsa.gov.ae/en-us/Lists/D_Reports/Attachments/26/Issue%2011%20-%20Mission%20to%20Mars.pdf. Accessed December 2020.
[7] *Ibid.*
[8] *Ibid.*

In 2014, the UAE Space Agency was created to complement EIAST and organize the country's space sector. The country also asserted its Mars exploration ambitions. The next year, the EIAST was restructured into the Mohammed bin Rashid Space Center (MBRSC). Since then, the UAE has developed capabilities in telecommunication and Earth observation, while also extending its involvement in space exploration and human spaceflight.

2.2 Space sector governance

2.2.1 Institutional framework

Managing space activities in the UAE involves several federal authorities (the Federal Supreme Council, The President and Vice-President, the Council of Ministers, and the Federal National Council), as well as dedicated bodies such as the UAE Space Agency and the MBRSC. The table below provides a brief overview of the competencies/responsibilities of those major stakeholders.

Entity	Involvement in space
Council of Ministers	Supervises the implementation of federal laws & decrees. Decides annual general budget.
Telecommunications Regulatory Authority (TRA)	Federal telecommunication regulatory agency of the UAE. Enacts regulations for the space sector.
UAE Space Agency (UAESA)	Organizes, supervises, and manages the UAE space sector.
Mohammed bin Rashid Space Center (MBRSC)	Implements space programmes, conducts scientific research, and provides services.
Space Reconnaissance Center (SRC)	Operates early-warning and security systems and gathers satellite intelligence.

Table 1: UAE institutional framework

The UAE Space Agency (UAESA)

The UAE Space Agency is the federal public authority for space activities. It is organized within Chapter 2 of the Federal Law No. 12 of 2019 on the Regulation of the Space Sector. Despite subordination to the Council of Ministers which may assign additional functions, it benefits from independence in regard to financial and administrative decisions, as well as the capacity to undertake actions to fulfil its objectives.[9]

The Agency aims to encourage, develop, and promote the importance of space activities.[10] Its mission is to organize, supervise, and manage the UAE space sector.[11] The Agency has the mandate to grant authorization for space activities, finance projects, represent the UAE, conclude bilateral or international programmes, and provide support and guidance to the space programmes.[12] Additionally, the Agency affects the legal and political realms as it is tasked with proposing space-related legislation. UAESA played a role in the creation of the National Space Policy, National Space Strategy, and the Space Law.

[9] Federal Law no. 12 (2019), *Regulation of the Space Sector*. Available at: https://bit.ly/3gZr01V. Accessed April 2021.
[10] *Ibid.*
[11] "Space science and technology", UAE Government Portal. Available at: https://bit.ly/3eSd8Un. Accessed December 2020.
[12] Federal Law no. 12 (2019), *Regulation of the Space Sector*. Available at: https://bit.ly/3gZr01V. Accessed April 2021.

The Mohammed bin Rashid Space Center (MBRSC)

The MBRSC is the scientific and technological hub of the UAE. Its activities revolve around scientific research and exploration, satellites and space systems development, satellite imagery, ground station services, observation, and remote sensing.[13] MBRSC worked on the manufacturing of DubaiSat-1, DubaiSat-2, Nayif-1, and KhalifaSat, the first domestically designed and manufactured satellite.[14] Recently, it managed technical aspects of the EMM Hope Probe, while the UAESA funded and supervised the project.[15] [16]

Another key role of the MBRSC is to oversee the 2017 National Space Programme and particularly the UAE Astronaut Programme. The MBRSC also oversees the Mars 2117 Strategy, which aims to build a city on Mars by 2117 and plans for the construction of the Mars Science City outside Dubai to replicate Mars conditions and train future astronauts.[17] [18]

According to Federal Law No. 17 of 2015, the MBRSC aims to "compete with developed countries in the field of advanced sciences and in making scientific discoveries" and "contribute to enhancing the UAE standing as a leading international hub for space sciences and technologies."[19] Therefore, the MBRSC is at the service of the Emirates' international ambitions in the space sector.

The Space Reconnaissance Center (SRC)

The SRC was formed in 2000 with the goal of directly and independently providing high resolution satellite imagery for systems that assist in early warning, monitoring, and planning security missions of the UAE Armed Forces. The products generated by the SRC can be used for a wide variety of applications, including facility monitoring and classification, indication and warning systems, detecting camouflage and deception, monitoring of the environment, and urban planning, among others.[20] The data received by the station comes either from satellite constellations such as IKONOS (US), IRS (India), and KOMPSAT (Korea), or aerial platforms like aircrafts.[21] Users of the data include the Armed Forces of the UAE; the Military Intelligence Directorate (MID); the Intelligence, Surveillance, and Reconnaissance Sections of the Army, Air Force, and Navy; as well as coastal and border protection forces, and police. Outside of security and defence, environmental affairs agencies and directorates, urban planning bodies, and research institutions also make use of the SRC's satellite imagery.[22]

The SRC also operates the Falcon Eye satellite, which provides surveillance, intelligence, target acquisition, and reconnaissance capabilities to the Emirati military with a resolution of 70 cm. In 2019, the French group Arianespace failed to launch the Falcon Eye 1 satellite after the second stage of the Vega rocket ignited. Falcon Eye 2 was then successfully launched by a Soyuz ST Fregat rocket in 2020.[23]

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[13] "Services", MBRSC. Available at: https://www.mbrsc.ae/satellite-programme/services. Accessed December 2020.
[14] *It should be noted that the project started off in South Korea and was "supervised" by Satrec with tests undertaken at KARI.*
[15] "Services", MBRSC. Available at: https://www.mbrsc.ae/satellite-programme/services. Accessed December 2020.
[16] "Space science and technology", UAE Government Portal. Available at: https://bit.ly/3teJxty. Accessed December 2020.
[17] "About", MBRSC. Available at: https://www.mbrsc.ae/about. Accessed December 2020.
[18] "National Space Programme". UAE Government Portal. Available at: https://bit.ly/3eR2YDw. Accessed December 2020.
[19] Federal Law no. 17 (2015), *Establishing the Mohammed Bin Rashid Space Centre.* Available at: https://bit.ly/3efFpVO. Accessed April 2021.
[20] "Applications", United Arab Emirates Space Reconnaissance Center. Available at: http://www.src.gov.ae/applications.html. Accessed April 2021.
[21] "Sensors", SRC. Available at: http://src.gov.ae/Sensors.html. Accessed December 2020.
[22] "End Users", SRC. Available at: http://www.src.gov.ae/EndUsers.html. Accessed April 2021.
[23] Foust, Jeff. "Soyuz launches Falcon Eze 2 satellite for UAE". 2020. *SpaceNews*. Available at: https://spacenews.com/soyuz-launches-falcon-eye-2-satellite-for-uae/. Accessed May 2021.

2.2.2 Space industry and economy

The UAE's space industry has developed rapidly since the country's creation in 1971. As space technologies emerged, the focus was largely on telecommunication since terrestrial systems were not very developed. Thuraya was founded in 1997 and was the UAE's first satellite operator. In 2007, Yahsat was also established to provide communication services to the UAE and the Arab region.[24] The satellites launched by these two companies focus on mobile telecommunications, television broadcasting, and satellite broadband coverage. As of 2018, both Thuraya and Yahsat are owned by the Mubadala Investment Company, the Abu Dhabi sovereign wealth fund.[25]

In the early 2000s, the UAE sought to develop its space industry as part of a long-term policy of economic diversification. Additionally, Earth observation technologies were developed to fill the need for scientific data and images as tools for monitoring the implementation of social, economic, and security policies.[26] According to EARSC, the UAE's efforts to develop its space industry are the result of a "three-step approach intended to achieve full capabilities, knowledge, facilities, and research ability to develop advanced satellite missions by Emirati scientists and engineers on UAE soil".[27] To achieve this goal, the UAE relied on international partnerships to gain expertise. The UAE then integrated this knowledge to develop Emirati capabilities. This was the case in the EO field with the development of DubaiSat-1, DubaiSat-2, and KhalifaSat, which started in the framework of a cooperation with South Korea. According to Hubert Foy, the launch of KhalifaSat represents "a shift in UAE's economy from being dependent on importing space technologies to in-house development."[28]

Now there is a focus on attracting investment and creating an environment for the space sector to thrive. The goal of economic diversification is still at the centre of the UAE's policies. The Abu Dhabi Economic Vision 2030 lists aerospace as one of the "sectors expected to provide the growth that will be necessary to achieve the goal of economic diversification and to target both regional and global markets."[29]

According to UAESA Chairwoman Sarah Al Amiri, for the UAE, "The next big bet when it comes to the space sector in the Emirates is transferring a lot of the experiences that we've gained over the course of the last 15 years and transferring that onto the private sector… This is fundamental to enabling the new space economy that other countries are also capitalizing on."[30] Despite the UAE's desire to capitalize on the New Space movement, government priorities still play a significant role. Entities such as Mubadala Investment Company, the Dubai Future Foundation, and the Abu Dhabi Holding Company are major providers of public investments in the space sector.[31] According to the Space Investment Plan, the country seeks increased investment in the space industry in a way that contributes to achieving the UAE's strategic goals, and more broadly to diversity and sustain the UAE economy.[32] In addition, the document also defines precise conditions for businesses who seek to benefit from public funding. The UAESA advises on submitted business proposals to determine if they support the objectives of the NSP.[33]

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[24] "About Mubadala" Mubadala. Available at: https://bit.ly/33nuTFz. Accessed May 2021.
[25] https://www.yahsat.com/en/news/2018/yahsat-completes-thuraya-acquisition-and-appoints-new-ceo
[26] Foy, Hubert. "EIAST: The United Arab Emirates Space Program". *Space Safety Magazine*. 2014. Available at: https://bit.ly/3eWbBN0. Accessed May 2021.
[27] "EIAST: The United Arab Emirates Space Program" EARSC. 2014. *EOMag.* Available at: https://eomag.eu/eiast-the-united-arab-emirates-space-program/. Accessed May 2021.
[28] Foy, Hubert. "EIAST: The United Arab Emirates Space Program". 2014. *Space Safety Magazine*. Available at: https://bit.ly/3eWbBN0. Accessed May 2021.
[29] *The Abu Dhabi Economic Vision 2030*. 2008. Government of Abu Dhabi. Available at: https://bit.ly/3eZ5J5T. Accessed May 2021.
[30] Brunswick, Shelli. "More than Hope, UAE is transforming its future in space". 2021. *SpaceNews.* Available at: https://spacenews.com/op-ed-more-than-hope-uae-is-transforming-its-future-in-space/. Accessed May 2021.
[31] N. Al Rashedi et al. UAE Approach to Space and Security in: Schrogl, K.-U. (Ed.). 2020. Handbook of Space Security
[32] *Space Investment Plan. 2020.* UAE Space Agency. Available at: https://bit.ly/2QXCMiD. Accessed April 2021.
[33] *Ibid.*

The UAE's "free zones", which offer special business-friendly regulatory regimes are designed to attract national and foreign businesses. In 2019, the U.S. commercial space company NanoRacks established an office in Abu Dhabi's Hub71, a technology centre which constitutes one of the country's 45 free zones.[34] Aerospace accelerator Starburst also established an office in Hub71. Hub71 seeks to attract over 100 technology start-ups by 2022.[35]

The UAE's stance on space resources and space mining aims at positioning the country in a niche and emerging sector. The White Paper of the Dubai Chamber of Commerce on Space Economy Investment Opportunities identifies ten areas of the space economy that offer the most investment potential for the UAE, including space mining.[36] As most space powers did not take a stance on this issue, the UAE could attract investments in this field and become an important part of the commercial space sector.[37]

Capability	Examples
Launch systems /components manufacturers	n/a
Satellite/Space system / components manufacturers	Strata (Mubadala)
Operators	Thuraya, Yahsat
Applications and VAS	Stratign, Cygnus Telecom, iSAT Africa, HORIZONSAT, SkyStream, Ayn Astra, Farmin, Smart Navigation System, RAZRLab, Safeen.

Table 2: Overview of the UAE space industry

Most UAE commercial space companies are are positioned in the field of downstream applications and value added services (Stratign, Cygnus Telecom, iSAT Africa, HORIZONSAT, SkyStream, Ayn Astra, Farmin, Smart Navigation System, RAZRLab, Safeen). An overview of established UAE space companies is provided below.

[34] "Nanoracks to Make Space More Accessible to the World from the United Arab Emirates/ Hub 71". 2019. *Nanoracks*. Available at: https://nanoracks.com/making-space-more-accessible/. Accessed May 2021.
[35] *Ibid.*
[36] "Dubai Chamber Working Paper Examines Growth Potential of UAE Space Economy". 2020. Dubai Chamber of Commerce and Industry. Available at: https://bit.ly/3ekTzVH. Accessed April 2021.
[37] Brunswick, Shelli. "More than Hope, UAE is transforming its future in space". 2021. SpaceNews. Available at: https://spacenews.com/op-ed-more-than-hope-uae-is-transforming-its-future-in-space/. Accessed May 2021.

Foundation

1997

Core Business

Telecommunication, Satellite operator

Products & Services

- THURAYA series operation
- Satellite phones
- MarineStar (voice communication with tracking and monitoring)
- Broadband services (*e.g.* maritime broadband terminal)

Foundation

2007

Core Business

Telecommunication, Satellite operator

Products & Services

- Al Yah series operation
- YahClick (broadband)
- YahLink (management of high capacity IP requirements)
- Yahlive (TV broadcast)

Foundation

2007

Core Business

Communication security, Intelligence, surveillance and reconnaissance

Products & Services

- Communication interception (interception systems for GSM, CDMA, C & Ku Band satellite trunk, Thuraya, Iridium, INMARSAT)
- Electronic warfare, communication jamming (jammers for radiocom, GPS, VSAT)
- Search & rescue

Foundation

2019

Core Business

Earth observation data

Products & Services

- Geo-spatial data collection
- Data integration through AI
- Satellite multispectral high-resolution imagery utilization
- IoT integration

2.2.3 Research centres and academia

Different research and academic institutions contribute to the national space sector in the UAE. Notable universities are Khalifa University of Science and Technology (KUST), American University of Ras Al Khaimah (AURAK), University of Technology and Applied Science – Higher Colleges of Technology (HCT), NYU Abu Dhabi, Zayed University, University of Sharjah, and UAE University. They offer students the opportunity to partake in projects such as satellite manufacturing or launch service observation.

Several research centres have developed from these universities, such as the Sharjah Center for Astronomy & Space Sciences (SCASS) and the National Space Science and Technology Center (NSSTC).

Sharjah Center for Astronomy & Space Sciences (SCASS)

The SCASS is affiliated with the University of Sharjah.[38] Their research is divided into astrophysics, space sciences, and space technology with specific curricula focusing on the Mars atmosphere and geology,

[38] "About SCASS", SCASS. Available at: https://scass.sharjah.ac.ae/en/About1/Pages/default.aspx. Accessed December 2020.

spectrometry, GIS and remote sensing, renewable energy, space robotics, and life support systems.[39] It also opened five research laboratories: the GIS and Remote Sensing Centre, the Meteorite Centre, the Radio Astronomy Laboratory, the Ionospheric Laboratory, and the CubeSat Laboratory.[40]

The SCASS is also involved in collaboration with the Kazakhstan Gharysh Sapary Company for space technology and systems. The company will provide space images and remote sensing data in the UAE from its KazEOSat-1 and KazEOSat-2 satellites in exchange for data processing services. The agreement is also intended to promote training and information exchange.[41]

National Space Science and Technology Center (NSSTC)

The NSSTC, incubator for space research and innovation, finds its origin in a tripartite initiative involving the UAE University, the UAESA, and the Telecommunication Regulatory Authority (TRA).[42] Its mission is to develop research programmes in space science and technology to further the national agenda, educate and train leaders, develop new technologies, and promote the industry more broadly.[43]

The NSSTC is conducting multiple research projects such as Design, Development, and Analysis of 3U CubeSats; Frequency-Agile Space Radio; Earth and Mars Atmospheric Studies; and Emirates Mars Mission Graduation Projects.

Yahsat Space Laboratory (YSL)

The YSL stems from collaboration between academia and industry, specifically between the Masdar Institute of Science and Technology at Khalifa University, Yahsat, and Orbital ATK (now Northrop Grumman Innovation Services).[44]

The laboratory's mission is to develop UAE space technologies and provide students with the opportunity to develop and launch Cubesats. During the first project, MYSAT-1, Yahsat was charged with providing opportunities to Masdar Institute's students, while Orbital ATK provided testing facilities.[45]

Assembly, Integration, and Testing Satellite Facility (AIT)

Located in Al Ain, the AIT facility is under construction at the NSSTC in the UAE University. Among other things, the AIT will house two thermal vacuum chambers and an anechoic chamber. Additionally, UAE University students will have access to the facility and will be able to test satellites.[46] Airbus will provide training for Emirati students and engineers to build both small and medium satellites. Both the Arab Space Cooperation Group's first satellite and two satellites for the future Global Navigation Satellite Systems – Augmentation System (GNSSaS) will be constructed at the AIT.[47]

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[39] "Our research", SCASS. Available at: https://scass.sharjah.ac.ae/en/or/Pages/default.aspx. Accessed December 2020.
[40] "Laboratories", SCASS. Available at: https://scass.sharjah.ac.ae/en/or/Pages/lab.aspx#. Accessed December 2020.
[41] https://satelliteprome.com/news/sharjah-university-partners-with-kazakh-firm-for-space-research/
[42] "Sharjah University partners with Kazakh firm for space research" 2019. *Satellite Pro Me.* Available at: https://bit.ly/3xK4q39. Accessed April 2021.
[43] "NSSTC: Vision and Mission", UAE University. Available at: https://bit.ly/3tgvfsc. Accessed December 2020.
[44] "Yahsat Space Laboratory Launched at Masdar Institute Campus". 2017. Yahsat. Available at: accessed December 2020, https://www.yahsat.com/en/news/2017/yahsat-space-laboratory-launched-at-masdar-institute-campus.
[45] *Ibid.*
[46] Nasir, Sarwat. 2020. "Inside Al Ain's New Hi-Tech Space Satellite Facility" *The National News.* Available at: https://bit.ly/3eQDztz. Accessed April 2021.
[47] *Ibid.*

2.3 Policy and legal framework

The major instruments making up the policy and legal framework of UAE space activities are the National Space Policy (NSP), the National Space Strategy (NSS), Federal Law No. 12, and various regulations.

2.3.1 Space policies and strategy

National Space Policy

The 2016 National Space Policy (NSP), developed by the UAE Space Agency in its competence provided by Federal Decree No.1/2014 is an extension of UAE Vision 2021, the Higher Policy for Science, Technology and Development, and the relevant parts of the National Innovation Strategy.[48]

The overarching goal of the NSP is, "to build a strong and sustainable UAE space sector that supports and protects national interests and vital industries, contributes to the diversification and growth of the economy, boosts UAE specialized competencies, develops scientific and technological capabilities, engrains the culture of innovation and national pride, and strengthens UAE's status and role regionally and globally."[49] The NSP communicates the drivers behind the UAE's rising interest in the space sector.

The main principles of the NSP are:[50]

- Enhance the lives of citizens,
- Support UAE national interests (safety and security),
- Support growth and diversification of the economy,
- Promote collaboration and support UAE status,
- Respect international laws and treaties.

The NSP also outlines specific goals. These include:[51]

- Expand the use of space to protect vital sectors,
- Develop a sustainable, competitive, and innovative commercial space industry,
- Conduct scientific space missions,
- Promote a safe and stable space environment that supports sustainable space activities,
- Establish and expand UAE's leadership in space regionally and internationally.

According to the NSP, there are three key interdependent areas of space activities in the UAE: national functions; science and exploration, and commercial activities. While the last two areas are clear, national functions include the advancement of national interests, including safety and security. Measures tackling safety, security and defence are:

- Enhance the level of security and protection of the national space capabilities, including cyber security and business continuity,
- Develop and acquire space capabilities and technologies, and collaborate with international partners for the purposes of space situational awareness; identify potential threats and improve preparedness,

[48] "Introduction to UAE's National Space Policy" 2016. UAE Space Agency. Available at: https://bit.ly/3hcY4nh. Accessed December 2020.
[49] *National Space Policy of the United Arab Emirates*. 2016. UAE Government. Available at: https://space.gov.ae/Documents/PublicationPDFFiles/UAE_National_Space_Policy_English.pdf. Accessed December 2020.
[50] *Ibid.*
[51] *Ibid*

- Develop and acquire appropriate capabilities and technologies to enable various national security activities in times of peace, crisis, and conflict, and ensure continuity of government and critical operations,
- Promote regional and international cooperation to mutually benefit and leverage the space capabilities of other allied countries, exchange information to improve crisis management and recovery, and provide appropriate support when needed to ensure business continuity,
- Develop and acquire space capabilities and technologies and cooperate with international partners for the purposes of maritime domain awareness, border and ports security, and early warning systems against various threats.

According to Emma Soubrier, visiting scholar at the Arab Gulf States Institute in Washington, when Mohammed Bin Zayed came into power in 2014, one of his first projects was to create a credible army and centre its military doctrine around border control.[52] This objective is also reflected in the measures of the national space policy, in which space systems are put at the service of border protection and security.

National Space Strategy

In 2019, the UAESA approved the National Space Strategy 2030 (NSS).[53] The NSS seeks to achieve the goals of the NSP, translating them into national programmes and initiatives, which are additionally detailed in implementation plans.[54] The NSS also considers the UN SDGs, the COPUOS Long Term Sustainability Guidelines, the ISECG Roadmap, and the OST and its subsequent Treaties and Principles.[55]

The UAESA is responsible for the implementation of the NSS and must also review the strategy every five years. The NSS is aligned with the UAE Vision 2021, which mostly focuses on the diversification of the economy from oil and gas. The NSS recalls past achievements and current developments in the national space sector. The strategy also mentions that the country has no launch capacities but highlights the country's interest in investment in future projects for sub-orbital flights. Awareness-raising campaigns and communication efforts are particularly highlighted in the strategy to raise public interest in space and increase engagement with the sector.[56]

[52] Sylvain Lepetit. La nouvelle guerre du Golfe. ARTE Documentary
[53] National Space Sector Strategy. UAE Space Agency. Available at: https://www.space.gov.ae/Page/20122/20170/National-Space-Sector-Strategy. Accessed December 2020.
[54] *Ibid.*
[55] *National Space Strategy 2030: Summary.* 2019. UAE Space Agency. Available at: https://www.space.gov.ae/Documents/PublicationPDFFiles/2030-National-Strategy-Summary-EN.pdf. Accessed December 2020.
[56] *Ibid.*

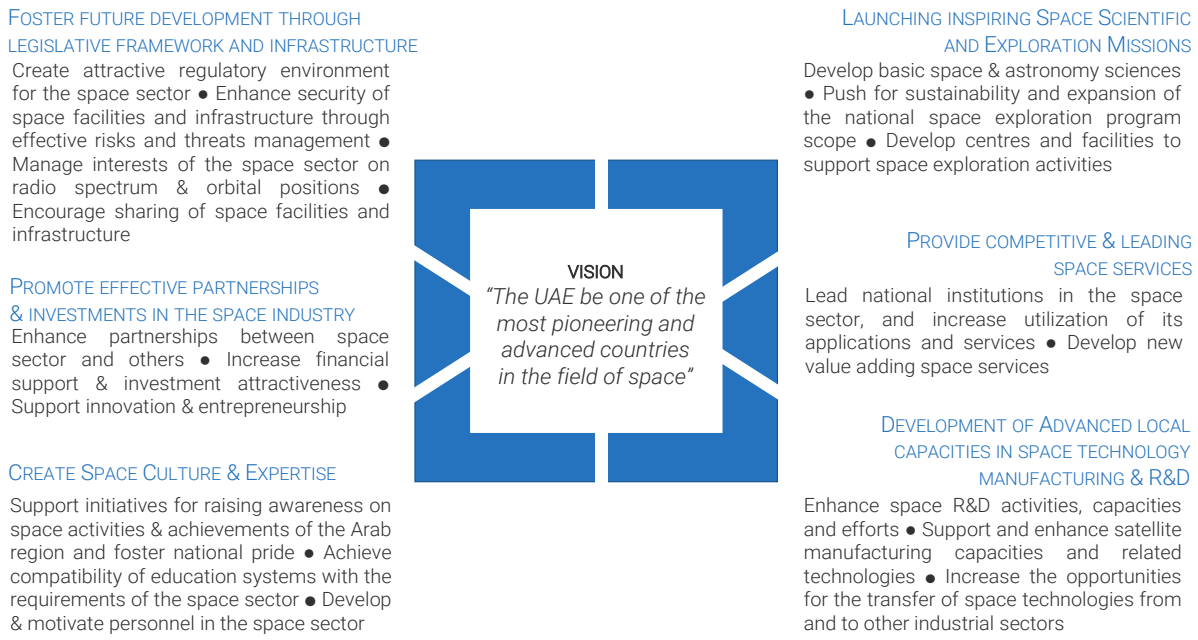

Figure 9: UAE Space Strategy content (adapted from UAESA)

Mohammed Bin Rashid Space Centre Strategy 2021-2031

Announced in September 2020, the MBRSC Strategy 2021-2031 is the centre's ten-year roadmap and a way for it to strengthen its international competitiveness through new collaboration and the development of new national capabilities.[57] [58] The strategy focuses on space exploration and technology and covers six key programmes: Hope Probe, Mars 2117, the UAE Astronaut Programme, the UAE Satellite Programme, and the UAE Space Sector Sustainability Programme, as well as the latest Emirates Lunar Mission.[59]

2.3.2 Legal and regulatory regime

Federal Law No. 12

Federal Law No. 12 of 2019 on the Regulation of the Space Sector establishes the UAE's legal and regulatory framework for the space sector. Federal Law No. 12 translates the international treaties and measures adopted at UNCOPUOS into UAE national law. The law defines the competencies of the UAESA and enables the commercial use of space by setting the rules for licensing, the registration of space objects, space debris mitigation, and liability insurance. A particular aspect of this law is Article 18, which outlines the UAE's favourable position on the commercial exploitation and use of space resources. This

[57] "Vice President reviews Mohammed bin Rashid Space Centre strategy 2021-2031" 2020. Government of Dubai. Available at: https://bit.ly/3eegTUT. Accessed December 2020.
[58] "Space science and technology", UAE Government Portal. Available at: https://bit.ly/2Rq95GB. Accessed December 2020.
[59] "Vice President reviews Mohammed bin Rashid Space Centre strategy 2021-2031" 2020. Government of Dubai. Available at: https://bit.ly/3eegTUT. Accessed December 2020.

stance was adopted following the release of the US Space Act of 2015 and the 2017 Luxembourg Space Law, both of which take similar positions.[60] [61] [62]

Additional regulations have been passed to supplement Federal Law No. 12 that address different topics in more detail. These include the Regulation on Registration of the Space Object and the Earth Observation Space-Based Data Policy Guidelines. Many other regulations are in progress, including the Regulation on Human Spaceflight Guidelines and the Space Degree Mitigation Guidelines, among others.

UAE Space Court

In January 2021, a space court was established in Dubai, aimed at settling commercial disputes in the space sector. Beyond the creation of a court, this move was part of the Dubai International Financial Centre (DIFC) Courts, and the Dubai Future Foundation (DFF) new global initiative called the Courts of Space. The initiative was tasked with creating an international working group of public and private sector experts to explore legal issues in the space sector and provide input to help create a judicial system to keep pace, offering assurance and certainty to support and protect commercial space companies.[63] [64] Experts will also help create a Space Dispute Guide consisting of proposals to resolve space-related disputes. The Dubai space court will be open to Emirati and foreign companies.

2.3.3 International affairs

International cooperation

The UAE is a party to all space treaties, except for the Moon Agreement. It has transposed most international principles stemming from those instruments into their domestic legislation. According to Florence Gaillard-Sborowsky, researcher at the Foundation for Strategic Research, the UAE wants to appear as a responsible and law-abiding actor on the international stage and often communicates on their compliance with international treaties.[65]

With respect to telecommunication and radiocommunication, the UAE is a party to the ITU Constitution and Convention of 1992, the ITU Radio Regulations of 2012, the ITSO Agreement of 1971, the IMSO Convention of 1976, and the ARABSAT Agreement of 1976.[66]

According to Federal Law No. 12, the competencies and objectives of the UAESA include to "suggest concluding bilateral or international agreements with the relevant entities in the Space Sector, in order to achieve the objectives of the Agency", "represent the State in international forums and programs, after coordination with the concerned Government Entities in the State", and "support national and international initiatives that seek to make the Outer Space environment more sustainable and stable".[67]

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[60] Florence Gaillard Sborowsky. Les Emirats Arabes Unis et l'espace: un développement accéléré pour une stratégie aux objectifs multiples. Diplomatie, n°58. p.75-77
[61] Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace.. Journal Officiel du Grand Duché du Luxembourg. Available at: http://legilux.public.lu/eli/etat/leg/loi/2017/07/20/a674/jo Accessed April 2021
[62] Public Law No: 114-90 (11/25/2015). US Government Publishing Office. Available at: https://www.congress.gov/bill/114th-congress/house-bill/2262/text. Accessed April 2021.
[63] Nasir, Sawat. "Dubai launches 'space court' to support thriving global sector." 2021. *The National News.* Available at: https://bit.ly/33cBL8T. Accessed April 2021.
[64] "Dubai launches new court to rule on commercial space disputes in space" 2021. *Arab News.* Available at: https://arab.news/c3qvn. Accessed April 2021.
[65] Florence Gaillard Sborowsky. Op cit.
[66] "International Law". UAE Space Agency. Available at: https://bit.ly/3tivljd. Accessed December 2020.
[67] Federal Law no. 12 (2019), *Regulation of the Space Sector*. Available at: https://bit.ly/3gZr01V. Accessed April 2021.

Figure 10: UAE International Cooperation (adapted from UAESA)

The UAE is a member of both regional and international institutions and groups and signed MoUs with several foreign space agencies.[68] The UAE is cooperating with all major space actors, including Europe, the United States, China, and Russia. Indeed, the UAE's first astronaut Hazza Al Mansouri was trained at the Yuri Gagarin Cosmonaut Training Centre in Moscow, Russia prior to his mission to the ISS in 2019[69] and the Emirati Operations Support Centre (UAE OSC) benefited from ground support personnel training at ESA's Astronaut Centre in Cologne, Germany.[70] Then, in September 2020, MBRSC signed an agreement with NASA for four future Emirati astronauts to train at the Johnson Space Center.[71] The UAE also signed a cooperation agreement with China on space exploration and science.[72]

The UAE and Luxembourg share many motivations for their respective space agencies. In 2017, the two countries signed an MoU for bilateral cooperation on space exploration and space resources. Additionally,

[68] International Law", UAE Space Agency. Available at: https://bit.ly/2Sqvrsj. Accessed December 2020.
[69] "UAE's MBRSC and European Space Agency Sign Astronaut Training Agreement" 2018. *SpaceWatch Global.* Available at: https://bit.ly/3tnv4eY. Accessed April 2021.
[70] "ESA expertise aids in UAE spaceflight" 2019. *European Space Agency Science and Exploration*. Available at: https://bit.ly/3aZKhfL. Accessed April 2021.
[71] "MBRSC agreement with NASA to train four Emirati astronauts". 2020. *Arabian Aerospace*. Available at: https://bit.ly/3xIcK3n. Accessed December 2020,
[72] "UAE and China to sign space cooperation agreement" 2015. *The National News*. Available at: https://bit.ly/3ugYDQB. Accessed April 2021.

the countries' space agencies hosted a UAE-Luxembourg Space Investor Forum in 2020 to emphasise common interests and promote the economic and political cooperation between their two countries.[73]

Despite geopolitical tensions between some major space actors, the UAE is open to collaboration with a diverse range of space powers.[74] It seems to view international cooperation as a way to facilitate knowledge transfer in order to increase its national expertise and enhance its credibility on the international stage.

The UAE's diplomatic efforts in the space sector are very visible:

- As a Member State of UNOOSA, the UAE Space Agency signed an MoU with the UN Office in 2017 to increase their cooperation. Both entities have agreed to work on the technical and legal aspects of the peaceful uses of outer space as well as initiatives to promote the SDGs. Initiatives will particularly focus on the Middle East and STEM education, which align with their national goals to promote science and establish themselves as a regional leader in the space sector.[75]

  Moreover, over the last few years, the UAE Space Agency hosted and funded several international events and forums with UNOOSA such as the 2020 World Space Forum.[76] In addition, the UAE will open an international UNOOSA project office in Abu Dhabi, which will focus on space sustainability and the promotion of the SDGs.[77]
- As a Member State of UNCOPUOS, the UAE has led several initiatives. In 2016, the Dubai Declaration was adopted at the first High Level Forum on Space as a driver for socio-economic sustainable development, which aimed at strengthening UNCOPUOS and preparing UNISPACE+50.[78] In 2019, the UAE submitted a resolution on Space Resources Utilization, which mostly aimed at establishing a working group that would analyse the status quo, as well as current practices of Member States on space resources utilisation, and define recommendations and principles on the issue.[79] In addition, in 2020, it submitted a proposal to establish a working group on long-term sustainability as well as a proposal on Voluntary Implementation Reporting Survey for the Guidelines related to Long-Term Sustainability of Outer Space Activities.[80] [81]

Furthermore, the UAE aims to position itself as a space leader at the regional level through cooperation.

In 2008, the UAE proposed the creation of a Pan-Arab Space Agency, which aimed to provide Arab states with access to space, and more specifically to reduce the costs of putting satellites in orbit.[82] The Agency was envisaged as a civilian space agency similar to ESA.[83] However, the negotiations surrounding the Agency's establishment continued for many years and led to no result. While the UAE created its own national space agency in 2014, the UAE later proposed a similar initiative to bring together Arab countries.

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[73] Kommel et.al. "Exploring Insights from Emerging Space Agencies". 2020. *The George Washington University Elliot School of International Affairs*. Available at: https://bit.ly/33cJDXZ. Accessed April 2021.
[74] "Mohammed Bin Rashid Space Centre" Government of Dubai. Available at: https://bit.ly/33cDxXB. Accessed April 2021.
[75] "UNOOSA and UAE Space Agency sign MOU for increased cooperation" 2017. UNOOSA. Available at: https://www.unoosa.org/oosa/en/informationfor/media/2017-unis-os-487.html. Accessed April 2021.
[76] "UAE to Host 4th Young Professionals in Space Conference 2019". 2018. *Albawaba Business.* Available at: https://bit.ly/3tguM9E. Accessed April 2021.
[77] "UAE Space Agency and UNOOSA sign deal to set up UN office in Abu Dhabi". 2020, *SatelliteProMe.* Available at: https://bit.ly/3nWuYdb. Accessed April 2021.
[78] *Dubai Declaration*. 2016. UNOOSA. Available at: https://bit.ly/3b3rznk. Accessed April 2021.
[79] *Report of the Committee on the Peaceful Uses of Outer Space.* 2019. United Nations General Assembly. Available at: https://www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf. Accessed April 2021.
[80] *Long-term sustainability of outer space activities- Proposal by the United Arab Emirates.* 2020. Committee on the Peaceful Uses of Outer Space, Scientific and Technical Subcommittee UNOOSA. Available at: https://bit.ly/3ulzhRm. Accessed April 2021.
[81] *Ibid.*
[82] McClenaghan, Gregor. "Calls for pan-Arab space agency". 2008. *The National News.* Available at: https://www.thenationalnews.com/uae/call-for-pan-arab-space-agency-1.511240. Accessed April 2021.
[83] "Pan-Arab Group for Space Collaboration Founded in Abu Dhabi" 2019. *SpaceWatch Global.* Available at: https://bit.ly/3xNJZlN. Accessed April 2021.

In 2019, the Arab Group for Space Collaboration was founded, which gathers 11 Arab states.[84] The goal of the programme is to promote regional cooperation through joint projects and the sharing of knowledge.[85] The group's first project is the development of an advanced satellite to monitor climate change, which is undertaken by a diverse group of Arab scientists in the UAE.[86] Mohammed Nasser Al Ahbabi, director general of the UAESA, explicitly outlined that the group serves the UAE regional ambitions during the Dubai Air Show in 2019: "the UAE and the Arab countries are all complementary and they all serve each other, and therefore the UAEs' initiatives are [also] the Arab world's initiatives."[87]

Additionally, the UAE Space Agency hosts the Global Space Congress, an annual event bringing together leaders in the global space industry.[88] Both public and private stakeholders attend the conference, and the event hosts discussions and initiatives relating to the space sector in the Middle East, and globally.[89] The organisation of this event contributes to establishing the UAE as a regional leader for space, which was a key point in Sheikh Mohammed Bin Rashid Al Maktoum's speech at the 2019 Global Space Congress.[90]

These international and regional examples showcase the importance of soft power and prestige in the UAE's space ambitions.[91] In general, soft power is high on the political agenda with the creation of the Soft Power Council in 2017, and the release of the Soft Power Strategy in 2017.[92][93][94] The National Space Policy also outlines that establishing and expanding "the UAE's leadership in space regionally and internationally" is a goal of the UAESA.[95] In addition, the Space Investment Plan aims at "establishing and highlighting the country's position in the global satellite map."[96]

International and regional competition

While soft power and prestige are important drivers for emerging spacefaring nations, space is also a field of competition between Middle Eastern powers for regional and international leadership.[97][98] Several Arab states now have a satellite in orbit, established their space agency, and developed a space

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[84] Member States include Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Saudi Arabia, Sudan, and the United Arab Emirates.
[85] Nasir, Sarwat. "UAE launches Arab Space Collaboration Group". 2019. *Khaleej Times*. Available at: https://www.khaleejtimes.com/uae-launches-arab-space-collaboration-group. Accessed April 2021.
[86] Pan-Arab Group for Space Collaboration Founded in Abu Dhabi". 2019. *SpaceWatch Global.* Available at: https://bit.ly/3xNJZlN. Accessed April 2021.
[87] Connie Lee. Middle East Allies Look to Expand Space Capabilities. 2020. National Defense. Available at: https://www.nationaldefensemagazine.org/articles/2020/2/3/middle-east-allies-look-to-expand-space-capabilities
[88] "Global Space Congress 2021". World Aviation Safety Summit. Available at: https://www.worldaviationsafety.com/global-space-congress-2021. Accessed April 2021.
[89] "Global Space Congress". 2017. DLR. Available at: https://event.dlr.de/event/global-space-congress/. Accessed April 2021.
[90] "Pan-Arab Group for Space Collaboration Founded in Abu Dhabi". 2019. *SpaceWatch Global.* Available at: https://bit.ly/3xNJZlN. Accessed April 2021.
[91] Soft Power was defined by Joseph Nye as "the ability to achieve goals through attraction rather than coercion" and "the ability to get others to want the outcomes that you want", which is different from hard power (the use of coercion and military power to achieve political goals). Read more: Joseph, Nye, Soft Power: The Means to Success In World Politics, Public Affairs, 2005.
[92] *The UAE Soft Power Strategy*. 2013. UAE Government. Available at: https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/the-uae-soft-power-strategy. Accessed April 2021.
[93] "Sheikh Mohammed launches UAE Soft Power Council". 2017. *The National News.* Available at: https://bit.ly/3nLN6pU. Accessed April 2021.
[94] "The UAE Soft Power Strategy". 2017. UAE Government. Available at: https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/the-uae-soft-power-strategy. Accessed April 2021.
[95] *National Space Policy of the United Arab Emirates.* 2016. UAE Government. Available at: https://space.gov.ae/Documents/PublicationPDFFiles/UAE_National_Space_Policy_English.pdf. Accessed April 2021.
[96] *Space Investment Plan.* UAE Space Agency. Available at: https://space.gov.ae/Documents/PublicationPDFFiles/Space_Invest_Plan_AR_Summary_042020.pdf. Accessed April 2021.
[97] Salacanin, Stasa. "Is there a space race in the middle east?". 2021. *TheNewArab.* Available at: https://english.alaraby.co.uk/english/indepth/2021/3/22/is-there-a-space-race-in-the-middle-east. Accessed May 2021.
[98] Soliman, Mohammed. "The geopolitics of space: Why did the UAE send a probe to Mars?". *MEI@75,* March 2021. Available at: https://www.mei.edu/publications/geopolitics-space-why-did-uae-send-probe-mars. Accessed April 2021.

programme.[99] [100] Important drivers for pursuing space activities in the Middle East include economic diversification and military developments.[101] [102]

Indeed, the diplomatic and foreign policy of the UAE has evolved over the years. According to Ebtesam Al Ketbi, member of the Board of Directors of the Arab Gulf States Institute in Washington D.C, from the creation of the country in 1971 to the passing of Sheikh Zayed bin Sultan Al Nahyan, the UAE's policies were focused on diplomacy and soft power. Today, the UAE is more active on the international stage and uses smart power (a combination of hard and soft power) to advance and protect its interests.[103] According to Bader Al-Saif from the Carnegie Middle East Center, the UAE aims to differentiate itself from other Gulf countries through space activities and position itself in a domain in which its regional adversaries are active.[104]

According to Charles W. Dunne from the Arab Center in Washington D.C, the UAE and Saudi Arabia are the most advanced countries in the Arab Gulf and "the Saudi program is the only one that rivals that of the UAE in scope and ambition".[105] While the two kingdoms are allied, economic, technological, and political competition is common between Mohammad bin Salman al-Saud (Saudi Arabia) and Mohammed bin Zayed Al Nahyan (UAE).[106] [107]

Other non-Arab emerging spacefaring nations in the MENA region include Israel, Iran, and Turkey. The table below depicts key space achievements of countries in the Middle East.

	Creation of Space Agency	First satellite in orbit	Military satellite in orbit	No. of satellites in orbit	Launch capacities	Human spaceflight	Space exploration
Saudi Arabia	2018	Arabsat-1A (1985)	Yes	16	No	First Arab astronaut in space (1985)	Cooperation with China on Chang'e-4 mission
Qatar	Unknown	Es'hail 1 (2013)	Yes	2	No	N/A	N/A
Egypt	2019	Tiba-1 (2019)	Yes	9	No	First Egyptian astronaut to be sent to	N/A

[99] Mohammed Soliman. The geopolitics of space: Why did the UAE send a probe to Mars? 2021. Available at: https://www.mei.edu/publications/geopolitics-space-why-did-uae-send-probe-mars. Accessed May 2021.
[100] John Beck. Mars Mission Is Next Step in Intensifying Middle East Space Race. 2020. Available at: https://www.bloomberg.com/news/features/2020-06-24/saudi-arabia-and-u-a-e-have-entered-their-own-space-race. Accessed May 2021.
[101] Stasa Salacanin. Is there a space race in the Middle East? 2021. Available at: https://english.alaraby.co.uk/english/indepth/2021/3/22/is-there-a-space-race-in-the-middle-east. Accessed May 2021.
[102] Charles W. Dunne. Arab Space Programs Level Up. Arab Center Washington DC. 2021. Available at: http://arabcenterdc.org/policy_analyses/arab-space-programs-level-up/. Accessed May 2021.
[103] Al Ketbi, Ebtesam. Contemporary Shifts in UAE Foreign Policy: From the Liberation of Kuwait to the Abraham Accords. 2020. *Israel Journal of Foreign Affairs*, 14:3, 391-398. Available at: https://bit.ly/3uhpTOF. Accessed April 2021.
[104] Bader Al-Saif. The United Arab Emirates plans a space mission to Mars this week, bolstering the country's regional power status. Carnegie Middle East Center. Available at: https://carnegie-mec.org/diwan/82282. Accessed May 2021.
[105] Charles W. Dunne. Op cit
[106] Ryan Bohl. Saudi Arabia & UAE: Competition Among Allies. 2021. Newlines Institute. Available at: https://newlinesinstitute.org/saudi-arabia/saudi-arabia-uae-competition-among-allies/. Accessed May 2021.
[107] Sylvain Lepetit. La nouvelle guerre du Golfe. Documentaire ARTE.

						space by 2026	
Iran	2004	Sina-1 (2004)	Yes	10	Yes	First Iranian astronaut to be sent to space by 2023	N/A
Turkey	2018	Turksat 1A (1994)	Yes	7	No	Moon landing planned for 2023	N/A
Israel	1983	Ofeq-1 (1998)	Yes	22	Yes	First Israeli astronaut sent to space in 2003	Lunar robotic lander Beresheet (2019)
Bahrain	2014	3U CubeSat (August 2021)	No	0	No	N/A	N/A
Oman	N/A	Planned for 2024	No	0	No	N/A	N/A
Kuwait	N/A	1U CubeSat QMR-KWT (June 2021)	No	0	No	N/A	N/A
Jordan	N/A	JY1Sat (2018)	No	1	No	N/A	N/A

Table 3: MENA states' space developments highlights

2.4 Programmes and infrastructure

2.4.1 Resources and infrastructure

The budget allocated to UAESA activities amounted to USD47 million in 2019. Over a period of six years, the UAE attributed approximately USD200 million to the design, development, and testing of the Emirates Mars Mission (EMM). [108] According to UAESE, in 2020, the space sector employed over 3100 people, 18% of whom were women.[109] Over 100 Emiratis worked on the EMM; the average age was 27 and 30% of the engineers and scientists were women.[110] This is part of a broader ambition, coined "Emiratization" to diversify the economy from reliance on fossil fuels, promote STEM education, and encourage Emiratis to enter strategic sectors.[111] Emiratization policies are often mentioned by the UAESA and the MBRSC.[112]

The UAESA is responsible for defining the country's strategic and operational plans within the space sector, meaning that the Agency also plays a large role in determining budget. When goals for the space industry are established at a federal level, other sectors generally follow.[113] The UAESA is also an influential player in facilitating funding within the private sector.[114]

2.4.2 Space programmes and activity

As of December 2020, the UAE had commissioned 14 spacecrafts, 12 of which are currently operational. While half the fleet has telecommunication purposes, the other half is devoted to Earth observation, science and technology, or space exploration.[115] Historically, the UAE had relied on partnerships with South Korea to manufacture satellites (DubaiSat-1, DubaiSat-2, and Nayif-1). Launched in 2018, KhalifaSat was the first UAE-designed and manufactured satellite.[116] The country currently does not possess launch capabilities but has signed an MoU with Virgin Galactic for the construction of commercial spaceport at Al Ain International Airport.[117]

The UAE also launched a National Space Programme, which includes different projects covering Mars exploration and human spaceflight. The nation is also building an astronaut corps, with one astronaut already having travelled to the ISS.

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[108] "United Arab Emirates successfully sends its first mission toward Mars". 2020. *Spaceflight Now*. Available at: https://bit.ly/2RoesGi. Accessed December 2020.
[109] Alrashedi, Naser. "UAE Approach Towards Sustainable Space Economy" 2020. UAE Space Agency. Available at: https://www.unoosa.org/documents/pdf/Space%20Economy/1._Al_Rashedi_UAE_Approach.pdf. Accessed April 2021.
[110] Ann M. "The United Arab Emirates launches a plan to colonize Mars by 2117". 2017. *Los Angeles Times.* Available at: https://www.latimes.com/world/la-fg-uae-space-20170531-story.html. Accessed April 2021.
[111] Esposito, Mark & Elsholkamy, Mona. "The UAE and The Future of Work". 2017. Available at: https://www.researchgate.net/publication/322241969_The_UAE_and_The_Future_of_Work. Accessed April 2021.
[112] "Mohammed Bin Rashid Space Centre". 2019. UNOOSA. Available at: https://www.unoosa.org/documents/pdf/copuos/2019/copuos2019tech24E.pdf. Accessed April 2021.
[113] Kommel et.al. "Exploring Insights from Emerging Space Agencies". 2020. *The George Washington University Elliot School of International Affairs.* Available at: https://bit.ly/33cJDXZ. Accessed April 2021.
[114] *Ibid.*
[115] "Space Science and Technology". UAE Government. Available at: https://bit.ly/3aYqXiS. Accessed April 2021.
[116] "Satellite Programme", MBRSC. Available at: https://www.mbrsc.ae/satellite-Programme. Accessed December 2020.
[117] "Virgin Galactic Planning Arabia Spaceport" 2019. *LATTE.* Available at: https://latteluxurynews.com/2019/03/27/virgin-galactic-planning-arabia-spaceport/. Accessed April 2021.

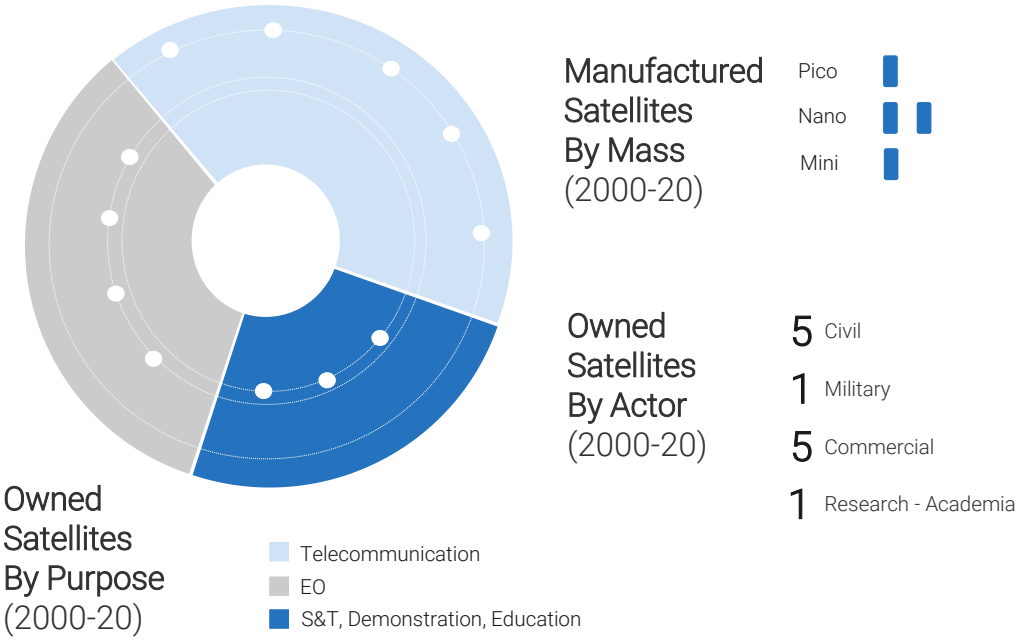

Figure 11: UAE's space infrastructure overview (ESPI database)

Telecommunication

The telecommunication sector is led by two companies, Thuraya and Yahsat, which respectively have an operational fleet of 2 and 3 telecommunication satellites. Thuraya and Al Yah's series provide mobile and fixed communication, broadband, and broadcast services over parts of Europe, the Middle East, Africa, Asia, Latin America, and Australia.

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit & Mass	Customer	Purpose
Thuraya 2, Thuraya 3	Boeing	Sea Launch	2003, 2008	GEO, 5200 kg	Thuraya	Mobile communication. L-band, C-band. Covers Europe, Middle East, Africa, Asia, Australia.
Al Yah 1 & Al Yah 2	Airbus, Thales	Arianespace, ILS	2011, 2012	GEO, 6000 kg	Yahsat	Fixed communication, broadcasting, broadcast. C-band, Ku-band, Ka-band. Covers Middle East, Africa, Europe, central & SW Asia. Extends to rural & remote areas.
Al Yah 3	Orbital ATK	Arianespace	2018	GEO, 3800 kg	Yahsat	Broadband & broadcast. Ka-band. Extends coverage in Africa and to Latin America

Table 4: UAE Telecommunication satellites (ESPI database)

Earth observation

The UAE Earth observation satellites serve both civilian and military purposes. The first national EO satellite, DubaiSAT-1, was developed as part of a 10-year knowledge and technology transfer programme with South Korea and successfully launched in 2009. DubaiSAT-1 notably contributed to the urban planning and construction process of the artificial island Palm Jumeira in Dubai.[118] Then, the UAE kept working with South Korea on the development of DubaiSAT-2, but this time with a predominantly Emirati team. DubaiSAT-3, later renamed KhalifaSAT, was entirely designed and manufactured in the UAE and launched in 2018 from Japan's Tanegashima Space Center.[119] Therefore, knowledge transfer programmes and international cooperation played a significant role in the development of the UAE as a spacefaring nation.

In 2020, the UAE announced it will launch the satellite MBZ-SAT in 2023. The EO satellite will be entirely designed and developed in the UAE by Emirati engineers from the MBRSC and EPI, a precision manufacturing company based in Abu Dhabi. This is part of MBRSC's policy to develop national manufacturing capacities. EPI previously worked with MBRSC on the Emirates Mars Mission project.[120] While the satellites mentioned above are operated by the MBRSC, Falcon Eye-2, a high-resolution optical reconnaissance satellite, is operated by the SRC due to its dual purpose.[121]

Spacecraft	Manufacturer	Launch Service Provider	Launch Year	Orbit & Mass	Customer	Purpose
DubaiSAT 1	Satrec Initiative	ISC Kosmotras	2009	LEO, 200 kg	MBRSC (EIAST)	Remote-sensing, mid-resolution images Urban planning, environment
DubaiSAT 2	Satrec Initiative	ISC Kosmotras	2013	LEO, 300 kg	MBRSC (EIAST)	Remote-sensing, high-resolution optical images. Same purpose as DubaiSat1
KhalifaSAT (DubaiSAT 3)	MBRSC	JAXA	2018	LEO, 330 kg	MBRSC	Remote sensing, capture & transmit detailed 3D images. Environmental monitoring, urban management, disaster relief.
Falcon Eye 2	Airbus	Arianespace	2020	LEO, 1200 kg	UAE Armed Forces	Dual. High-resolution optical reconnaissance system. Commercial imagery.

Table 5: UAE EO satellites (ESPI database)

[118] "DUBAISAT-1". MBRSC. Available at: https://www.mbrsc.ae/satellite-programme/dubai-sat-1. Accessed May 2021.
[119] "KHALIFASAT" MBRSC. Available at: https://www.mbrsc.ae/satellite-programme/khalifasat. Accessed May 2021.
[120] Richardson, Jack. "EPI to Supply MBZ-SAT" 2021. *European Security and Defence.* Available at: https://euro-sd.com/2021/02/news/industry-news/21517/epi-to-supply-mbz-sat/. Accessed May 2021.
[121] Doffman, Zack. 2019. "Crashed UAE Military Spy Satellite Raises Possibility of Enemy Cyberattack" Forbes. Available at: https://bit.ly/3eg4y2J. Accessed April 2021.

Science, Technology, and Education

The promotion of STEM education, as well as training programs are part of the National Space Policy objectives. These goals have been translated into concrete projects.

In 2017, the UAE launched its first nanosatellite, Nayif-1 as part of a knowledge transfer programme with the American University of Sharjah.[122] In 2018, the MYSAT1 CubeSat was launched. The CubeSat was the first nanosatellite developed at the Yahsat Space Lab within Khalifa University. This Lab was established by Yahsat and Orbital OTK (Northrop Grumman) in 2017.[123] In 2020, the MeznSat CubeSat was launched on a Soyuz-2 rocket from the Plesetsk Cosmodrome. The satellite was developed by Khalifa University, the American University of Ras Al Khaimah (AURAK), and the UAE Space Agency to monitor greenhouse gases. The CubeSat has an Argus 2000 spectrometer as a primary payload and a high-definition camera as a secondary payload.[124]

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit & Mass	Customer	Purpose
Nayif 1	MBRSC	Antrix Corporation	2017	LEO, 1,32 kg	MBRSC	Education, knowledge development & transfer. Collaboration with academic institutions to train engineering students.
MYSAT1	Masdar Institute of Science and Technology	Orbital ATK (Northrop Grumman)	2018	LEO, 1 kg	Masdar Institute of Science and Technology	Education, vegetation monitoring & technological demonstration.
Meznsat	KUST, AURAK	Exolaunch	2020	LEO, 3 kg	UAESA, KUST, AURAK	Education, monitor climate change & greenhouse gases.

Table 6: UAE S&T, education satellites (ESPI database)

Navigation

The Global Navigation Satellite Systems – Augmentation System (GNSSaS) is a LEO cubesat constellation expected to be operational by 2022, which will offer commercial navigation services to complement other GNSS.[125] [126] The project is part of the Science and Technology Roadmap created by the UAE Space Agency and the NSSTC on developing new technologies and aims at demonstrating technological capabilities rather than replacing or competing with other GNSS.[127] According to Florence

[122] "NAYIF-1" MBRSC. Available at: https://www.mbrsc.ae/satellite-programme/nayif-1. Accessed May 2021.
[123] "MAYSAT 1" Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/mysat-1.htm, Accessed May 2021.
[124] "MezNSat" Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/meznsat.htm. Accessed May 2021.
[125] "Global Navigation Satellite Systems – Augmentation System (GNSSAS)". UAE Space Agency. Available at: https://bit.ly/3h1ow34. Accessed December 2020,
[126] AbdulKader, Binsal. "UAE to launch a navigation satellite next year". 2020. *Emirates News Agency.* Available at: https://bit.ly/3xVn2NQ. Accessed December 2020.
[127] UAE to launch a navigation satellite next year. Satellite News Agency. 2020 Available at: https://www.wam.ae/en/details/1395302861108. Accessed December 2020.

Gaillard-Sborowksy, researcher at the Foundation for Strategic Research, the development of a navigation system aims to increase their strategic autonomy.[128]

Space exploration

The UAE has a space exploration programme consisting of three main projects: Emirates Mars Mission, Mars 2117, and the Emirates Lunar Mission.

At the centre of the Emirates Mars Mission (EMM) is the Hope Probe, launched in 2020 and reaching the red planet's orbit in February 2021 to transmit information about Mars atmosphere.[129] This success made the UAE the sixth country to successfully launch a Mars mission.[130] The project is funded by UAESA, which also oversaw administrative and implementation procedures. MBRSC was in charge of the project's technical conception.[131] The Hope Probe is the result of a collaboration with the University of Colorado Boulder, the University of California, Berkeley, and the Arizona State University, which highlights the importance of international cooperation and exchange of know-how in the Emirati's strategy to establish itself as a spacefaring nation.[132]

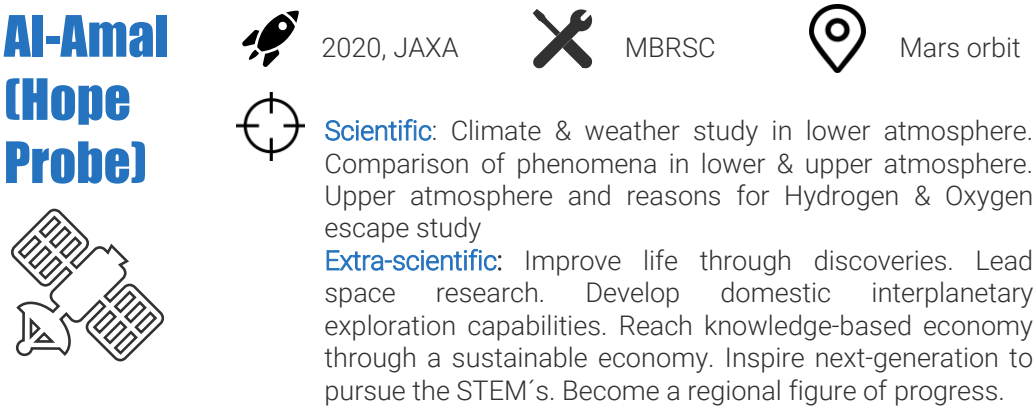

Figure 12: Hope Probe mission (adapted from MBRSC)

The Mars 2117 Programme aims to establish a human settlement on Mars in the next century.[133] To attain this goal, the UAE first seeks to build the Mars Science City, a training environment that will house laboratories mimicking the terrain and environment of Mars.[134] The city will host research projects and training exercises to test aspects of food, energy, and water production that will be vital for the Martian settlement.[135] The facility will also house a museum and offer opportunities for visitors to experience the Mars Science City. When completed, the project will cover 176,000 square metres of desert outside of Dubai and is estimated to cost USD135 million.[136]

The UAE is also conducting the UAE Mars Analog Project as part of the NASA Scientific International Research in Unique Terrestrial Stations (SIRIUS) 20/21 at the NEK Facility in Moscow, Russia from

[128] Florence Gaillard Sborowsky. Op cit
[129] "Emirates Mars Mission". MBRSC. Available at: https://www.mbrsc.ae/emirates-mars-mission. Accessed December 2020.
[130] "Policy in Action: Mission to Mars" 2019. Federal Competitiveness and Statistics Authority. Available at: https://bit.ly/3vI0HS2. Accessed May 2021.
[131] "Emirates Mars Mission". MBRSC. Available at: https://www.mbrsc.ae/emirates-mars-mission. Accessed December 2020.
[132] Jeremy Rehm. UAE Hope Mars orbiter: The Arab world's first interplanetary mission. 2021. Available at: https://www.space.com/hope-mars-mission-uae. Accessed April 2021.
[133] "Mars 2117". MBRSC. Available at: https://www.mbrsc.ae/mars-2117. Accessed December 2020.
[134] "Space science and technology", UAE Government Portal. Available at: https://bit.ly/3ehFRmE. Accessed December 2020,
[135] *Ibid.*
[136] "A prototype Martian city is being built in the desert outside Dubai" 2020. *Wion News.* Available at: https://www.wionews.com/world/a-prototype-martian-city-is-being-built-in-the-desert-outside-dubai-330653. Accessed April 2021.

November 2020 to July 2021. The mission is part of the Mars 2117 Programme and aims to test the effects of confinement on human psychology, physiology, and team dynamics, in preparation for future missions to Mars.[137]

The Emirates Lunar Mission - 2024 (EML) was announced in September 2020 and is aimed at constructing a lunar rover to study thermal properties of the Moon's surface, among other things.[138] The goal of the rover is to create data that will support and inform the establishment of a research station on the surface of the Moon.[139] Additionally, the construction of the rover will allow the UAE to test different exploration techniques that could then be employed in manned missions to Mars.[140] The rover is expected to be launched by 2024. The rover will be landed through a partnership with an international entity.[141]

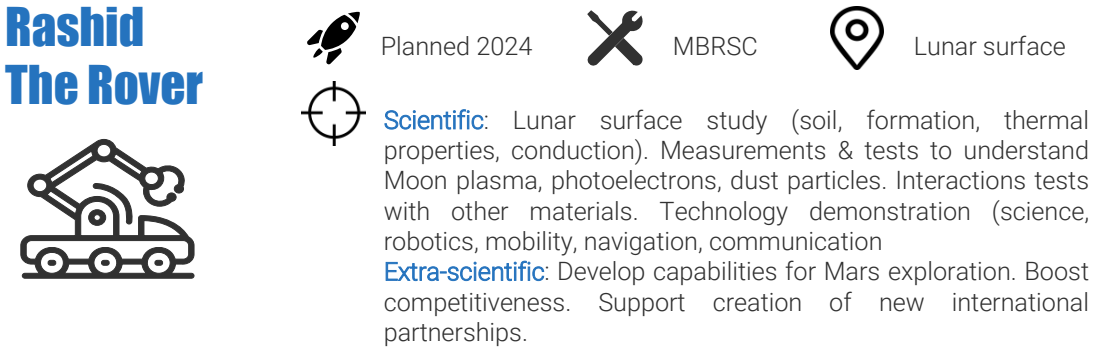

Figure 13: Rashid the Rover mission (adapted from WAM)

Human spaceflight

As part of the 2017 National Space Programme, the MBRSC founded the country's Astronaut Programme. In launching the programme and creating a contingent of Emirati astronauts, the UAE hoped to elevate them as public figures and inspire the population, among other objectives.[142] In 2018, the UAE's first two astronauts, Hazzaa Al Mansouri and Sultan Al Neyad, were selected. In 2019, Hazzaa Al Mansouri became the first Emirati astronaut to join the ISS crew.[143] [144] In April 2021, MBRSC selected two additional astronauts, including the country's first woman astronaut. Nora Al Matrooshi and Mohammad Al Mulla will begin training with NASA's Johnson Space Center in 2021.[145]

[137] "Analog Mission" MBRSC. Available at: https://www.mbrsc.ae/analog-mission. Accessed April 2021.
[138] "Space science and technology". UAE Government Portal. Available at: https://u.ae/en/about-the-uae/science-and-technology/key-sectors-in-science-and-technology/space-science-and-technology. Accessed December 2020.
[139] *Ibid.*
[140] Ismail, Esraa and Abubaker, Rasha. "Mohammed bin Rashid launches Emirates Lunar Mission". 2020. Emirates News Agency. Available at: https://bit.ly/3gWADOM. Accessed April 2021.
[141] *Ibid.*
[142] "Astronaut Programme", MBRSC. Available at: https://www.mbrsc.ae/astronaut-programme. Accessed December 2020.
[143] "Hazzaa Ali AlMansoori". MBRSC. Available at: https://www.mbrsc.ae/astronaut-programme/hazzal-al-mansoori. Accessed December 2020.
[144] Hazzaa AlMansoori chosen to become first Emirati in space". 2019. *Gulf News.* Available at: https://bit.ly/3tbncgo. Accessed December 2020.
[145] Foust, Jeff. "UAE selects new astronauts, including first woman". 2021. *SpaceNews*. Available at: https://spacenews.com/uae-selects-new-astronauts-including-first-woman/. Accessed May 2021.

2.5 Key takeaways

2.5.1 UAE space ambitions

The UAE's space efforts are driven by several goals, which have different implications. First, the UAE has been seeking to diversify its economy from reliance on fossil fuels and views space as an opportunity for economic growth. These goals are clearly outlined in the UAE Vision 2021, the UAE Centennial 2071, and the National Space Policy. As part of this diversification effort, the UAE aims to position the country as a hub for technological development and innovation to promote growth, attract investments, and develop its national industrial base. The UAE seeks to transition the space industry from a domain controlled solely by the government to one where private and public entities collaborate towards common goals. In this regard, the Space Investment Plan highlights that this goal relies on four pillars: sustaining the growth of the UAE Space Industry; increasing the UAE space sector's contribution to the diversification of the national economy, and towards a knowledge-based economy; supporting other national strategic interests; promoting partnerships at national and international levels.[146]

Furthermore, the UAE is promoting the space sector as a strategic domain for Emirati citizens to work in (Emiratization policy), through education and training programmes, the establishment of research centres, partnerships between industries and universities in the development of space systems, as well as the promotion of women in STEM. Therefore, the UAE is also looking to generate socio-economic benefits from its space activities.

The UAE also aspires to improve its prestige and soft power through space activities at both the international and regional levels. The promotion of UAE's leadership and national pride is often mentioned in the country's space policies. The goal is mostly achieved through strong communication and diplomatic efforts at the national and international levels, particularly regarding space exploration. The UAE has established itself as a regional leader in the space sector by developing its own space programme and successfully conducting exploration missions, which ultimately reinforced its credibility and legitimacy. This is a way to distinguish itself from other Gulf countries, which are also pursuing space activities. However, the UAE has also acted as a leader in promoting regional cooperation through the creation of the Pan-Arab Group for Space Collaboration.

Finally, while their communication efforts and promotional campaigns are mostly focused on exploration and science, the UAE is also pursuing space activities for defence and security purposes in order to ensure national security objectives and face regional security issues. This goal is the second principle of the National Space Policy. The policy further outlines specific measures to implement security and defence objectives.

2.5.2 Achievements and developments

Over the last 20 years, the UAE has developed its space activities and reached key milestones, making it an emerging spacefaring nation.

Politics

At the international level, the UAE is very active in the diplomatic scene as it has signed most international space agreements, except for the Moon Agreement. It is very active in international fora and is a Member State of UNOOSA and UNCOPUOS, where it often submits proposals. At the bilateral level, the UAE signed

[146] N. Al Rashedi et al. UAE Approach to Space and Security in: Schrogl, K.-U. (Ed.). 2020. Handbook of Space Security.

numerous cooperation agreements and partnerships, including with all space powers. At the national level, the UAE Space Agency was established in 2014 and the budget allocated to space activities has been increasing on a yearly basis. Several space policies have been adopted, such as but not limited to, the National Space Policy, the National Space Strategy, the Space Investment Plan, the Mars 2117 Strategy, as well as the Mohammed Bin Rashid Space Centre Strategy 2021-2031. Laws have been adopted to comply with international agreements. Federal Law No. 12 went beyond traditional legal measures that allow for space activities and enabled the exploitation of space resources, thereby positioning the UAE as a pioneer in this field alongside the U.S. and Luxembourg. The UAE also foresees the emergence of commercial disputes between space companies and established a Space Court. The national space ecosystem includes several entities that provide technical expertise (MBRSC), scientific research (Sharjah Academy of Astronomy, Space Sciences and Technology, National Space Science and Technology Center, Center for Space Science), training and education (Yahsat Space Laboratory).

As a result, the UAE has developed a comprehensive policy and legal framework to enable and regulate space activities and established national institutions to implement the country's objectives.

Programmes

At the programmatic level, the UAE gradually developed its national industrial base, technical expertise, and manufacturing capacities through international knowledge transfer programmes. The UAE first developed telecommunications, then extended activities to Earth Observation thanks to cooperation partnerships with South Korea. It launched its first satellite in 2009. In the last few years, the UAE developed its acitivites in the field of human spaceflight, space science, and space exploration. While the objective is now to develop independent capacities, the UAE still takes advantage of international cooperation with foreign agencies and universities to build up its technical expertise and increase its reliability.

The UAE's biggest achievement so far has been the Emirates Mars Mission, the first Arab interplanetary mission. The Hope probe reached Mars' orbit in February 2021 to collect scientific data on Mars' atmosphere. This mission was perceived as a major milestone by the Emirati authorities in establishing the country as an "advanced nation involved in space exploration".[147] The Kingdom is looking to expand its Mars exploration activities by establishing a human settlement on Mars by 2117. In addition, the UAE also signed the Artemis accords to facilitate cooperation in the field of exploration. It announced that it plans to send a rover and Emirati astronauts to the Moon by 2024.

In addition, an upcoming project is the Global Navigation Satellite Systems – Augmentation System (GNSSaS) is a LEO cubesat constellation expected to be operational by 2022. This development could play an important role in contributing to the UAE's strategic autonomy.

The UAE has neither a spaceport nor launching capacities and has partnered with various stakeholders to launch its satellites (France, Japan, Russia, etc.). Discussions are ongoing regarding the establishment of a commercial spaceport in partnership with U.S. company Virgin Galactic. The spaceport would likely be located in Al Ain and focus on horizontal launches, enabling space tourism.

[147] Bin Zayed, Mohamed (@MohamedBinZayed). "The transmission of the Hope Probe's first image of Mars is a defining moment in our history and marks the UAE joining advanced nations involved in space exploration. We hope this mission will lead to new discoveries about Mars which will benefit humanity." 14. February 2021, 10:22, Tweet.

3 AUSTRALIA

3.1 National space history

Australia's first steps in the space sector started in the 1960s as part of cooperation efforts with European countries. At the time, the UK and France decided to develop a launch program and created the European Launcher Development Organisation (ELDO) to build the Europa-1 rocket. In this effort, the first stage of the rocket consisted of the British Blue Streak missile, which was first tested from Woomera, South Australia in 1964. In 1967, WRESAT was launched, making Australia the seventh nation to have a satellite in orbit. However, space was not seen as a priority at the time and Australia did not take advantage of these first successes to build up a comprehensive space programme.[148] Today, Woomera and the space sector at large are the object of a renewed interest. The country is focusing on a wide range of space activities, particularly industrial development, and defence. Recent regional geopolitical developments have led Australia to seek partnerships in the region and develop autonomous capabilities.[149]

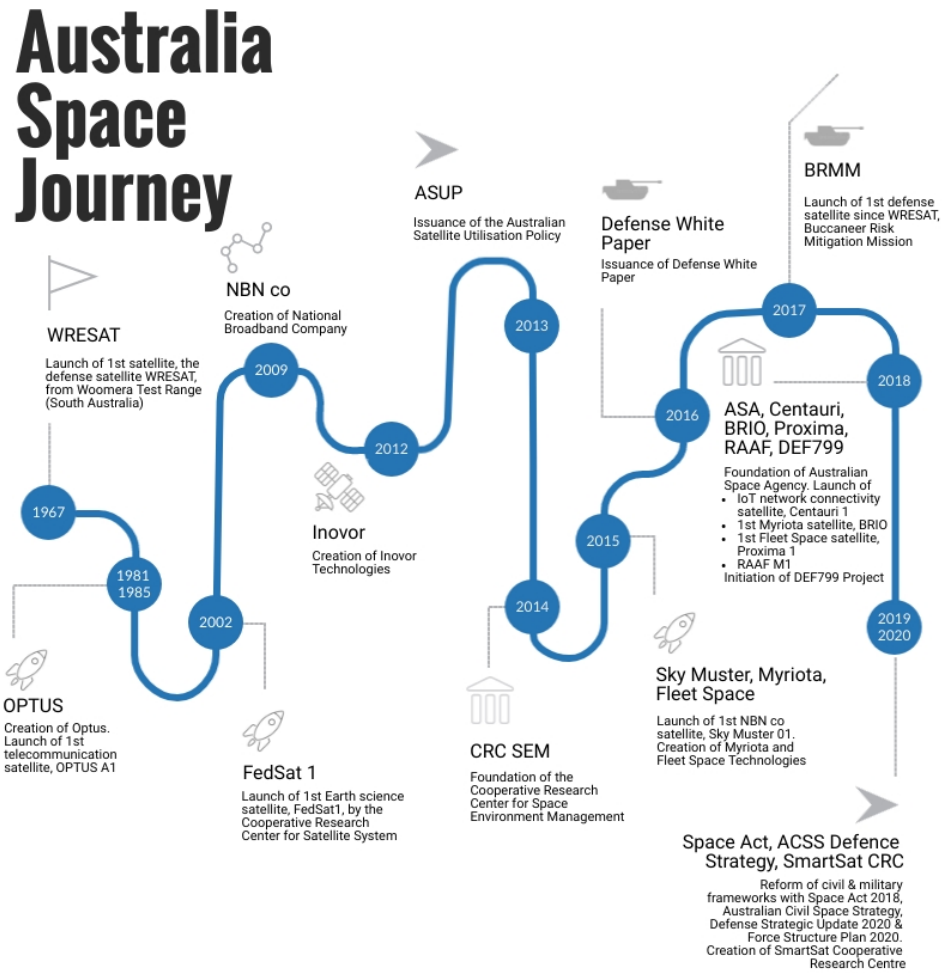

Figure 14: Timeline of Australia space journey[150]

[148] Phillips, Malcolm J. "How it started- Australia's early days in space at Woomera". 2018. Australian Strategic Policy Institute. Available at: https://www.aspistrategist.org.au/started-australias-early-days-space-woomera/. Accessed May 2021.
[149] Davis, Malcolm. Australia confronts a contested space domain and a rising China. China Aerospace Studies Institutes. 2020 CASI Conference. Available at: https://bit.ly/3oY5PPv. Accessed May 2021.
[150] Missile developments not considered in the timeline.

3.2 Space sector governance

3.2.1 Institutional framework

Space activities in Australia are conducted at both the state and federal levels. At the federal level, many government departments and agencies are involved in a variety of space-related activities. An overview of the major stakeholders is provided in the table below.

Entity	Involvement in space
Australian Space Agency (ASA)	Coordinates civil space activities & counsels on civil space policy (see details *infra*).
Australian Communications and Media Authority (ACMA)	Regulates broadcasting, internet, radiocommunication, and telecommunication. Manages radiofrequency spectrum access.
Attorney-General's Department (AGD) – Office of International Law	Provides legal advice on International Space Law.
Australian Trade and Investment Commission (Austrade)	Promotes trade, investment, and education. Aims to grow domestic exports: Carries space activities managed by its Advanced Manufacturing, Defence and Space Team.
Bureau of Meteorology	Provides satellite-derived products and space weather services. Operates and maintains ground stations for satellites.
Commonwealth Scientific and Industrial Research organisation (CSIRO)	Carries research on astronomy and space science (see details *infra*)
Department of Infrastructure, Transport, Regional Development and Communities	Oversees radiocommunications services and spectrum management policies and advises government on spectrum and radiocommunication allocation, and on telecommunication resilience and security).
Department of Defence (Defence)	Relies on civil and military space-based systems in its operations (see details *infra*).
Department of the Environment and Energy (DEE)	Make use of EO satellite data to support environmental management.
Department of Foreign Affairs and Trade (DFAT)	Collaborates with Defence on space security and manages UN engagement, agreements with foreign actors and space issues affecting foreign relations.
Department of Home Affairs (Home Affairs)	Implements the Critical Infrastructure Resilience Strategy (CIC) which includes space-related infrastructure.
Department of Industry, Science, Energy and Resources (DISER)	Advises on linkages between space and other industries on a policy level.
GeoScience Australia (GA)	National geoscience organization relevant for PNT and non-meteorological use of EO.

Table 7: Australian Institutional Framework (adapted from State of Space Report 2018-2019)

Australian Space Agency (ASA)

The ASA was established in July 2018 after a review of the capabilities of Australia's space industry.[151] The Agency is within the Australian Department of Industry, Science, Energy, and Resources. The ASA's charter outlines six roles and responsibilities:

- Providing strategic advice and national policy on the civil space sector,
- Coordinating Australia's domestic civil space sector activities,
- Supporting the growth of Australian space industry and the use of space across the broader economy,
- Leading international civil space engagement,
- Administering space activities legislation and delivering on international obligations.
- Inspiring the Australian community and the next generation of space entrepreneurs.[152]

A key task of the ASA is to maintain close linkages with all government agencies involved in space activities to ensure continuity and centralisation. ASA also cooperates and communicates with industry actors, as well as state and regional governments to further contribute to this task.[153]

A series of consultation and coordination entities support the ASA in maintaining coordination across different levels of government and with industry:[154]

- Australian Government Space Coordination Committee (SCC): The SCC is an inter-departmental committee established in 2012 that brings together all relevant Australian Government departments to coordinate and formulate priorities for the civil space sector. Notably, it coordinates with the Strategic Policy Division of the DoD.[155]
- Space Industry Leaders Forum: The Forum was established by the ASA to engage with the private sector in Australia to receive input on the business and technological aspects of the space industry which should be included in space policy and strategy. Members are industry representatives, academics, representatives from associations, and representatives from other non-government space organisations.
- State and Territory Space Coordination Meeting (S&T Meeting): The S&T meeting is a regularly scheduled meeting organised by the ASA to bring together representatives from states and territories.

Defence

Defence and security have been important drivers for pursuing space activities in Australia. Australia's space journey has always been tied to national security issues from the test of the Blue Streak ballistic missiles in the 1960s, to the establishment of ground stations for U.S missile early-warning systems in the 1970s, and the recent recognition of space as a warfighting domain in the 2020 Strategic Update.[156]

The Australian Government Department of Defence is involved in space activities in many respects. Key activities include:

- Collection of space-based geospatial intelligence in support of national security requirements,

[151] Davis, Malcolm. Why Maintaining Space Access Matters in *The Australian Defence Force and Contested Space*. 2019. Australian Strategic Policy Institute. Available at: http://www.jstor.com/stable/resrep23071.5. Accessed May 2021.
[152] Australian Space Agency, *Australian Space Agency Charter* (2018).
[153] Australian Space Agency, *Australian Space Agency Charter* (2018).
[154] Australian Space Agency, *Australian Space Agency Charter* (2018).
[155] Davis, Malcolm. Why Maintaining Space Access Matters in *The Australian Defence Force and Contested Space*. 2019. Australian Strategic Policy Institute. Available at: http://www.jstor.com/stable/resrep23071.5. Accessed May 2021.
[156] Biddington, Brett. "The Australian space Agency: rhetoric and reality". 2018. Australian Strategic Policy Institute. Available at: https://www.aspistrategist.org.au/australian-space-agency-rhetoric-reality/. Accessed May 2021.

- Utilisation of military and civil space-based systems for Position, Navigation and Timing (PNT), satellite communications, intelligence, surveillance and reconnaissance, mapping, and weather forecasting,
- Contribution to space situational awareness and space infrastructure security,
- Engagement with international partners on military use of space through the Combined Space Operations initiative and bilateral partnerships and talks,
- Management of the radiofrequency spectrum resources for its satellite networks,
- Support to space R&D and industry.

Australian Defence Force (ADF)

ADF was created by the Defence Act of 1903 and aims to:

- Defend Australia and its national interests through the conduct of operations and provision of support for the Australian community and civilian authorities in accordance with Government direction,
- Protect and advance Australia's strategic interests through the provision of strategic policy, the development, delivery and sustainment of military, intelligence and enabling capabilities, and the promotion of regional and global security and stability as directed by Government.[157]

ADF is composed of three branches (Navy, Army, Air Force). Considering the critical role of space systems for all three branches of the military, space activities are integrated within the Headquarters Joint Operations Command (HQJOC), which is charge of planning joint operations, allocating resources for military operations, as well as command and control (C2).[158]

The HQJOC hosts several entities with space-related responsibilities and activities:

- The Air & Space Operations Centre (AOC) is in charge of planning and directing air and space operations of the ADF.[159]
- The Australian Space Operations Centre (AUSSpOC), located within HQJOC's Air & Space Operations Centre (AOC), provides satellite vulnerability reports to deployed forces, warning reports of space debris re-entry, and Space Situational Awareness data. It also monitors the impacts of space weather on operational space capabilities. In addition, since Australia relies on many foreign space capabilities, the AUSSpOC is responsible for coordination with the U.S Department of Defense and the U.S led Combined Space Operations Centre (CSpOC). The ADF relies on CSpOC data to provide space support to Australian military operations.[160] [161]

The Royal Australian Air Force (RAAF) is also involved in Australia's space activities. The RAAF works with the ASA on developing SATCOM, PNT, and SSA capabilities.[162] One of their significant missions was developed in collaboration with a university. Indeed, the University of New South Wales in Canberra and the RAAF launched three Cubesats. In 2018, the Cubesat Mission 1 was launched by a Falcon-9 rocket, but communications with the space system could not be established after launch.[163] Following this failure,

[157] "Defence at a Glance" Australian Government Department of Defence. Available at: https://www1.defence.gov.au/about/at-a-glance. Accessed May 2021.
[158] Air and Space Power Centre, Air Force Doctrine Publication: Air-Space Integration (2019), 56-59
[159] Air and Space Power Centre, Air Force Doctrine Publication: Air-Space Integration (2019), 56-59
[160] Davis, Malcolm. Why Maintaining Space Access Matters in *The Australian Defence Force and Contested Space*. 2019. Australian Strategic Policy Institute. Available at: http://www.jstor.com/stable/resrep23071.5. Accessed May 2021.
[161] Air and Space Power Centre, Air Force Doctrine Publication: Air-Space Integration (2019), 56-59
[162] Australian Military Space: RAAF Preparing M1 And M2 Satellite Demonstration Missions". 2018. *SpaceWatch Global*. Available at: https://spacewatch.global/2018/12/australian-military-space-raaf-preparing-m1-and-m2-satellite-demonstration-missions/. Accessed May 2021.
[163] "RAAF M1" Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/raaf-m1.htm. Accessed May 2021.

the Cubesat Mission 2 Pathfinder was successfully launched in 2020 by an Electron KS vehicle in order to test radio communications technologies that could be used on more complex military space systems.[164] In March 2021, the Cubesat Mission 2 satellite was launched to test capabilities for maritime surveillance, quantum computing, artificial intelligence, and laser communications.[165]

Mission 1 and Mission 2 were designed as follow-up missions to the Buccaneer Risk Mitigation Mission (BRMM). BRMM consisted of two cubesats, which were launched in 2017 and developed by both the University of New South Wales in Canberra and the Defence, Science and Technology Group (DSTG).[166] [167]

The Department of Defence announces the creation of a Space Division headquarters

In May 2021, the DoD announced that it will establish a Space Division headquarters within the RAAF in 2022, bringing staff from all the branches of the army that are relevant to the space domain. A Space Domain Review is currently conducted by the DoD to improve the management, procurement, and operation of space capabilities.[168]

According to the Chief of Air Force, Air Marshal Mel Hupfeld AO, the establishment of this division should also be understood within a context of evolution of the Australian military doctrine with the progressive adoption of the concept of multidomain operations (MDO).[169]

MDO are usually understood as joint military operations conducted across multiple domains and contested spaces (including outer space) to overcome an adversary's Anti Access Area Denial capabilities (including jamming and spoofing).[170] In other words, it is about manoeuvring in all domains (land, sea, air, cyber and space) and connecting all the elements of the battlefield together within a digital infrastructure. Space is essential for the implementation of this doctrine as it connects and synchronises all the elements of the battlefield together through PNT services, EO provides situational awareness to soldiers and SATCOM are enabling real-time communications between the strategic, operational, and tactical levels as well as between several battlefields.

This doctrine was developed by the U.S. to regain freedom of action and counter near-peer adversaries such as China and Russia. This doctrine (or equivalent) is progressively being adopted by other countries, including Australia.[171]

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[164] "Australian Military Space: RAAF Preparing M1 And M2 Satellite Demonstration Missions". 2018. *SpaceWatch Global.* Available at: https://spacewatch.global/2018/12/australian-military-space-raaf-preparing-m1-and-m2-satellite-demonstration-missions/.
[165] "RAAF M2" Gunter's Space Page. Available at: "https://space.skyrocket.de/doc_sdat/raaf-m2.htm. Accessed May 2021.
[166] Australian Military Space: RAAF Preparing M1 And M2 Satellite Demonstration Missions. 2018. *SpaceWatch Global*. Available at: https://spacewatch.global/2018/12/australian-military-space-raaf-preparing-m1-and-m2-satellite-demonstration-missions/. Accessed May 2021.
[167] "Buccaneer CubeSat Mission" eoPortal Directory. Available at: https://directory.eoportal.org/web/eoportal/satellite-missions/b/buccaneer. Accessed May 2021.
[168] "Defence announces Space Division" 2021. Australian Government Department of Defence- Defence News. Available at : https://bit.ly/3fOmZLr. Accessed May 2021.
[169] *Ibid.*
[170] The US Army defined MDO as: "Operations conducted across multiple domains and contested spaces to overcome an adversary's (or enemy's) strengths by presenting them with several operational and/or tactical dilemmas through the combined application of calibrated force posture; employment of multi-domain formations; and convergence of capabilities across domains, environments, and functions in time and spaces to achieve operational and tactical objectives." Read More: U.S. Army (2018) The US Army in Multi-Domain Operations 2028, TRADOC, Pamphlet 525-3-1, p.GL-7.
[171] Rembroke, Paul. Synchronising Multi Domain Operations Using the Breach Mindset". Available at: https://cove.army.gov.au/sites/default/files/synchronising_multi_domain_operations_using_the_breach_mindset.pdf. Accessed May 2021.

Defence, Science and Technology Group (DSTG)

The DSTG was created in 1974 as part of the Australian Department of Defence. It provides scientific and technological support to the Australian Armed Forces and national security agencies.[172] It cooperates with universities, research centres, and industry to "tackle a range of problems, across the maritime, land, air, space and cyber domains".[173] Within DSTG, the Intelligence, Surveillance and Space Division is conducting research on satellite systems, advanced sensing, and sensor processing technologies, as well as systems for imagery collection. The main objective of the division's research is to improve the rapid extraction and dissemination of strategic intelligence in order to enhance the situational awareness and therefore speed up the OODA loop (observe, orient, decide and act).[174] The Division is divided into four units: Integrated ISR, Intelligence Analysis, Space Intelligence and, Surveillance Systems.[175]

Recently, the DST launched a research program, named CHORUS (Compact Hybrid Optical-RF User Segment) with academic and industrial stakeholders to develop innovative technologies for integrating hybrid optical-RF SATCOM terminals into military vehicles.[176]

The Australian Geospatial-Intelligence Organisation (AGO)

AGO is an intelligence agency within the Department of Defence, which is in charge of GEOINT. This is one of the main providers of space-based imagery to the DoD. However, Australia does not have EO satellites, and therefore images are acquired from commercial providers.[177]

In 2018, AGO launched a project called Defence Project DEF799-1, which aims at providing Australia with direct access to some EO commercial satellites through contractual arrangements with commercial space companies and the establishment of a Direct Tasking and Receipt Facility (DTRF) at the RAAF's Base in Edinburgh, South Australia, which would be linked to five ground antennas. At the moment, this project is only at an initial phase.[178]

3.2.2 Space industry and economy

After its first successes in the 1960s, Australia's space industry slowly developed. However, the development of sovereign space capabilities and a strong industrial base were not priorities for Australia at the time. Therefore, Australia mostly developed telecommunications to meet the needs for connectivity in remote areas and generated downstream applications and services, which provided socio-economic benefits to numerous sectors.[179] In 2015, most of the revenues generated by the space sector came from satellite television, broadband, and communications services.[180]

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[172] "Defence Science and Technology Group. Australian Government- Directory. Available at: https://bit.ly/34ofyFg. Accessed May 2021.
[173] "Science and Technology Group". Australian Government Department of Defence. Available at: https://www1.defence.gov.au/about/science-technology-group. Accessed May 2021.
[174] "Intelligence, Surveillance and Space Division". Australian Government Department of Defence- Defence Science and Technology Group. Available at. https://bit.ly/2SCxmtD. Accessed May 2021.
[175] "Integrated ISR". Australian Government Department of Defence- Defence Science and Technology Group. Available at: https://www.dst.defence.gov.au/capability/integrated-isr. Accessed May 2021.
[176] "DST launches SATCOM research collaboration". *Defence Connect*. 2020. Available at: defenceconnect.com.au/key-enablers/6081-dst-launches-satcom-research-collaboration. Accessed May 2021.
[177] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[178] *Ibid.*
[179] ACIL Allen Consulting. "Report to Department of Industry, Innovation of Science, Australian Space Industry Capability". 2017. Available at: https://www.industry.gov.au/sites/default/files/2019-03/australian_space_industry_capability_-_a_review.pdf. Accessed May 2021.
[180] Expert Reference Group for Review. "Review of Australia's Space Industry Capability". 2018. Available at: https://bit.ly/3bWXN4o. Accessed May 2021.

According to Malcolm Davis, Senior Analyst at the Australian Strategic Policy Institute, Australia missed opportunities in the space sector for many decades, but the government's perception of space has shifted in the last few years.[181] [182] In 2018, a review of the space industry was released, which led to the creation of the Australian Space Agency, whose goal is to triple the size of the Australian industry, investing AUD 10-12 billion a year by 2030. It also increased the government's awareness of the space sector's potential for economic growth. In addition, recent geopolitical developments in the Asia Pacific region, as well the build-up of space capabilities by other space powers such as China and Russia have prompted the government to reconsider its view of outer space as an operational domain.[183] [184]

Therefore, defence and economic growth have been key drivers for developing the space industry. Building sovereign capabilities is now more of a priority and Australia is developing its space industry by strengthening its defence industrial base. This can be identified in public policies such as the 2018 Defence Industrial Capability Plan, which identified ten sovereign industrial capabilities to develop in the coming years. "Surveillance and intelligence data collection, analysis dissemination and complex systems integration" constitutes one of Australia's ten priorities and includes the development of sovereign space situational awareness systems. In addition, the Defence Innovation Hub puts the development of capabilities in the field of "Intelligence, Surveillance, Reconnaissance, Electronic Warfare, Space and Cyber" as its first priority.[185] The main goal of this hub is to grow the Australian defence industrial base.[186]

Moreover, international cooperation is seen as a key enabler to increase the participation of Australian industries in joint projects, as well as to ensure access to services such as satellite imagery or GNSS since Australia does not have sovereign capabilities in these areas.[187] The government's review of the space industry in 2018 identified that existing international agreements on planetary science, astronomy, and space research with foreign agencies (DLR, ESA, NASA, JAXA, CNES, etc.) could be leveraged "to fast-track Australia's space industry".[188]

Overall, applications, telecommunications, and telescopes are the most developed domains of Australia's space industry. Australia has mature capabilities in the manufacture of ground systems and satellite laser ranging telescopes. It is also building capabilities to manufacture nanosatellites and microsatellites in partnership with universities. However, it has very limited manufacturing capabilities for large satellites and launchers.[189]

Australia is trying to position itself in areas where it can build on its existing strengths to gain a competitive advantage, namely communications, SSA, PNT, and data services for EO.[190] Australia is also trying to take

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[181] Davis, Malcolm. Why Maintaining Space Access Matters in The Australian Defence Force and Contested Space. 2019. Australian Strategic Policy Institute. Available at: http://www.jstor.com/stable/resrep23071.5. Accessed May 2021.
[182] Davis, Malcolm. Australia confronts a contested space domain and a rising China. China Aerospace Studies Institutes. 2020 CASI Conference. Available at: https://bit.ly/3oY5PPv. Accessed May 2021.
[183] Davis, Malcolm. Australia confronts a contested space domain and a rising China. China Aerospace Studies Institutes. 2020 CASI Conference. Available at: https://bit.ly/3oY5PPv. Accessed May 2021.
[184] Expert Reference Group for Review. "Review of Australia's Space Industry Capability". 2018. Available at: https://bit.ly/3bWXN4o. Accessed May 2021.
[185] Defence Innovation Hub. "Industry Information Guide". 2020. Australian Government. Available at: https://www.innovationhub.defence.gov.au/defence-innovation-hub-industry-information-guide-v1. Accessed May 2021.
[186] "Defence Industrial Capability Plan" Australian Government Department of Defence. Available at: https://www1.defence.gov.au/business-industry/capability-plans/defence-industrial-capability-plan. Accessed May 2021.
[187] Expert Reference Group for Review. "Review of Australia's Space Industry Capability". 2018. Available at: https://bit.ly/3bWXN4o. Accessed May 2021.
[188] *Ibid*.
[189] ACIL Allen Consulting. "Report to Department of Industry, Innovation of Science, Australian Space Industry Capability". 2017. Available at: https://www.industry.gov.au/sites/default/files/2019-03/australian_space_industry_capability_-_a_review.pdf. Accessed May 2021.
[190] Expert Reference Group for Review. "Review of Australia's Space Industry Capability". 2018. Available at: https://bit.ly/3bWXN4o. Accessed May 2021.

advantage of New Space to further develop its space economy. Australia seeks to take advantage of the miniaturisation of space systems to develop its industry by fostering partnerships between academia and the private sectors. Companies such as Myriota, Fleet Space Technologies, or Skykraft are developing capabilities to manufacture and operate miniaturised satellites.[191] Additionally, start-up incubators have been established to attract both national and foreign entities. Examples of this include the Venture Catalyst Space Program, which is part of the University of South Australia's Innovation and Collaboration Centre and helped companies such as Lux (space robotics), Astrogate Labs (laser communication for small satellites), or Firefly Biotech (biological research in space).[192]

The contribution of Australian companies to the space industry can be classified by their sector of involvement. Some companies position themselves in more than one sector alongside the supply chain.

Capability	Examples
Launch systems /components manufacturers	Southern Launch, BlackSky, Gilmour, ELA, Hypersonix, Heliaq Advanced Engineering, Nextaero, Neumann Space
Satellite/Space system / components manufacturers	Fleet Space, Inovor, Sitael Australia, UNSW Canberra, Lockheed Martin Australia, Myriota, Melbourne Space Programme. (tbl picosat Systems), CSIRO Manufacturing, Quintessence Labs
Operators	Optus, NBN, Sirion Global, Inovor, SES
Applications and VAS	Telstra, Myriota, Elmtek, Saber, SpeedCast, Otus Intelligence Group, Airbus Defence & Space Australia, EOS Space Systems

Table 8: Overview of Australia space industry

An overview of some selected companies' profiles is provided below:

OPTUS

Foundation

1981

Core Business

Telecommunication, Satellite operator

Products & Services

- Digital services to both end users and other service providers (Exetel + Amaysim)
- Covers rural and remote areas
- Operates ground infrastructure (Optus Earth Stations)

nbn™

Foundation

2009

Core Business

Telecommunication, Satellite operator

Products & Services

- "Government Business Enterprise"
- Wholesale-only, open-access broadband network

[191] *Ibid.*
[192] Filosi, Benjamin. "Global startups join Australia's first dedicated space incubator program". The Lead. 2021. Available at: http://theleadsouthaustralia.com.au/industries/startups/global-startups-join-australias-first-dedicated-space-incubator-program/. Accessed May 2021.

FLEET

Foundation

2015

Core Business

Communication systems, Satellite manufacturer, Satellite operator

Products & Services

- IoT nanosatellite constellation (Proxima, Centauri)
- "The Portal" (plug-and-play Edge Server, LoRaWAN Gateway and satellite modem)

Myriota

Foundation

2015

Core Business

Communication systems, Satellite manufacturer

Products & Services

- Narrowband signal transmitters
- Provides direct-to-orbit satellite connectivity
- Transmission of IoT data to nanosatellites
- "Internet of Military Things" (DST prototype of terminals)

INOVOR TECHNOLOGIES

Foundation

2012

Core Business

Satellite technology provider, Consultant, Satellite manufacturer

Products & Services

- Apogee (nanosatellite bus)
- Consulting services to Defence
- Skyris (Earth Imaging nanosatellite constellation)
- Hyperion (SDA constellation)
- Fully integrated Australian supply chain

EOS

Foundation

1983

Core Business

Intelligence, surveillance and reconnaissance, EO systems & infrastructure, GPS

Products & Services

- Satellite tracking and SSA data
- Sensor scheduling
- Space debris management
- Missile defense capabilities
- Optical communication systems
- Calibration of GNSS satellites

GILMOUR SPACE

Foundation

2012

Core Business

Micro Launch Systems, Propulsion Systems, Orbital & Sub-orbital Systems

Products & Services

- RASTA (hybrid rocket using 3D-printed fuel)
- One Vision & Eris rocket
- Ground control station operations
- Mobile launch platform
- hybrid rocket propulsion system

SOUTHERN LAUNCH

Foundation

2017

Core Business

Micro Launch Systems Facilities, Orbital & Sub-orbital Systems

Products & Services

- Whalers Way Orbital Launch Complex (orbital launch) & Koonibba Test Range (suborbital launch) operations

3.2.3 Research centres and academia

There are currently 20 Australian universities providing space-related education. Leading universities in this field are the University of New South Wales at Canberra and the Australia National University:

- UNSW Canberra is an Australian university affiliated to the Australian Defence Force.[193] The University is conducting space research activities on: advanced materials and impact dynamics, artificial intelligence for space, system and control, fluid structure interaction, satellite imagery, optimisation and design, space ethics, astronomy and astrophysics, and space situational awareness.[194]

  UNSW Canberra Space has been involved in several satellite missions in collaboration with the DSTG and the RAAF, such as the Buccanneer Risk Mitigation Mission, Mission 1, Mission 2 Pathfinder, and Mission 2.[195] UNSW Canberra Space hosts several space infrastructures such as the Advanced Composite Research Unit (ACRU) Composites Laboratory (manufactures thermoplastic composite parts and polymer matrix composite components, etc), the Falcon Telescope (part of the U.S Falcon Telescope Network), satellite ground stations, a cleanroom, and a thermal vacuum chamber laboratory.[196]
- Australia National University (ANU) is also located in Canberra and offers curriculums in astronomy and astrophysics, aerospace engineering, and space law. ANU also hosts the Advanced Instrumentation and Technology Centre (AITC) and the Australian National University Institute for Space (also called InSpace).

  InSpace was established to coordinate space-related activities within the university and create synergies between the different faculties.[197] [198] Its goal is to shape public policy, stimulate funding, and encourage students to pursue careers in space.[199] InSpace's work is aligned with the priorities of the ASA and focuses on positioning, navigation and timing, Earth observation, communications technologies and services, situational awareness and debris monitoring, leapfrog R&D, robotics and automation, and access to space.[200] It hosts the National Space Test Facility and the Centre for Space Situational Awareness Research.[201]

The Advanced Instrumentation and Technology Centre (AITC)

The AITC was established in 2006 at Mount Stromlo Observatory in Canberra.[202] It is managed by the Research School of Astronomy and Astrophysics of the Australian National University (ANU) in Canberra. It is a national facility for the design, manufacture, assembly, and test of space systems. The Centre hosts several cleanrooms, space simulation facilities, and thermal cycling facilities.[203]

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[193] Lachlan Colquhoun *et al.*, *Australian Space Outlook 2019*, Faircount Media Group (2019), 1.
[194] "Space Research". UNSW Canberra. Available at: https://www.unsw.adfa.edu.au/our-research/priorities/space/research.
[195] "The Space to Create a Better Earth". UNSW Canberra Space. Available at: https://www.unsw.adfa.edu.au/unsw-canberra-space. Accessed May 2021.
[196] "Research Facilities". UNSW Canberra. Available at: https://www.unsw.adfa.edu.au/our-research/facilities?keywords=&tid=1143. Accessed May 2021.
[197] Grosse, David, et al. *Space Situational Awareness at the Australian National University*. 2019. First International Orbital Debris Conference. Available at: https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6176.pdf. Accessed May 2021.
[198] "About". ANU Institute for Space. Available at: https://inspace.anu.edu.au/about. Accessed May 2021.
[199] "Objectives". ANU Institute for Space. Available at: https://inspace.anu.edu.au/about/objectives. Accessed May 2021.
[200] *Ibid.*
[201] "Centre for Space Situational Awareness Research". ANU Institute for Space. Available at: https://inspace.anu.edu.au/centre-space-situational-awareness-research. Accessed May 2021.
[202] "History". Research School of Astronomy and Astrophysics- ANU College of Sciences. Available at: https://rsaa.anu.edu.au/aitc/about/history. Accessed May 2021.
[203] "Facility". Research School of Astronomy and Astrophysics- ANU College of Sciences. Available at: https://rsaa.anu.edu.au/aitc/about/facility. Accessed May 2021.

The Centre first contributed to the development of ground-based astronomical telescopes (e.g., Australian Astronomical Observatory, Gemini, Subaru, and Keck telescopes located in the U.S, and the Giant Magellan Telescope located in Chile).[204] It is now testing CubeSats, developing adaptive optics for SSA, a plasma thruster engine, ground stations, and operations and test facilities for the Antarctic Broadband Program, etc. in partnership with national and foreign industries.[205] [206]

Commonwealth Scientific and Industrial Research Agency (CSIRO)

CSIRO is Australia's national research agency that conducts research in environmental science, medical sciences, natural disasters, plants, and technology and space, among other things. The technology and space research at CSIRO addresses a wide array of topics, including radio astronomy technologies, telescopes, spacecraft tracking capacities, and EO applications for environmental purposes.[207] CSIRO also helps leverage space technologies in other sectors, including agriculture, for example.[208]

In 2018, CSIRO FUTURES, the strategy advisory arm of CSIRO published, "Space: A roadmap for unlocking future growth opportunities in Australia". The roadmap identifies short-term and long-term potential for industry development and opportunities for Australia in a series of domains. The goal of the document is to help industry actors identify opportunities and ultimately grow the Australian space industry.[209]

In 2018, CSIRO also announced the creation of the Space Technology Future Science Platform to develop "frontier space technologies and applications". The objective of the platform is "to build world-leading capability and drive cutting-edge research within CSIRO in support of Agency's goal of tripling the size of the Australian space industry by 2030."

Cooperative Research Centres (CRCs)

The Cooperative Research Centres Program is a government initiative to foster industrial competitiveness by bringing together the industrial sector and the research sector. Centres can apply to two types of government grants: CRC grants that support medium to long-term research (up to ten years), or CRC Projects grants for short-term project (up to three years).

In the space sector, there are two centres of this type: the SmartSat CRC and the CRC for Space Environment Management.[210]

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[204] Grosse, David, et al. *Space Situational Awareness at the Australian National University*. 2019. First International Orbital Debris Conference. Available at: https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6176.pdf. Accessed May 2021.
[205] "Projects". Research School of Astronomy and Astrophysics- ANU College of Science. Available at: https://rsaa.anu.edu.au/aitc/projects. Accessed May 2021.
[206] Petkovic, Mike. "The Advanced Instrumentation and Technology Centre". Australian National University. Available at: https://www.acser.unsw.edu.au/sites/acser/files/uploads/cubesat2017/10-MikePetkovic.pdf. Accessed May 2021.
[207] "Astronomy and Space: Our research". CSIRO. Available at: https://www.csiro.au/en/Research/Astronomy. Accessed December 2020.
[208] "Technology and space". CSIRO. Available at: https://www.csiro.au/en/research/technology-space. Accessed May 2021.
[209] Lachlan Colquhoun *et al*. *Australian Space Outlook 2019*. 2019. Faircount Media Group.
[210] Lachlan Colquhoun *et al*. *Australian Space Outlook 2019*. 2019. Faircount Media Group.

Name	Composition	Focus Areas
SmartSat CRC	Led by University of South Australia & Nova Systems Overall, partners 84 industry and research actors (incl. start-ups, confirmed companies, and universities)	Enable advanced communication, Deliver domestically owned smart satellite systems, sensors, and technologies (real-time connectivity, surveillance, land & sea RS, climate monitoring, etc.), Provide next generation EO data services, Create jobs & prevent brain drain, Train and educate university students and promote diversity in STEM fields,
CRC for Space Environment Management	Led by the Space Environment Research Center (SERC)	SSA, Challenges of satellites constellations, Optical tracking and identification of space debris.

Table 9: Australia CRC's overview (Australian space outlook 2019)

Therefore, universities are widely involved in Australia's space developments for scientific, commercial, and defence purposes.

3.3 Policy and legal framework

3.3.1 Space policies and strategy

Australia Satellite Utilisation Policy (ASUP)

Australia's Satellite Utilisation Policy, released 2013, is based on the Principles for a National Space Industry Policy, which were released in 2011: [211]

- Focusing on space applications of national significance,
- Assuring access to space capabilities,
- Strengthening and increase international cooperation,
- Contributing to a stable space environment,
- Improve domestic coordination,
- Support innovation, science, and skills development,
- Protect and enhance national security and economic wellbeing.

The AUSP replaces the Principles for a National Space Industry Policy with a statement of similar objectives: it "does not commit Australia to human spaceflight, domestic launch capabilities or the exploration of other planets. Instead, the policy safeguards interest closer to home, by recognising that space capabilities enhance services Australians depend on and seeking to protect and enhance our access to those capabilities."

Advancing Space – Australian Civil Space Strategy 2019-2028

The Australian Civil Space Strategy 2019-2028 was released in 2019 and outlines Australia's plans to transform the space sector over the next decade in order to diversify the economy, develop international partnerships and national capabilities, ensure the security of the space infrastructure, and generate socio-economic benefits. The strategy will be implemented by ASA in three phases. The first phase aims at setting the conditions for growth over the year 2019 and puts the priority on PNT and Earth observation. The second phase is planned to be implemented from 2019 to 2021 with a strong focus on SATCOM. The third phase is planned to be implemented from 2021 to 2028 with a strong focus on R&D, robotics and autonomation, SSA, and access to space. [212]

The strategy is based on four principles:

- Open doors approach at the international level (leveraging international partnerships and develop the space industry),
- Increase national capabilities (develop the space sector in areas where Australia can have a competitive advantage),
- Promote responsible regulation, risk management and culture (ensure safety and security and apply international norms),
- Inspire and build a future workforce (encourage the youth to pursue careers in STEM and identify required skills for the future workforce).

[211] "Principles for a National Space Industry Policy". 2011. Australian Government. Available at: https://www.spaceindustry.com.au/wp-content/uploads/2019/04/Principles-for-a-National-Space-Industry-Policy.pdf. Accessed May 2021.

[212] Australian Space Agency. "Advancing Space, Australian Civil Space Strategy 2019-2028". 2019. Available at: https://bit.ly/3xIvVPy. Accessed May 2021.

The Australian Civil Space Strategy identifies seven priorities areas.

Figure 15: National Civil Space Priority Areas (adapted from ACSS 2019-28)

2016 Defence White Paper

In February 2016, Australia released three policy documents: The Defence White Paper, The Integrated Investment Program and The Defence Industry Policy Statement.

The 2016 Defence White Paper provides an overview of Australia's defence policy and its assessment of the changing geopolitical landscape as well as potential national security risks for the 20 years. While the Defence White Paper focuses on developments in the Indo-Pacific region, a section is dedicated to cyberspace and outer space, and significant measures regarding space capabilities or the space environment are highlighted.

The 2016 Defence White Paper recognizes that the strategic environment will be shaped by "complex nongeographic threats" in space. It sees offensive space-based capabilities as a threat that will shape the security environment in the near future. The document also recognizes the ADF's dependence on space systems for military operations and notes that the development of counterspace capabilities could threaten the ADF's networks. Moreover, the document acknowledges the fact that space is becoming easily accessible for other countries, private, and non-state actors, which could provide them with sensitive information about Australia's security arrangements and military bases.

In this context, the Defence White Paper outlines that Australia will protect its space-enabled capabilities through increased space situational awareness and increased cooperation with the United States: "the Government will strengthen Defence's space surveillance and situational awareness capabilities, including through the space surveillance radar operated jointly by Australia and the United States, and the relocation of a United States optical space surveillance telescope to Australia."[213]

In terms of capabilities, Australia prioritises upgrading intelligence, surveillance, and reconnaissance (ISR) capacities such as the Jindalee Operational Radar Network. In addition, space situational awareness is a key priority for Australia in order to track and detect objects in space and protect its systems. In this regard, it will keep working with the United States on the "establishment of the space surveillance C-band radar operated jointly by Australia and the United States, and the relocation of a United States optical space surveillance telescope to Australia".[214]

Finally, Australia mostly relies on commercial space-based capabilities for Earth observation and the White Paper. It states that enhanced imagery capacities will provide the basis to develop ISR capabilities in the future. Investments are planned in ISR space-based and ground-based systems.[215]

2020 Defence Strategic Update

In 2020, Australia released the Defense Strategic Update with three new strategic objectives: to shape Australia's strategic environment, to deter actions against Australia's interests, and to respond with credible military force when required.[216]

The Strategic Update was published in a context in which the Indo-Pacific is becoming the centre of economic, political, and military developments, making the region more contested. The Covid-19 pandemic, China's rising ambitions and power, as well as strained relations between the United States and China put Australia at the "centre of a dynamic strategic environment". Indeed, the Strategic Update clearly states that Australia is "in the midst of the most consequential strategic realignment since the Second World War, and trends including military modernisation, technological disruption and the risk of state-on-state conflict are further complicating our nation's strategic circumstances."[217]

In its analysis of the changing environment, Australia views space as a domain under pressure, in which the activities that could lead to casus belli are unclear due to a lack of defined boundaries and norms. Australia also assesses that space capabilities have reduced strategic warning times, that is to say, "the time a country estimates an adversary would need to launch a major attack against it, one the adversary's intent to do so has been established."

The Strategic Update, in line with the 2016 Defence White Paper, further recognizes the key role of space systems for warfighting effectiveness, situational awareness on the battlefield, and real-time communications during military operations.

The Strategic Update indicates that the Government has agreed to invest around seven billion AUD in space capabilities over the next ten years, notably on sovereign communications networks and space situational awareness. To further develop its space capabilities, the Department of Defence will work with industries and government agencies, including the Australian Space Agency.

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[213] "2016 Defence White Paper". 2016. Australian Government Department of Defence. Available at: https://www.defence.gov.au/whitepaper/Docs/2016-Defence-White-Paper.pdf. Accessed May 2021.
[214] *Ibid.*
[215] *Ibid.*
[216] "2020 Defence Strategic Update & 2020 Force Structure Plan". Australian Government Department of Defence. Available at: https://www1.defence.gov.au/strategy-policy/strategic-update-2020. Accessed May 2021.
[217] *Ibid.*

Australia will continue to develop GEOINT capabilities to support "strategic intelligence requirements and support precision guided weapons". While the 2016 Defence White Paper outlined that Australia would keep using commercial providers for imagery, the Strategic Update specifies that Australia will acquire a sovereign space-based imagery capability to improve its coverage of the Indo-Pacific region.[218]

2020 Force Structure Plan (FSP20)

The 2020 Force Structure Plan, released at the same time as the Strategic Update, presents the envisaged investments in defence capabilities until 2040 that would support the three objectives of the Strategic Update. Regarding space, the capability program architecture of the DoD relies on two aspects: space services (providing communications, PNT and GEOINT services) and space control (freedom of operations in space; SSA and SST).

As space is now considered an operational domain, the FSP highlights that Australia will work "closely with the United States and other Combined Space Operations Initiative partners, the Australian Space Agency, and industry to transform the way the ADF operates in space."[219]

Australia plans to develop "options to enhance ADF space control through capabilities to counter emerging space threats to Australia's free use of the space domain and that assure our continued access to space-based intelligence, surveillance and reconnaissance." While the measure could be misinterpreted, nothing indicated that Australia is currently developing counterspace weapons. Capabilities to counter emerging space threats usually rely on SSA capabilities, which is the foundation of "space control" in the FSP. Additionally, the FSP acknowledges that the development of SSA capabilities generates large amounts of data, which could lead to cognitive overload. Therefore, additional investments will be made to increase "the intelligence and supporting workforce" in order to "take advantage of the large volumes of information that will be developed".[220]

Additionally, Australia plans to "include a rolling upgrade program to assure position, navigation and timing information in a contested environment."[221] While nothing is further detailed, it likely refers to threats such as but not limited to jamming and spoofing. Electronic warfare capabilities are also a priority in all domains in both the Strategic Update and the FSP. Investments from 2020 to 2040 are envisaged in the following way:

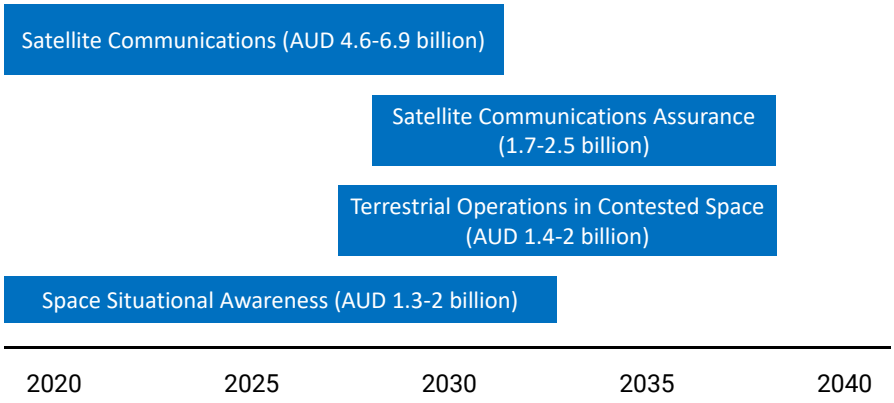

Figure 16: SP Space Investment forecast for the 2020-2040 period

[218] "2020 Defence Strategic Update & 2020 Force Structure Plan". Australian Government Department of Defence. Available at: https://www1.defence.gov.au/strategy-policy/strategic-update-2020. Accessed May 2021.
[219] "Force Structure Plan 2020". 2020. Australian Government Department of Defence. Available at: https://www1.defence.gov.au/sites/default/files/2020-11/2020_Force_Structure_Plan.pdf-. Accessed May 2021.
[220] *Ibid.*
[221] *Ibid.*

3.3.2 Legal and regulatory instruments

Space (Launches and Returns) Act 2018

The Space Act of 2018 repealed the Space Activities Act of 1998 and the Space Activities Regulations of 2001, as well as the Space Activities Guidelines of 2015. The Act aims at reducing the barriers for entry in the space industry and includes high power rockets launches from aircrafts (horizontal launches) in the regulatory framework.[222] The Space Act of 2018 regulates space activities on Australian soil such as launch permits, return authorisation, insurance requirements and liability for damage by space objects and rockets, registration of space objects, and the procedure to follow in case of accident related to space activities. The Space Act of 2018 allows and encourages commercial space activities and implements international obligations discussed at UNOOSA and UNCOPUOS.[223]

1997 Telecommunications Act, 2001 Telecommunications Regulations & 1992 Radiocommunications Act

The 1997 Telecommunications Act is the main legal tool regulating telecommunication services in Australia.[224] The 2001 Telecommunication Regulations contains provisions for service providers, industrial standards, protection of communications, carrier license conditions, etc.[225]

According to the Radiocommunications Act of 1992, the Australian Communications and Media Authority (AMCA) is in charge of allocating and managing radiofrequency spectrum licenses for satellite networks.[226]

AUSSPREDPLAN 2017

The Australian Space Re-entry Debris Plan of 2017 outlines the arrangements and principles to apply in order to manage the re-entry of space debris, which could affect Australia. The management of re-entry is conducted in collaboration with the U.S STRATCOM, JAXA, and the Department of Defence. The DoD provides data to Emergency Management Australia (within the Department of Home Affairs), which will assess the risks and advise the Government on actions to take.[227]

3.3.3 International affairs

International and regional cooperation

One of the Australian Space Agency's missions is to transform the national space industry through strong national and international engagement. International partnerships are a priority in Australia's space policies, providing access to global supply chains and exchange of data.[228]

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[222] Laidlaw, Hunter. *Space Activities Amendment (Launches and Returns) Bill 2018.* 2018. Parliament of Australia. Available at: https://www.aph.gov.au/Parliamentary_Business/Bills_Legislation/bd/bd1819a/19bd015. Accessed May 2021.
[223] *Space (Launches and Returns) Act 2018, No. 123, 1998*. 1998. Federal Registrar of Legislation. Available at: https://www.legislation.gov.au/Details/C2019C00246. Accessed May 2021.
[224] *Telecommunication Act 1997, No. 47, 1997.* 1997. Federal Registrar of Legislation. Available at: https://www.legislation.gov.au/Details/C2019C00104. Accessed May 2021.
[225] *Telecommunications Regulations 2001, Statutory Rules No. 65, 2001.* 2015. Federal Registrar of Legislation. Available at: https://www.legislation.gov.au/Details/F2015C00887. Accessed May 2021.
[226] Radiocommunications Act 1992, No. 174, 1992. 2019. Federal Registrar of Legislation. Available at: https://www.legislation.gov.au/Details/C2019C00262. Accessed May 2021.
[227] "AUSSPREDPLAN 2017- Australian Government Space Re-Entry Debris Plan". 2017. Australian Government. Available at: https://www.homeaffairs.gov.au/emergency/files/plan-space-re-entry-debris.pdf. Accessed May 2021.
[228] ACIL Allen Consulting. "Report to Department of Industry, Innovation of Science, Australian Space Industry Capability". 2017. Available at: https://www.industry.gov.au/sites/default/files/2019-03/australian_space_industry_capability_-_a_review.pdf. Accessed May 2021.

At the diplomatic level, Australia ratified all five space treaties, including the Moon Agreement. Australia is also part to the Nuclear Test Ban Treaty, the Satellite Convention, the Wassenaar Arrangement, the Missile Technology Control Regime, the SKA Construction Treaty, the Treaty on the Non-proliferation of Nuclear Weapons, the ENMOD Convention, the IMSO Agreement, the ITSO Convention, and the ITU Constitution and Convention. Australia is also a member of UNOOSA and UNCOPUOS. Australia recognized the need for rules and norms "to maximise the benefits of greater access to space while tackling challenges such as debris" in its 2017 Foreign Policy White Paper. The paper also recognizes that such norms will be difficult to establish "because of differences in political systems, interests and values".[229]

At the multilateral level, Australia is mostly cooperating with the Five Eyes (the United Kingdom, the United States, Canada, New Zealand). In addition, through the Combined Space Operations Initiative led by the United States, Australia is cooperating with Five Eyes countries, as well as France and Germany on Space Domain Awareness, support to military forces, as well as launch and re-entry assessments.[230] At the regional level, Australia is a member of the Asia-Pacific Regional Space Agency Forum (APRSAF).

At the bilateral level, Australia's most important partner is the United States for both international affairs at large and space affairs. For instance, Australia is cooperating with the U.S. Department of Defense for SSA data sharing, with the U.S. Geological Survey on the Landsat EO Programme, and with NOAA on the COSMIC-2 program by hosting a ground station near Darwin, etc.[231] Australia's partnership with NASA covers many activity areas such as deep space missions and the management of geodetic infrastructures (jointly operate a SLR station at Yarragadee, Western Australia).[232] In 2019, ASA and NASA signed a Letter of Intent for Australia to join in on Moon and Mars missions by providing its expertise in fields such as robotics, automation, and remote asset management. Additionally, Australia signed the Artemis Accords in 2020.[233] Australia also signed arrangements with ESA, CNES, UKSA, DLR, the New Zealand Space Agency, and the Italian Space Agency.[234] Australia also cooperates with China by hosting ground stations of the Fengyun-2 satellite.[235]

[229] "2017 Foreign Policy White Paper". 2017. Australian Government. Available at: https://www.dfat.gov.au/publications/minisite/2017-foreign-policy-white-paper/fpwhitepaper/pdf/2017-foreign-policy-white-paper.pdf. Accessed May 2021.
[230] "Combined Space Operations Initiative Welcomes France and Germany". 2020. *SpaceWatch Europe*. Available at: https://spacewatch.global/2020/02/combined-space-operations-initiative-welcomes-france-and-germany/. Accessed May 2021.
[231] Australian Government State of Space Coordination Committee. "2017 State of Space Report." 2017. Available at: https://www.industry.gov.au/sites/default/files/June%202018/document/pdf/state_of_space_report_2017.pdf?acsf_files_redirect Accessed May 2021.
[232] *Ibid*.
[233] Davis, Malcolm. "Commitment to Artemis Accords affirms Australia's rising star in space". 2021. Australian Strategic Policy Institute. Available at: https://www.aspistrategist.org.au/commitment-to-artemis-accords-affirms-australias-rising-star-in-space/. Accessed May 2021.
[234] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[235] Bala, Sumathi. "No Prospects for China-Australia relations to get back on track soon, political analyst says". 2021. CNBC. Available at: https://www.cnbc.com/2021/05/07/china-australia-relations-wont-be-back-on-track-soon-political-analyst.html. Accessed May 2021.

Figure 17: Australia international cooperation

International and regional competition

According to Malcolm Davis, Senior Analyst in Defence Strategy and Capability at the Australian Strategic Policy Institute, while Australia used to see space as a peaceful global common, geopolitical developments in the region push Australia to develop its own space capabilities and reconsider space as a warfighting domain.[236]

Indeed, the epicentre of international relations is now shifting to the Indo-Pacific with several geopolitical dynamics that affect Australia's strategic environment.[237] Geopolitical evolutions in the region must be seen against a context in which, the rising power (China) is challenging the established power (the United States), which redefines the balance of power and could lead to increased tensions (Thucydides' Trap theory).[238] [239]In this context, the strained relations between the U.S and China also overlap with regional rivalries or local crises, which can have spill-over effects in the entire region (e.g., South China Sea, Hong Kong, North Korea, India-Pakistan, etc). Due to its geographic position, its economic and political ties with both China and the United States, Australia stands in the middle of these developments. On top of these developments, space powers are developing capabilities that can disrupt Australian or allied space

[236] Davis, Malcolm. Australia confronts a contested space domain and a rising China. China Aerospace Studies Institutes. 2020 CASI Conference. Available at: https://bit.ly/3oY5PPv. Accessed May 2021.
[237] Australia in the Asian Century White Paper". 2012. Australian Government. Available at: https://www.defence.gov.au/whitepaper/2013/docs/australia_in_the_asian_century_white_paper.pdf. Accessed May 2021.
[238] Graham, Allison. Destined for War: can America and China escape Thucydides's Trap? 2017. Mariner Books.
[239] POLIS 7004 - International Relations in the Indo-Pacific Region. University of Adelaide. https://www.adelaide.edu.au/course-outlines/109608/1/sem-1/2020/

systems, which is seen as a threat in the 2017 Foreign Policy White Paper.[240] According to Malcolm Davis, Australia is developing its space capabilities and is shifting its view of space as a warfighting domain due to China's military and space capability build-up, including counterspace weapons.[241]

To mitigate these risks, Australia is seeking regional partners in the region with similar interests such as India or Japan. Beyond space affairs, the 2020 Strategic Update focuses mainly on the Indo-Pacific region due to these recent developments. Additionally, Australia, Japan, India, and the United States are meeting through the Quadrilateral Security Dialogue (the Quad), which was established in 2004. The Quad is a multilateral initiative, which aims at soft balancing and contain China through cooperation and joint military exercises. After an eight-year break, the Quad reconvened in 2017 in light of China's ambitions and behaviour.[242] According to John Blaxland and Ashok Sharma from the Australian National University, "Additional collaboration (within quad) can be expected in the cyber, space, and maritime domains to enhance surveillance and deterrence".[243] Australia has recently declared its willingness to increase collaboration within Quad amid worsening relations with China.[244]

[240] "2017 Foreign Policy White Paper". 2017. Australian Government. Available at: https://www.dfat.gov.au/publications/minisite/2017-foreign-policy-white-paper/fpwhitepaper/pdf/2017-foreign-policy-white-paper.pdf. Accessed May 2021.
[241] Davis, Malcolm. Australia confronts a contested space domain and a rising China. China Aerospace Studies Institutes. 2020 CASI Conference. Available at: https://bit.ly/3oY5PPv. Accessed May 2021.
[242] Buchan, Patrick Gerard; Rimland, Benjamin. "Defining the Diamond: The Past, Present, and Future of the Quadrilateral Security Dialogue". 2020. Center for Strategic & International Studies. Available at: https://www.csis.org/analysis/defining-diamond-past-present-and-future-quadrilateral-security-dialogue. Accessed May 2021.
[243] Blaxland, John; Sharma, Ashok. "Bolstering the Quad beyond its military dimensions" 2021. EastAsiaForum. Available at: https://www.eastasiaforum.org/2021/04/30/bolstering-the-quad-beyond-its-military-dimensions/. Accessed May 2021.
[244] "US, Australia looking forward to doing more through QUAD collaboration". 2021. Daily Excelsior. Available at: https://www.dailyexcelsior.com/us-australia-looking-forward-to-doing-more-through-quad-collaboration/. Accessed May 2021.

3.4 Programmes and infrastructure

3.4.1 Resources and infrastructure

In 2019, the government allocated AUD 73.2 million to develop the Australian space sector (without taking defence spending into account). This budget consisted of AUD 47.7 million to establish the Australian Space Agency and AUD 6 million for the Space Discovery Centre.[245] Australia's defence budget accounts for AUD 44.62 billion, including AUD 7 billion on space.[246] [247]

The International Space Investment Initiative (ISI) is an AUD 15 million commitment as part of the 2018-2019 national budget for the 2019-2020 period to develop the space industry and international space projects that generate socio-economic benefits.[248]

The Space Infrastructure Fund (SIF) is an AUD 19.5 million investment fund established as part of the 2019-2020 national budget to develop the Australian space sector. The main objectives are socio-economic, namely creating 20,000 jobs and tripling the size of the space sector by 2030. The SIF targets several projects related to:

- Robotics, automation, AI, and Command and control,
- Space data analysis facilities,
- Mission Control facilities,
- Tracking facilities upgrade,
- Space manufacturing capability,
- Space payload qualification facilities,
- Growing readiness in industry for launch from Australian soil.[249]

The announced budget of the Australian Space Agency for the 2020-2021 period is AUD 3.405 million. Similar budgets have been announced for the 2021-2022, 2022-2023, and 2023-2024 periods.[250] In May 2021, the Government announced it will provide the Australian Space Agency with additional funding accounting for AUD 13.3 million as part of the Covid-19 economic recovery plan.[251]

Space Infrastructure

Overall, Australia has 20 satellites in orbit, mostly in the field of telecommunications. Australia does not have EO satellites and mainly relies on commercial and/or foreign space systems. The strength of its

[245] The Hon Karen Andrews MP, "Budget 2019-20 - Further boost for Australian jobs and the economy. 2019. Department of Industry Available at: "https://www.minister.industry.gov.au/ministers/karenandrews/media-releases/budget-2019-20-further-boost-australian-jobs-and-economy. Accessed May 2021.
[246] Ziesing, Katherine. "2021 Defence Budget at a glance". 2021. Australian Defence Magazine. Available at: https://www.australiandefence.com.au/news/2021-defence-budget-at-a-glance. Accessed May 2021.
[247] "Shape. Deter. Respond". 2020. Australian Government- Department of Defence. Available at: https://www.defence.gov.au/StrategicUpdate-2020/docs/Factsheet_Space.pdf. Accessed May 2021.
[248] "International Space Investment Initiative: design consultation". Australian Government- Department of Industry, Science, Energy and Resources". Available at: https://consult.industry.gov.au/space/international-space-investment-initiative-design/. Accessed May 2021.
[249] "Supporting space infrastructure growth". Australian Government- Department of Industry, Science, Energy and Resources. Available at: https://www.industry.gov.au/funding-and-incentives/supporting-space-infrastructure-growth. Accessed May 2021.
[250] "Budget 2021-2022, Budget Related Paper No. 19". 2019. Department of Industry, Science, Energy and Resources". Available at: https://www.industry.gov.au/sites/default/files/2021-05/2021-22-department-of-industry-science-energy-and-resources-pbs.pdf. Accessed May 2021.
[251] "Budget boost to manufacturing to secure Australia's recovery". 2021. Ministry for Industry, Science and Technology. Available at: https://www.minister.industry.gov.au/ministers/porter/media-releases/budget-boost-manufacturing-secure-australias-recovery. Accessed May 2021.

space infrastructure mostly relies on the ground segment as it hosts many national and international ground stations, as well as telescopes.

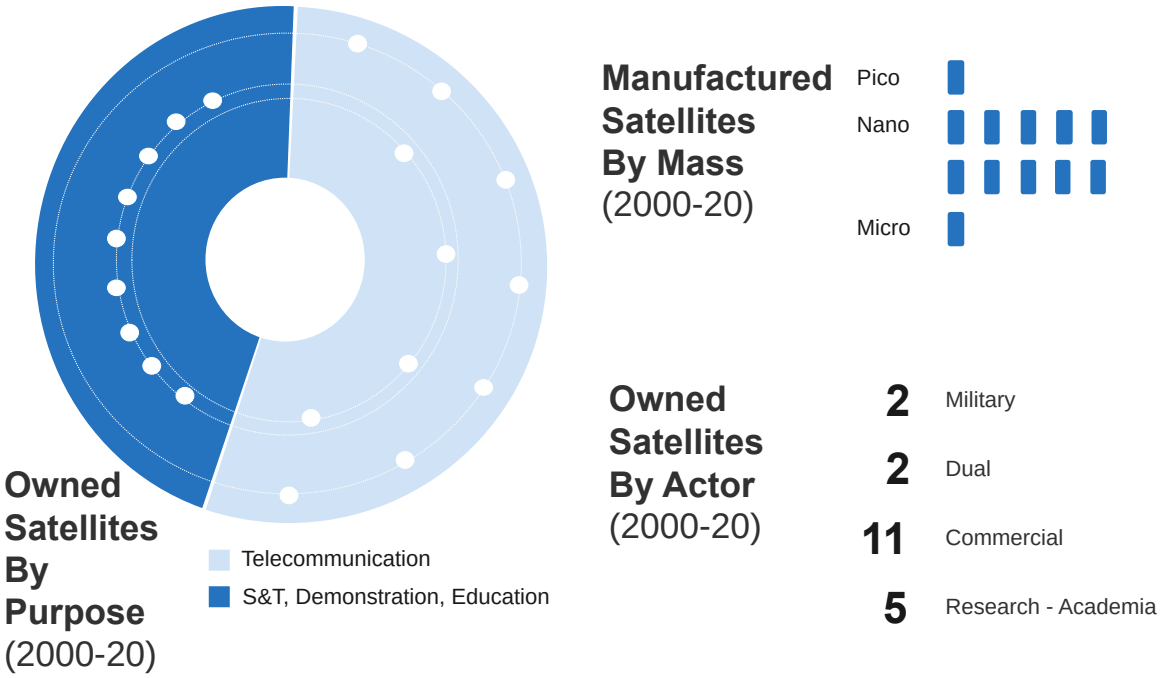

Figure 18: Australia's space infrastructure overview

3.4.2 Space programmes and activity

Telecommunications

Telecommunication satellites in Australia are mainly focused on providing broadband and broadcasting services, especially in remote and rural areas. Recently, the nation has started to work on developing connectivity for IoT networks through missions such as Proxima and Centauri.

These satellites provide several services, such as, but not limited to:

- NBN Co Sky Muster satellite services, which provide access to fast broadband to over 400,000 homes and businesses, predominantly in rural and remote Australia. As of 2019, more than 95,000 homes and businesses had an active NBN Co Sky Muster satellite service,
- Viewer Access Satellite Television Service (VAST) provides free-to-air television and radio broadcasts to more than 500,000 viewers, plus 30,000 travellers, mostly in regional and remote areas,
- Universal Service Guarantee (UGS), which gives access to broadband and voice services in premises across the country through the National Broadband Network).[252]

The Department of Defence does not have sovereign SATCOM capabilities and is therefore looking to launch a constellation of around four GEO satellites that covers the Australian territory.[253] However, the representative of Airbus Defence and Space for Australia outlined that it could take between three to five years to develop and deploy such a system.

[252] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[253] Lachlan Colquhoun *et al. Australian Space Outlook 2019*. 2019. Faircount Media Group.

Earth Observation

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit& Mass	Customer	Purpose
Optus C1	Mitsubishi Electric	Arianespace	2003	GEO, 4800 kg	Optus, ADF	Military & commercial communication.
Optus D1	Orbital ATK	Arianespace	2006	GEO, 2300 kg	Optus	Fixed communication & TV broadcast. Ku-band.
Optus D2 & D3	Orbital ATK	Arianespace	2007, 2009	GEO, 2500 kg	Optus	Fixed communication & direct TV broadcast.
Optus 10	Maxar, Space Systems Loral	Arianespace	2014	GEO, 3270 kg	Optus	Broadcast & two-way voice and data communication.
NBN Co 1A & 1B	Maxar, Space Systems Loral	Arianespace	2015, 2016	GEO, 6500 kg	NBN Co	High-speed broadband. Ka-band.
Proxima 1 & 2	Fleet Space, Pumpkin Inc	Rocket Lab	2018	LEO, 2 kg	Fleet Space	Pathfinder for planned global connectivity to IoT network.
Centauri 1 & 2	Fleet Space	ISRO & SpaceX	2018	LEO, 4 kg	Fleet Space	Pathfinder for planned global connectivity to IoT network.

Table 10: Australia telecommunication satellites

Australia does not have Earth observation satellites and mostly relies on commercial and foreign assets for acquiring satellite imagery. Therefore, in the field of Earth observation, Australia is mostly focused on

developing services and applications (e.g., Bushfire Earth Observation Taskforce; EO-derived products generated by the Bureau of Meteorology; Digital Earth Australia for climate monitoring, etc). [254] [255]

Positioning, Navigation, Timing

Australia does not possess its own GNSS, nonetheless funding is allocated to PNT infrastructures and downstream application. Navigation data mostly come from the U.S. GPS, but Australia also uses data from Galileo, Glonass, Beidou, QZSS, and IRNSS.[256]

According to the Department of Industry's Space Report of 2019, the Bureau of Meteorology monitors the potential disruptions to PNT services caused by space weather. The DoD is conducting a project that aims to harden GPS user terminals to avoid jamming and spoofing, but also to identify alternatives to GPS capabilities in case they are disrupted or unavailable. Airservices, CASA, and Geospatial Australia are cooperating to acquire the Southern Positioning Augmentation Network (a satellite-based augmentation system) in order to improve PNT services for the air and maritime sectors. In addition, Geospatial Australia is establishing the National Positioning Infrastructure Capability (NPIC) and a Satellite-Based Augmentation System (SBAS), which will consist of 200 ground stations in Australia.[257]

Science, Technology, and Education

Australia has small LEO satellites for S&T demonstration and education purposes. Mostly developed by Australian research institutions and launched by U.S. launch services providers, these satellites are intended to test new technologies for civil and defence purposes and to lead scientific research. While Australia does not have EO satellites, the South Australian start-up Inovor Technologies is developing EO CubeSat CSIROSat-1, which will be acquired by CSIRO. The CubeSat is built for scientific purposes and will demonstrate advanced on-board data processing capabilities.[258] [259]

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit & Mass	Customer	Purpose
FedSat 1	Satellite System CRC	Mitsubishi Heavy Industries	2002	LEO, 58 kg	Satellite System CRC	Test satellite computing and positioning technologies, and communication.
Buccaneer RMM	UNSW, Pumpkin Inc, DST	ULA	2017	LEO, 4 kg	UNSW, DST	Calibrate measurements for JORN to locate target.
i-INSPIRE 2	Sydney University, UNSW	ULA	2017	LEO, 2 kg	Sydney University	Thermospheric research. Capacity building

[254] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[255] *Ibid.*
[256] Expert Reference Group for Review. "Review of Australia's Space Industry Capability". 2018. Available at: https://bit.ly/3bWXN4o. Accessed May 2021.
[257] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[258] *Ibid.*
[259] "CSIROSat-1 CubeSat" CSIRO. Available at: https://research.csiro.au/cceo/underpinning-technologies/csirosat-1-cubesat/. Accessed May 2021.

SUSat	Adelaide University	ULA	2017	LEO, 2 kg	Adelaide University	Gather science data in upper atmosphere. Radiocommunication tests.
UNSW-ECO	UNSW	ULA	2017	LEO, 2 kg	UNSW	Technology. Thermospheric research.
RAAF M1	UNSW	SpaceX	2018	LEO, 4 kg	RAAF	Test SSA capabilities, communication, surveillance.
Sirion Pathfinder 2	Astro Digital	SpaceX	2018	LEO, 12 kg	Sirion Global	Demonstrate IoT and Helios Wire's communication constellation.
ACRUX 1	Melbourne Space Programme	Rocket Lab	2019	LEO, 1 kg	Melbourne Space Programme	Provide students with the opportunity to develop Cubesats.
RAAF M2 Pathfinder	UNSW	Rocket Lab	2020	LEO, 4 kg	RAAF	Test sensors and payloads for space-based MDA.

Table 11: Australia S&T, education satellites (ESPI database)

Space transportation

Whilst Australia does not have orbital launching capacities, it supports private actors seeking to provide commercial launch services from its territory. The state's policy and investment efforts currently aim at creating the conditions for conducting orbital launches from Australian soil. To this end, launch sites are being developed in Abbot Point (North Queensland), Nhulunbuy (Northern Territory), and at Whalers Way Orbital Launch Complex (Eyre Peninsula). The country enjoys an ideal geographic situation that would enable competitive commercial access to space, with latitudes allowing both equatorial and polar launches.[260]

In addition, ASA signed a Statement of Strategic Intent and Cooperation with Gilmour Space, the first Australian company to test a privately developed hybrid rocket in 2016.[261] Glimour Space obtained authorization from the Queensland government to build a small rocket launch pad in Abbot Point to launch satellites in LEO.[262] Southern Launch, in partnership with the RAAF, DEWC Systems, and T-minus engineering conducted the first sub-orbital launch of the TED-01 DART rocket, carrying a military payload from the Koonibba Test Range in South Australia.[263]

Commercial launch companies include Black Sky Aerospace, Equatorial Launch Australia, Hypersonix, Southern Launch, and Gilmour Space. These companies are mainly focused on the development of micro-launchers targeting both national and foreign demand. An overview of the launch capabilities being developed by these companies is provided below.

[260] Lachlan Colquhoun *et al.*, *Australian Space Outlook 2019*, 2019. Faircount Media Group (2019).
[261] "We Build Rockets: About". Gilmour Space. Available at: https://www.gspacetech.com/about.. Accessed December 2020.
[262] Kwan, Campbell. "Queensland approves new small rocket launch site at Abbot Point". *ZDNet*. Available at: https://www.zdnet.com/article/queensland-to-build-small-rocket-launch-site-at-abbot-point/. Accessed May 2021.
263 Kuper, Stephen. "Lift-off for Australia's first commercial space capable rocket". 2020. Space Connect. Available at: https://www.spaceconnectonline.com.au/launch/4536-lift-off-for-australia-s-first-commercial-space-capable-rocket. Accessed May 2021.

Launch Vehicle	Manufacturer	Characteristics	Performance (kg)	Launch Year	Launch site
DART	Southern Launch	3.4m h Sub-orbital 2 stages	Miniature payloads, 500gr up to 85 km	2020 (Success)	Koonibba Test Range, South Australia
ERIS	Gilmour	30 m h Orbital 3 stages	Up to 305 kg in LEO (500 kg SSO)	2022	Abbot Point, North Queensland
Sighter 190	Black Sky	4 m h Sub-orbital	Reached altitude of 17000 feet	N/A	Westmar, Queensland
AUSRO C Nano	ASRI	120m h Orbital 3 stages Liquid fuel	10 kg to LEO (300 km)	N/A	Can be transported and launched from any facility

Table 12: Launch capabilities under development (ESPI database)

SSA

Space Situational Awareness is a cornerstone of Australia's space capabilities and a policy priority for both the Australian Space Agency and the Department of Defence. Additionally, the Space Act of 2018 requires a debris mitigation strategy to obtain an authorisation to launch or operate some space systems.[264]

Australia's geographic position in the southern hemisphere provides ideal conditions for hosting ground stations, telescopes, and radars for SSA purposes. This unique location enabled Australia to sign international cooperation agreements and partnerships with foreign space agencies to host their antennas and benefit from data-sharing agreements. Australia hosts several foreign antennas such as the European Space Agency's New Norcia Deep Space Antenna near Perth,[265] NASA's Canberra Deep Space Communication Complex,[266] the U.S. C-Band Space Surveillance Radar System, the U.S. Space Surveillance telescope at the Harold E. Holt Naval Communication Station in Western Australia,[267] and the U.S. Air Force Academy's Falcon telescope in Canberra.[268]

[264] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[265] European Space Agency. "ESA to build second deep space dish in Australia". 2021. PhysOrg. Available at: https://phys.org/news/2021-04-esa-deep-space-dish-australia.html. Accessed May 2021.
[266] "Deep Space Network: Canberra Deep Space Communication Complex". NASA. Available at: https://www.cdscc.nasa.gov. Accessed May 2021.
[267] Kelly, Finian. "C-Band (Holt) Radar: One Year On". 2018. Air Force Space Command (Archived). Available at: https://www.afspc.af.mil/News/Article-Display/Article/1457949/c-band-holt-radar-one-year-on/. Accessed May 2021.
[268] "Falcon Telescope". UNSW Canberra. Available at: https://unsw.adfa.edu.au/our-research/facilities/falcon-telescope. Accessed May 2021.

Australia has its own SSA infrastructure, either developed nationally or in partnership with international consortiums or groups such as Raven telescopes in Exmouth, DST telescopes in Adelaide, and Murchison Widefield Array (MWA) at the Murchison Radio-astronomy Observatory (MRO) in Western Australia.

Various governmental entities are involved in SSA activities:

- The Bureau of Meteorology monitors the Earth's ionosphere, which contributes to SSA data for LEO. The Bureau is also advising the Australian Space Agency's Technical Advisory Group for SSA by providing expertise on space weather.
- CSIRO is tracking asteroids through the Canberra Deep Space Communication Complex (CDSCC) and the Compact Array and Parkes radio telescopes. The data contributes to the NASA Near Earth Asteroid Program.
- GeoScience Australia operates the national Satellite Laser Ranging Network, which has ground stations at Mount Stromlo and Yarragadee. The data contributes to the International Laser Ranging Service (ILRS).

  Department of Defence jointly established a C-band space surveillance radar at the Harold E. Holt Naval Communications Station with the U.S. It also hosts the Space Surveillance Telescope of the U.S. Space Force.[269]

Moreover, SSA is a key aspect of Australia's space defence policies. SSA was already a priority in the Defence White Paper of 2009.[270] It is considered a key component of "space control" in the 2020 Force Structure Plan. According to Malcom Davis, the Strategic Update acknowledges that space is a contested and congested domain and SSA is viewed as a way to mitigate threats coming from counterspace weapons, as well as space debris.[271]

As a result, the DoD plans to upgrade current capabilities and acquire new ones. Indeed, the 2016 Defence White Paper outlined that "the Government will upgrade facilities at the Harold E. Holt Communications Facility in Exmouth, Western Australia to support our enhanced space situational awareness and communications capabilities and will similarly upgrade the Jindalee Operational Radar Network and other surveillance and air-defence related facilities in northern Australia over the next decade."[272] In addition, the 2016 Integrated Investment Program states that "Australia's existing space situational awareness capability relies on access to comprehensive United States-sourced and processed space situational awareness information. Existing arrangements will be strengthened through the re-location of the C-band radar and optical space surveillance telescope to Australia, enhancing our access to space situational awareness information. Defence will also examine other ground-based sensors, including radar and optical systems, to develop options for expanding Australia's space situational awareness sensor coverage in the future."[273] To this end, the DoD launched several dedicated projects. The JP 9350 and JP 9351 projects aims at providing a sovereign SSA Mission System as well as SSA sensors produced by Australian industries. The JP 9360 aims at providing the DoD with a sovereign SDA capability by investing

[269] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[270] "Australia- United States Space Situational Awareness Partnership AUSMIN 2010". Australian Government- Department of Foreign Affairs and Trade. Available at: https://www.dfat.gov.au/geo/united-states-of-america/ausmin/Pages/australia-united-states-space-situational-awareness-partnership. Accessed May 2021.
[271] Davis, Malcolm. Australia confronts a contested space domain and a rising China. China Aerospace Studies Institutes. 2020 CASI Conference. Available at: https://bit.ly/3oY5PPv. Accessed May 2021.
[272] 2016 Defence White Paper". 2016. Australian Government Department of Defence. Available at: https://www.defence.gov.au/whitepaper/Docs/2016-Defence-White-Paper.pdf. Accessed May 2021.
[273] "2016 Integrated Investment Program". 2016. Australian Government Department of Defence. Available at: https://www.defence.gov.au/WhitePaper/Docs/2016-Defence-Integrated-Investment-Program.pdf. Accessed May 2021.

in command and control systems, as well as sensors.[274] The 2016 Integrated Investment Program allocated an investment of up to AUD 2 billion in SSA capabilities.

Furthermore, non-governmental entities are also contributing to the improvement of national SSA capabilities. For instance, the Space Environment Research Centre (a CRC project) is developing technologies for space debris management and space sustainability through four programmes: Identification of Space Objects and Preservation of the Space Environment (1), Orbit Determination and Predicting Behaviours of Space Objects (2), Space Asset Management (3), and Space Segment (4).[275] Additionally, in 2017, Curtin University and Lockheed Martin signed an agreement to conduct joint R&D and establish an SSA network in Australia. The goal is to adapt meteorite tracking technologies already developed by Curtin University to track satellites and large debris. The project, FireOPAL, will provide additional SSA data to Australian institutions.[276]

Finally, Australia is developing space based SSA capabilities. For instance, the company HEO Robotics is developing in-orbit satellite inspection services. HEO Robotics established agreements with several partner satellites equipped with on-board cameras, which have downloaded HEO Robotics' software. The partner satellite can conduct in-orbit operations around a target satellite and HEO Robotics can directly access the data to provide identification and verification, deployable check, and damage assessment services to satellite companies.[277] In addition, the start-up Inovor Technologies is also developing space-based SSA capabilities through the Hyperion mission, a constellation of 12 nanosatellites in LEO observing MEO and GEO.[278] These services can therefore provide additional information on satellites in orbit as well as the space environment.

[274] Australian Government Space Coordination Committee. "State of Space Report". 2018-2019. Australian Government and Australian Space Agency. Available at: https://www.industry.gov.au/sites/default/files/2020-05/state-of-space-report-2018-19.pdf. Accessed May 2021.
[275] "Research Programs". Space Environment Research Centre. Available at: https://www.serc.org.au/research/. Accessed May 2021.
[276] "Industry". Space Science and Technology Centre, Curtin University. Available at: https://www.serc.org.au/research/. Accessed December 2020.
[277] "HEO Inspect: World's First On-orbit Satellite Inspection Service". High Earth Orbit Robotics. Available at: https://www.heo-robotics.com/inspect. Accessed May 2021.
[278] "Inovor Technologies". South Australian Space Industry Centre. Available at: https://sasic.sa.gov.au/industry/industry-success-stories/inovor-technologies-pty-ltd/. Accessed May 2021.

3.5 Key takeaways

3.5.1 Australia's space ambitions

Australia's space efforts are driven by several goals, which have different implications. The most important drivers are defence, industrial development, and socio-economic benefits.

First, defence has always been an important component of the Australian space programme and continues to retain a key role today. In light of the development of counterspace weapons by other spacefaring nations, as well as rising tensions in the Asia Pacific, Australia now views space as a congested and contested domain in which its space systems could be disrupted. Australia's perception of space evolved from being a shared global common to a warfighting domain. To counter these threats, Australia seeks to develop sovereign space capabilities, particularly in SSA and SST and committed to an AUD 7 billion investment in developing space capabilities. It is also strengthening cooperation with allies, both in the Indo-Pacific region, and within the Five Eyes. These goals and perceptions are clearly outlined in the 2017 Foreign Policy White Paper, the 2016 Defence White Paper, the 2020 Strategic Update, and the 2020 Force Structure Plan.

Furthermore, this geopolitical context creates opportunities to develop the space industry. Industrial development and economic growth are key drivers for pursuing space activities in Australia. Investments in defence capabilities contribute to the development of the space industry, as well as the strengthening of the defence industrial base. In addition, ASA's main priority is to triple the size of the space industry to AUD 10-12 billion a year and create 20,000 jobs by 2030.

Beyond industrial considerations, Australia is looking to generate socio-economic benefits from its space activities. The civil space strategy 2019–2028 aims at developing the space industry through international partnerships, increasing national capabilities in areas where Australia can have a competitive advantage, and encouraging the youth to pursue careers in STEM. Space is viewed as a sector that can diversify the economy, have spill over effects in other areas of the economy, foster innovation, and create jobs.

Finally, although Australia is very well positioned in the Global Soft Power Index 2021 (ranked 10th out of 100 countries)[279] and soft power is a goal of its 2017 Foreign Policy White Paper, it is rarely mentioned in space policies. Still, it is one of the responsibilities of ASA to "inspire and build a future workforce", build national pride, and effectively communicate to the Australian people the "expanding role of space in the nation's economy, security, safety as well as living standards".[280]

3.5.2 Key achievements and developments

Since the 1960s, Australia has developed its space activities and reached key milestones, making it an emerging spacefaring nation.

Politics

Australia signed all international space agreements, including the Moon Agreement. At the international level, it is active in international forums and takes part in UNOOSA and UNCOPUOS. It often advocates for international rules and norms in outer space.

[279] "Global Soft Power Index". 2021. BrandFinance. Available at: https://brandirectory.com/globalsoftpower/download/brand-finance-global-soft-power-index-2021.pdf. Accessed May 2021.
[280] Expert Reference Group for Review. "Review of Australia's Space Industry Capability". 2018. Available at: https://bit.ly/3bWXN4o. Accessed May 2021.

At the bilateral level, Australia has been developing its strategic partnership with the United States. Australia relies on the U.S. for accessing several key systems (space-track, GPS, Earth observation, etc.). It is also taking part in U.S. projects as a way to develop its industry and know-how. Australia signed numerous cooperation agreements and partnerships with foreign space agencies and international organisations.

At the national level, Australia established its space agency in 2018. It developed several policies such as the Satellite Utilisation Policy and the Civil Space Strategy. Defence policies also increasingly tackle space issues (e.g., 2016 Defence White Paper, 2020 Strategic Update, etc). It remains to be seen whether the DoD will release a space defence strategy. Regions have also established their own space strategies such as the Queensland Aerospace 10-Year Roadmap and Action Plan, which aims at developing the local space economy.[281] In addition, laws have been adopted and updated to comply with international agreements and foster space activities on Australian soil.

The national space ecosystem also relies on entities which provide training and education, technical expertise, and enable scientific research such as CSIRO, UNSW Canberra Space, InSpace, and the Advanced Instrumentation and Technology Centre at the Australian National University. Several key missions have resulted from partnerships between universities and the DoD.

Therefore, Australia recently developed a comprehensive policy and legal framework to enable and regulate space activities and established national institutions to implement the country's objectives.

Programmes

Several aspects give Australia a competitive advantage, notably its geographic location in the southern hemisphere, which makes it an ideal area for positioning ground stations or antennas for SSA, as well as for launching satellites.[282] This aspect enabled Australia to develop capabilities and know-how in SSA and build key partnerships with foreign space agencies and companies to host their ground stations and telescopes.

Australia launched its first satellites in 1967, making it the seventh nation to have a satellite in orbit. Since then, Australia has developed competitive and mature capabilities in the field of telecommunications with commercial satellites in GEO and the creation of related services.

While Australia does not have launching capacities, several spaceports are being developed in Abbot Point (North Queensland), Nhulunbuy (Northern Territory), and at Whalers Way Orbital Launch Complex (Eyre Peninsula). Only tests and sub-orbital launches have been conducted so far. Several companies are seeking to develop Australian rockets to launch satellites from Australia.

At the moment, Australia does not have neither sovereign EO systems, nor a GNSS constellation. It relies on foreign and commercial systems for procuring satellite imagery and PNT services. However, Australia's space policy has evolved from reliance on foreign assets to a willingness to develop its own space capabilities. Australia seeks to build on its strengths to develop capabilities in areas such as communications, SSA, EO applications and data services, miniaturised technologies, scientific research in planetary science, astronomy, and robotics.

[281] Advance Queensland. "Queensland Aerospace 10-Year Roadmap and Action Plan". Department of State Development, Manufacturing, Infrastructure and Planning. Available at: https://www.statedevelopment.qld.gov.au/__data/assets/pdf_file/0014/17231/aerospace-roadmap.pdf. Accessed May 2021.
[282] ACIL Allen Consulting. "Report to Department of Industry, Innovation of Science, Australian Space Industry Capability". 2017. Available at: https://www.industry.gov.au/sites/default/files/2019-03/australian_space_industry_capability_-_a_review.pdf. Accessed May 2021.

4 ARGENTINA

4.1 National space history

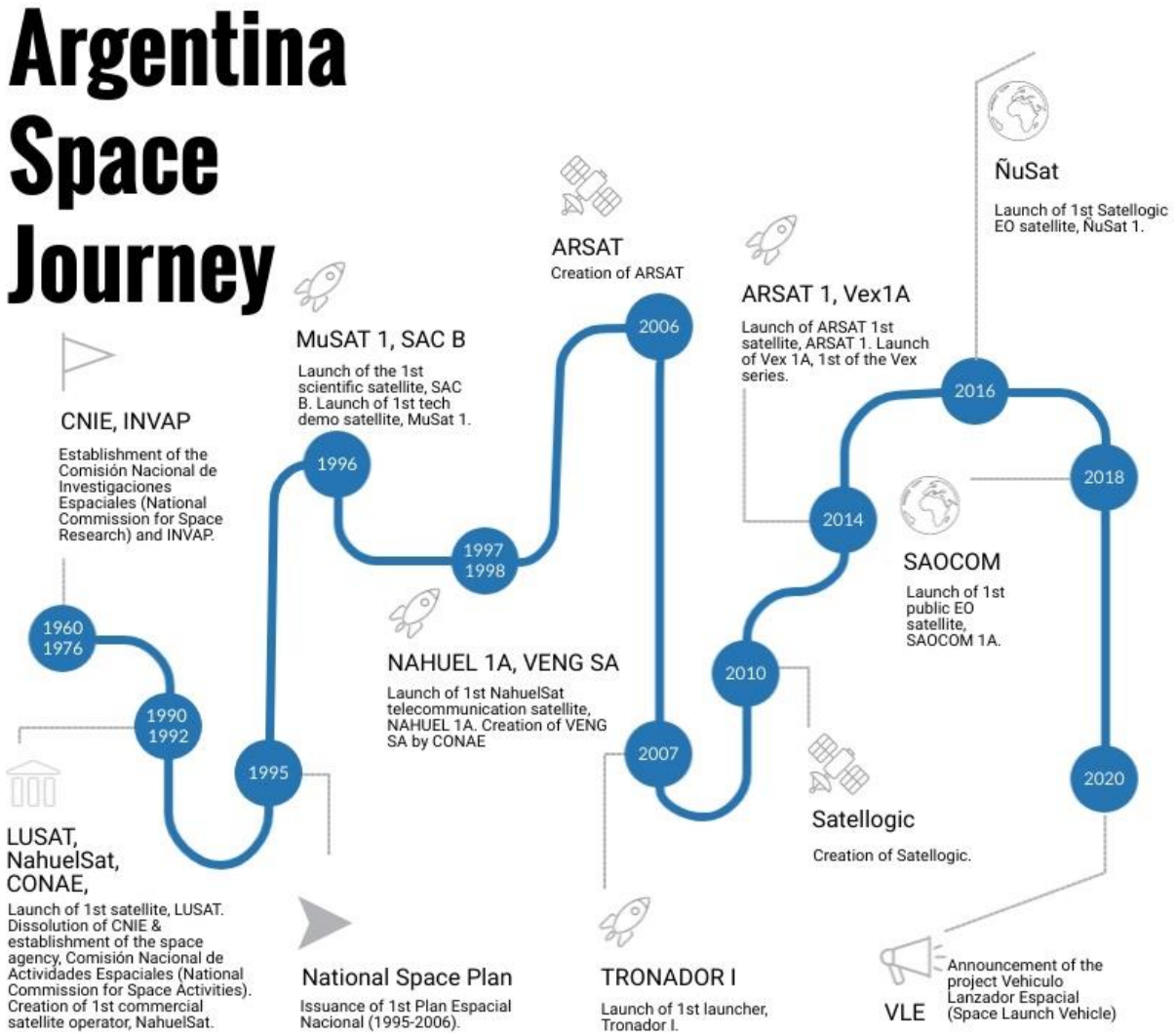

Figure 19: Timeline of Argentina space journey

Argentina's space journey first began with liquid rocket engine research in the 1950s and sounding rocket developments in the 1960s. Space developments were mostly related to defence and security interests, in particular Argentina's ballistic missile program.

Indeed, in 1961, the first space-related institution, named the National Commission for Space Research (CNIE), was established under the authority of the Air Force. Then, the Aeronautical and Space Research Institute, which was part of the Military Aircraft Factory developed sounding rockets (e.g. Orion, Canopus, Castor).[283]

[283] "Antecedentes". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/institucional/antecedentes. Accessed May 2021.

In 1965, Argentina launched the Gamma Centauro rocket from the Matienzo base in Antarctica in order to measure temperature and X radiation in the upper atmosphere.[284] In 1966, Argentina also launched its Orion II rocket from Antarctica.[285] In the 1970s, Argentina developed the Condor I missile due to border disputes with Chile and the United Kingdom.[286] After Argentina's defeat in the Falklands War, the Condor I missile proved to have limited capability, which led Argentina to further developed its ballistic missiles with the Condor II program.[287] [288]

However, under U.S. pressure, the program was dismantled due to concerns that Argentina was exporting missiles and space-based technologies to Egypt and Iraq. This led Argentina to stop its rocket developments and completely change the direction of its space program and focus mostly on civil activities. As a result, the National Space Activities Commission (CONAE) was created in 1991. When the Kirchners came to power in the early 2000s, some space developments were once again linked to the Ministry of Defence.[289] [290]

4.2 Space sector governance

4.2.1 Institutional framework

Different governmental entities are responsible for the conduct of space activities. Their involvement is summarized in the table below.

Entity	Involvement in space
National Space Activities Commission (CONAE)	Argentinian Space Agency. Coordinates civil space activities, proposes, and implements national space policy
Ministry of Science, Technology, and Innovation (MINCYT)	Disseminates information on national ventures in space-related projects.
Interinstitutional Council for Science and Technology (CICYT)	Coordinates common national S&T policies and reinforces linkages with the socio-economic sector. Composed amongst others of CONAE, CNEA, CONICET, and INTI (within Ministry of Science).
Chief of Cabinet of Ministers (Jefatura de Gabinete de Ministros)	Proposes and implements the connectivity plan.

[284] https://www.sciencedirect.com/science/article/abs/pii/S0094576500000710
[285] "Argentina Missile Chronology". 2010. Media NTI. Available at: https://media.nti.org/pdfs/argentina_missile.pdf. Accessed May 2021.
[286] "Argentina". 2015. NTI. Available at: https://www.nti.org/learn/countries/argentina/delivery-systems/. Accessed May 2021.
[287] Long, William. "Argentina Abolishes Missile Program with Iraq: Military: It turns over 'missing' parts, and in return wants to buy sensitive U.S. technology". 1993. *Los Angeles Times.* Available at: https://www.latimes.com/archives/la-xpm-1993-09-26-mn-39403-story.html. Accessed May 2021.
[288] Bilnder, Daniel. "Towards an Argentine Space Policy". Centro de Estudios sobre Ciencia, Desarrollo y Educacion Superior. Available at: https://www.redalyc.org/pdf/924/92438580003.pdf. Accessed May 2021.
[289] "Argentina's Space Program Sets Its Sights on Indigenous Launch Capabilities". 2016. *World Politics Review.* Available at: https://www.worldpoliticsreview.com/trend-lines/19423/argentina-s-space-program-sets-its-sights-on-indigenous-launch-capabilities. Accessed May 2021.
[290] Khol, Barbara. *Argentina: Condor Missile Project Dismantled.* 1991. Available at: https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=7644&context=notisur. Accessed May 2021.

National Atomic Energy Commission (CNEA)	Contributes to the satellite industry with micro and nano technologies, solar panels, and radar antennas.
National Scientific and Technical Research Council (CONICET)	Promotes national S&T, *e.g.*, astronomy (within Ministry of Science).
Federal Council of S&T (COFECyT)	Elaborates, assesses, and proposes policy and national priority strategies in order to develop STI activities. Releases studies such as on the historical development of the national satellite industry (within Ministry of Science).
National Communications Entity (ENACOM)	Merger of the Federal Authority of IT and Communication (AFTIC), and the Federal Authority of Audio-visual Communication Services (AFSCA) in 2016. Sets the conditions for a stable market that guarantees all Argentinians access to telecommunication services (within the Chief of Cabinet).
National Institute of Industrial Technology (INTI)	Promotes industrial competitivity through transfer of technologies to the benefit of SME's. Launched a strategic programme for aeronautic and aerospace development. (Within Ministry of Productive Development).
Ministry of Defence (Defence)	Promotes the utilisation of space assets for defence purpose. Enacts defence policies.

Table 13: Argentina's institutional framework (adapted from MINCYT, INTI and ENACOM)

National Space Activities Commission (CONAE)

In 1992, the National Space Research Commission (CNIE), which was under the authority of the Air Force, was dismantled after the termination of the Condor II missile program. It led to the establishment of the National Space Activities Commission (CONAE), under authority of the Presidency, to redirect Argentina's space efforts towards civilian objectives. Since 2016, CONAE has been under the responsibility of the Ministry of Science, Technology, and Innovation.[291]

CONAE is Argentina's space agency and has competence over the scientific, technical, industrial, commercial, administrative, and financial aspects of space activities.[292] CONAE is in charge of drafting and implementing the National Space Plan.

CONAE 's mission is to take advantage of space by:

- Gathering space-based data on the Latin American continent in order to improve the living standards of the population,
- Providing space-based data to economic and industrial sectors to increase productivity competitiveness at the national and international level,

[291] "Antecedentes". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/institucional/antecedentes. Accessed May 2021.
[292] "Misión". CONAE. Available at: https://www.argentina.gob.ar/institucional/mision. Accessed December 2020.

- Driving the development of the national industry through the creation of new companies that develop innovative technologies with the goal of expanding Argentina's participation in the global high added value supply chain,
- Taking part in international efforts in the field of space exploration and peaceful use of outer space,
- Providing advanced scientific knowledge as well as job and education opportunities in STEM.[293]

Scientific and Technical Research Institute for Defence (CITEDEF)

In 1954, CITEDEF was established under the Secretary of Planning of the Ministry of Defence. It mainly conducts research and development projects for the Ministry of Defence.[294] Among its various projects, CITEDEF developed the two Gradicom rockets.[295] In 2009, Gradicom I, a one-stage rocket, was launched and reached 40 km. In 2011, Gradicom II, a two-stage rocket, was launched and reached 100 km.[296]

4.2.2 Space industry and economy

According to Andres Lopez et al., the Argentinian space industry is one of the few high-tech sectors where Argentina managed to develop both design and manufacturing capabilities. Argentina developed its space industry by exploiting knowledge and capabilities from the civil nuclear industry and the military.[297]

Indeed, when CNIE was dissolved, CONAE was able to use to facilities that were previously exploited by the Air Force, which enabled CONAE to retain both capabilities and human resources of the Condor II programme.[298] According to Vera et al., the projects conducted by CNIE allowed Argentina to develop capabilities to design and build a satellite despite a lack of economic resources.[299]

In addition, Argentina took advantage of the knowledge and capabilities of its nuclear industry to apply and adapt them to the space sector.[300] INVAP is a state-owned company whose first activities were centred around nuclear energy. However, due to public budget restrictions in the 1990s, INVAP had to seek market shares outside Argentina and develop new activities. Also, when CONAE was established, it concluded that INVAP was the only company capable of carrying out space projects in Argentina.[301] According to Seijo and Cantero, technologies specific to the nuclear sector such as electronics, monitoring and control systems, vibration resistance, thermal and chemical analysis, quality assurance, software development, as well as the machining of high-quality complex components enabled INVAP to enter the space sector.[302] The capabilities and know-how derived from the nuclear industry shared similarities with aerospace technologies. As a result, INVAP has designed, developed, and manufactured most Argentinian satellites. INVAP manufactured most of Argentina's satellites. Today, INVAP and CONAE are still the main drivers of innovation in the Argentinian space sector.[303]

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[293] "Misión". CONAE. Available at: https://www.argentina.gob.ar/institucional/mision. Accessed December 2020.
[294] "Instituto de Investigaciones Científicas y Técnicas para la Defensa – CITEDEF". Government of Argentina. Available at: https://www.argentina.gob.ar/defensa/citedef. Accessed May 2021.
[295] "Gradicom 2". Astronautix. Available at: http://www.astronautix.com/g/gradicom2.html. Accessed May 2021.
[296] "The Argentine Institute of Scientific and Technical Research Will Launch the Gradicom II Rocket". 2011. Dialogo- Digital Military Magazine. https://dialogo-americas.com/articles/the-argentine-institute-of-scientific-and-technical-research-will-launch-the-gradicom-ii-rocket/. Accessed May 2021.
[297] Lòpez, A., Space Policy (2018). Available at: http://doi.org/10.1016/j.spacepol.2018.06.001.
[298] *Ibid.*
[299] Vera M.N. et al. La participacion de la Argentina en el campo espacial, Ciencia, Docencia y Technologia, 26.
[300] *Ibid.*
[301] *Ibid.*
[302] Seijo G. Cantero. J.H. Como hacer un satélite espacial a partir de un reactor nuclear ? Elogio de las technologis de investigacion en INVAP, Redes 18 (35) (2012).
[303] *Ibid.*

Argentina's space industry has capabilities to build GEO telecommunication satellites and LEO Earth observation satellites.[304]

Capability	Examples
Launch systems /components manufacturers	Veng, LIA Aerospace, TLON Space, Aeropac S.A., Nanotek
Satellite/Space system / components manufacturers	Satellogic, INVAP, Mecanica 14, Space Sur, Ascentio, DTA SA, CEATSA, GSATCOM, Innova Space, VDS Ingeneria, Arsultra
Operators	ARSAT, Satellogic, Ascentio, INVAP
Applications and VAS	Aeroterra S.A., Telecom Argentina SA, SERSAT, Tesacom, Telespazio Argentina, Frontec

Table 14: Overview of Argentina's space industry

Some foreign companies established offices or subsidiaries in Argentina (e.g., Telespazio), and Argentinian companies are increasingly establishing themselves overseas, opening international offices and exporting their products and services (e.g., Satellogic, INVAP).

An overview of selected Argentinian companies is provided below:

ARSAT

Foundation

2006

Core Business

Communication systems , Satellite operator

Products & Services

- ARSAT series operation
- Cybersecurity
- Rural connectivity
- Optic Fiber Network
- Data National Center

INNOVA SPACE

Foundation

2020

Core Business

Communication systems, Satellite manufacturer, Satellite operator

Products & Services

- Picosatellites
- Nanotechnology
- IoT/ M2M
- PocketQube constellation under development

[304] *Seijo G. Cantero. J.H. Como hacer un satélite espacial a partir de un reactor nuclear ? Elogio de las technologis de investigacion en INVAP, Redes 18 (35) (2012).*

Foundation

2010

Core Business

Earth observation systems, Satellite manufacturer, Satellite operator

Products & Services

- Geospatial analytics
- ÑuSat constellation
- High-frequency and high-resolution Earth remapping

Foundation

1998

Core Business

Satellite manufacturer, Defense, Nuclear, Medical systems

Products & Services

- ARSAT, SAC, SAOCOM series manufacturing
- Geo information
- Consulting
- Small to large, EO & communication systems

Foundation

2019

Core Business

Communication systems, Satellite manufacturer

Products & Services

- ARSAT SG1 in development
- GSATCOM series in development
- space system Assembly, Integration and Test facilities

Foundation

1976

Core Business

Micro Launch Systems, Propulsion Systems, Orbital & Sub-orbital Systems, EO systems

Products & Services

- Ground segment services
- SAC D & SAOCOM series instruments
- Tronador and VEX series rockets
- SAOCOM imagery distribution

Foundation

2014

Core Business

Micro launch systems, Propulsion systems, Orbital & sub-orbital systems

Products & Services

- Launch pad projects
- Procyon rocket

Foundation

2010

Core Business

Micro launch systems, Propulsion systems, Orbital & sub-orbital systems

Products & Services

- Green propellants
- Aventura I rocket
- SICOM (control site for remote bench test operations)

4.2.3 Research & Academia

Several Argentinian universities participate in space research including the University of Comahue (UComa), the National University of San Martin (UNSM), the University of Cordoba (UNC), and the National University of la Plata (UNLP).

The UNLP houses the Argentine Institute of Radio Astronomy (IAR), which conducts research on astrophysics, compact objects, gravitation and numerical relativity, interstellar medium, planetary science, pulsar astronomy, massive stars, and machine learning.[305] The IAR also houses two single disc radio telescopes and two antennas to study radio astronomy. Students have access to the instruments at the IAR, and training and education are one of the main goals of the institute.[306] The UNLP also houses the Aerospace Technological Centre (CTA) and the Applied Mechanical Testing Group (GEMA), which participated in the development of the Argentine satellites SAC B, SAC A, and SAC D.[307]

CONAE also seeks to promote and provide academic and research programmes. The Agency has partnered with several universities in Argentina to establish master's degrees in spatial issues, including:[308]

- Master in Spatial Information Applications at UNC,
- Master in Satellite Technology at the National Technological University,
- Master in the Computer Development of Space Application at the National University of La Matanza,
- Master in Satellite Instruments at the National Technological University.

CONAE has also established different research centres and institutions throughout Argentina, which are also involved in the aforementioned degree programmes:

- Teófilo Tabanera Space Centre (TTSC): CONAE's main space centre., It houses the Cordoba Ground Station, the Mission Operation Centre, testing and integration facilities, and the Mario Gulich Institute for Advanced Space Studies,
- The Colomb Institute is housed by UNSM and focuses on advanced satellite technologies such as platforms and distributed instruments.

4.3 Policy and legal framework

4.3.1 Space policies and strategy

Argentina's main strategic document is the National Space Plan (PEN). The first PEN covered the period from 1995-2006.[309] It is periodically revised, with the current plan running from 2016 to 2027. Two additional instruments exist to direct telecommunication activities: the Geostationary Satellite Plan and the *Plan Conectar*.[310]

[305] "Finalidad" Instituto Argentino de Radioastronomia. Available at: https://www.iar.unlp.edu.ar/institucional/finalidad/. Accessed May 2021.
[306] "Observatorio". Instituto Argentino de Radioastronomia. Available at: https://www.iar.unlp.edu.ar/slider/observatorio/.
[307] http://www.gema.ing.unlp.edu.ar/eng_activities.html. Accessed May 2021.
[308] "Maestrías". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/maestrias. Accessed May 2021.
[309] "Plan Espacial Nacional". Ministerio de Justicia y Derechos Humanos". Available at: http://servicios.infoleg.gob.ar/infolegInternet/anexos/105000-109999/106502/norma.htm. Accessed May 2021.
[310] *Plan Satelital Geoestacionario Argentino 2015-2035.* 2015. Available at: http://servicios.infoleg.gob.ar/infolegInternet/anexos/250000-254999/254823/ley27208.pdf. Accessed May 2021.

Additional instruments not focused exclusively on space activities include the National Institute of Industrial Technology's (INTI) Strategic Programme of Aeronautics and Space Development, released in 2019.[311] Additionally, in October 2020, the Ministry of Science announced that it would begin work on the National Plan for Science, Technology, and Innovation 2030. An advisory commission was created to work on the plan, and it remains to be seen what role space will play in its final elaboration. [312]

Plan Espacial Nacional (PEN)

The PEN constitutes Argentina's national space plan. The first PEN was adopted for the period 1995-2006, and revisions have been conducted for the subsequent ten-year periods. The current version covers the period from 2016-2027 and is focused on three main components:[313]

- Earth observation,
- Peaceful exploration and use of outer space,
- Technological development for space purposes.

The PEN is implemented through eight courses of action:[314]

- Use and management of spatial information,
- Data reception and control of satellites and launchers,
- Design and construction of satellite systems,
- Access to space, specifically with the development of the Satellite Injector Program for Light Payloads (ISCUL),
- Assembly, testing, and demonstration of space systems and selection of appropriate materials,
- Peaceful exploration and use of outer space,
- Investment in education and training for space-related fields,
- Promote the use of spatial information throughout different sectors and levels of government and engage in international cooperation.

CONAE has approved and operates under the current version of the PEN, but the document is still awaiting government approval.[315]

[311] Nicastro, Juan. 2019. "El INTI lanzó un Programa estratégico de desarrollo aeronáutico y espacial". INTI. Available at: https://www.inti.gob.ar/noticias/21-asistencia-regional/1555-el-inti-lanzo-un-programmea-estrategico-de-desarrollo-aeronautico-y-espacial?utm_source=tw&utm_campaign=aeronautico. Accessed May 2021.
[312] "Plan Nacional de Ciencia, Tecnología e Innovación 2030: Primera reunión de la Comisión Asesora". 2020. Science Ministry Available at: https://www.argentina.gob.ar/noticias/plan-nacional-de-ciencia-tecnologia-e-innovacion-2030-primera-reunion-de-la-comision. Accessed by May 2021.
[313] "Curos de accion". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/plan-espacial/cursos-de-accion. Accessed May 2021.
[314] *Ibid.*
[315] Lòpez, A., Space Policy (2018), Available at: http://doi.org/10.1016/j.spacepol.2018.06.001

Figure 20: Argentina space plan courses

Argentinian Geostationary Satellite Plan 2015-2035 (PSGA)

PSGA was approved in November 2015 by the National Congress of Argentina through the passage of the Law of Satellite Industry Development. The Law grants ARSAT the mandate to carry out the PSGA. The PSGA's main objective is to strengthen capacity for the development of geostationary telecommunications satellites, as well as the exploitation of Argentinian satellite services.[316]

The PSGA provides for the development and launch of eight telecommunications satellites by 2035, under the auspices of ARSAT.[317]

In line with PSGA, the design and manufacture of satellites ARSAT-2 and ARSAT-3 was envisioned. ARSAT-2 entered into service in 2015 with a 30% utilisation contract. Construction of ARSAT-3 was then halted due to financial concerns.[318] In 2020, the project was revived, and ARSAT-3 was redesigned as ARSAT-SG 1, scheduled for launch in 2023. This revival also marked the relaunch of PSGA.[319]

[316] "Satellite Industry Development Law". 2015. *Marval O'Farrell Mairal.* Available at: https://www.marval.com/publicacion/ley-n-27208-de-desarrollo-de-la-industria-satelital-12709&lang=en/. Accessed May 2021.
[317] *Ibid.*
[318] "ARSAT 3". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/arsat-3.htm. Accessed May 2021.
[319] "Relanzamiento del plan satelital geoestacionario". 2020. Government of Argentina. Available at: https://www.argentina.gob.ar/noticias/relanzamiento-del-plan-satelital-geoestacionario. Accessed May 2021.

Plan Nacional de Conectividad "Plan Conectar" 2020-2023

The National Plan for Connectivity 2020-2023 (*Plan Conectar*) aims to invest $37.9 million by 2023 to increase access to ICT services and provide broadband connections. The plan consists of four programmes, the launch of ARSAT-SG1, the update and expansion of the Federal Fibre Optic Network, the update and expansion of the National Data Centre, and the recovery of 100 transmission stations to provide improved television access for ten million homes.[320]

Programme	Objective and Content
ARSAT-SG1	Provide high-quality satellite connectivity to 200,000 rural households. *Development, manufacture and launch of ARSAT-SG1.* • Manufacture ARSAT-SG1 and launch mid-2023, • Raise the data traffic capacity to 50Gbps, • Enhance the 4G networks and support the deployment of 5G.
Federal Fibre Optic Network (REFEFO)	Connect 22 million Argentinians to REFEFO by 2023 *Update of equipment, finalization of stage 2, roll-out of stage 3* • Multiply REFEFO capacity by ten with the equipment update, • Build 4408 km of fibre optic and reach 38,808 km, • Add over 490,000 people to the "trunk network".
National Data Centre (CND)	Enhance political sovereignty over national data. *Development of the data centre and extension of services.* • Extension of cloud services to improve cost efficiency, • Update backup systems, • Implement contingency policies to meet international standards.
Digital TV Open (TDA)	Guarantee access to high-quality TV services to 10M households *Recovery of the 100 transmission stations.* • Renovate the transmission platform to improve the image quality, • Update equipment to prevent transmission losses.

Table 15: Programmes and objectives of Conectar (Chief of Cabinet of Ministers)

4.3.2 Legal and regulatory instruments

In Argentina, laws first provided a legal framework to institutions and space activities. For instance, the National Decree No. 995/91 of May 1991 established CONAE. The National Decree No. 125/95 of 1995 established the National Registry of Space Objects Launched into Outer Space.[321] In addition, the Decree 532/05 of 2005 outlines the development of space activities as a national priority and acknowledges the National Space Plan of 2004-2015 as a strategic plan, thereby translating the rising interest of the State in space.[322] However, Argentina does not seem to have adopted laws related to the commercialization of space, or taken an official legal position on the commercial exploitation of space resources or related

[320] "Conectar". Government of Argentina. Available at: https://www.argentina.gob.ar/jefatura/innovacion-publica/ssetic/conectar. Accessed May 2021.
[321] *Schematic Overview of National Regulatory Frameworks for Space Activities*. Committee on the Peaceful Uses of Outer Space UNOOSA. 2014. Available at: https://www.unoosa.org/pdf/limited/c2/AC105_C2_2014_CRP05E.pdf. Accessed May 2021.
[322] Froehlich et al. 2020. "Space Supporting Latin America, Latin America's Emerging Space Middle Powers". ESPI; Springer.

emerging issues. At this point, Argentina has not adopted national regulations or mechanisms on space debris mitigation.[323]

Law 26.095

Several legal tools form the framework of telecommunication activities, including Law 26.095, Law 27.208, and Decree 58/2019.

Law 26.092 of 2006 established the state-owned company ARSAT and defined its purpose, which is to design, develop, build (in Argentina), and launch GEO telecommunications satellites. The law provided the authorization for ARSAT satellites to use the orbital position 8° West Longitude and its associated frequency bands. The law also exempts ARSAT from paying any national tax, including VAT.

Law 27.208

In addition, Law 27.208 of 2015 places the development of the satellite industry as a national policy interest and a priority, in particular the development of telecommunication satellites. It also approved the Argentinian Geostationary Satellite Plan 2015-2035, which is considered as an integral part of this law.[324] The government will implement this law and the Satellite Plan through the ARSAT company. The law further details the governance of ARSAT as a state-owned company as well as its privileged procedures for frequency allocations.[325]

In 2019, Law 27.208 was modified through the Decree of Necessity and Urgency 58/2019. The decree still states that ENACOM will directly attribute the frequencies ARSAT needs for its activities. However, in order to prevent monopoly, enhance competitiveness, and promote regional development, ENACOM will assign frequencies to local and regional mobile providers, as well as ICT service providers.[326]

Law 27.078 Argentina Digital

In 2019, the Law 27.078 was adopted to develop telecommunications in Argentina, reduce the digital divide, and guarantee the "complete neutrality of the networks". To this end, the Federal Authority for Information and Communication Technologies will regulate, promote, and supervise the use and exploitation of the radioelectric spectrum, orbital resources, satellite services, and telecommunications networks. The law also gives priority to the use of Argentinian satellites to provide connectivity on its soil.[327]

4.3.3 International affairs

At the legal level, Argentina has ratified all UN Space Treaties except for the Moon Agreement. It is also party to the Nuclear Test Ban Treaty, ITSO Agreement, IMSO Convention, and ITU Constitution and Convention.

Moreover, Argentina is a Member State of UNOOSA and UNCOPUOS. While its diplomatic efforts are often discrete, Argentina's statements provide an overview of the country's space objectives, as well as its stance on the peaceful use of outer space. In 2018, the Permanent Mission of Argentina to International Organisations in Vienna declared that access to space for all countries is essential to the peaceful use of outer space, as space is a catalyst for socio-economic development and improving living standards.

[323] "Space Debris Mitigation Standards- Argentina". UNOOSA. Available at: https://www.unoosa.org/documents/pdf/spacelaw/sd/Argentina.pdf. Accessed May 2021.
[324] Law 27.208, *Desarrollo de la Industria Satelital*, art. 1.
[325] *Ibid.*
[326] Decree 58/2019, *Decreto de Necesidad y Urgencia modificando la Ley N° 27.208*
[327] Law N ° 27.078 Argentina Digital – 2014.

Argentina perceives space as a global common and common heritage of humanity.[328] In addition, Argentina hosted UNOOSA workshops on topics such as GNSS or space law for economic and social development.[329] CONAE is also part of the International Charter on Space and Major Disaster and provides satellite imagery for disaster monitoring purposes.[330]

Figure 21: Argentina international cooperation (adapted from CONAE)

At the bilateral level, Argentina cooperates with all space powers. CONAE signed partnership and cooperation agreements with ESA, NASA, CNES, DLR, Roscosmos, CNSA, UKSA, etc. As part of international cooperation, several deep space antennas have been installed on Argentinian soil. ESA's deep space antenna was set up in Argentina in 2012 and Chinese Moon Exploration Program's deep space antenna was also installed in 2017. 10% of the operative time of both antennas is available for

[328] Republica de Argentina, "INTERVENCION ARGENTINA PARA EL SEGMENTO DE ALTO NIVEL UNISPACE +50 (20-21 DE JUNIO 2018), PRONUNCIADA POR EL EMBAJADOR RAFAEL MARIANO GROSSI". 2018. Available at: https://www.unoosa.org/documents/pdf/copuos/2018/hls/07_03S.pdf

[329] "2nd United Nations/ Argentina International Conference on the Use of Space Technology for Water Management. 2011. Available at: https://www.unoosa.org/oosa/en/ourwork/psa/schedule/2011/international_conference_argentina_use-of-space-technology-for-water-management.html. Accessed May 2021.

[330] "About the Charter". International Charter Space and Major Disasters. Available at: https://disasterscharter.org/web/guest/about-the-charter. Accessed May 2021.

Argentinian scientific projects.[331] CONAE and the Russian Academy of Sciences signed a cooperation agreement to install three telescopes to track space debris, asteroids, and comets.[332]

At the industrial level, Argentina and Turkey are cooperating through INVAP and the Turkish Aerospce Industries, which have formed a joint venture named Gsatcom Space Technologies with the goal of developing and selling GEO telecommunication satellites.[333]

In Latin America, Argentina and Brazil have followed similar paths in their space journeys and have been cooperating extensively. Indeed, both countries have started to develop space activities within the military and both countries have transitioned to civilian activities in the 1990s. In 1989, the Joint Argentine-Brazilian Declaration on Bilateral Cooperation in the Peaceful Uses of Outer Space was signed and a working group for the creation of space cooperation programmes between the two countries was established. The Joint Declaration enables them to share information and use testing facilities of both countries. In 1996, the Framework Agreement for Cooperation in the Peaceful Applications of Space Science and Technology was signed. Argentina and Brazil have jointly developed an EO satellite (SABIA-MAR), which aims at monitoring the sea, agricultural fields, as well as deforestation and geology. In 2011, Argentina even suggested the establishment of a South American Space Agency.[334]

While this South American Space Agency was never established, in October 2020, Argentina signed a strategic agreement with Mexico that is expected to lay the foundation for the establishment of the ALCE, the Latin American and Caribbean Space Agency. The goal of this regional space agency is too pool financial, technological, and human resources. It is expected that Bolivia, Ecuador, El Salvador, and Paraguay will take part in this initiative. Colombia and Peru are expected to join as observers.[335]

[331] Colazo, Marcelo. "Space Science in Argentina- CONAE's Experience and International Cooperation. 2017. CONAE Argentina, Available at: https://www.unoosa.org/documents/pdf/psa/activities/2017/OpenUniverse/slides/Presentation23.pdf
[332] *Ibid.*
[333] Henry, Caleb. "Argentina, Turkey wade into tough GEO manufacturing market with joint venture". 2019. *SpaceNews.* Available at: https://spacenews.com/argentina-turkey-wade-into-tough-geo-manufacturing-market-with-joint-venture/. Accessed May 2021.
[334] Llendorazas, Elsa. "Nuclear and Space Cooperation- The Argentine-Brazilian Case: From Competition to Collaboration. REVISTA DE RELACÕES INTERNACIONAIS E COMÉRCIO EXTERIOR DA ESTÁCIO Nº1 Vº1 ANO 2019. Available at: http://revistaadmmade.estacio.br/index.php/rel_inter_comercio_exterior/article/viewFile/7542/47966645
[335] Valero, Myriam V. "Latin America's Moonshot". 2021. *Slate*. Available at: https://slate.com/technology/2021/05/latin-american-caribbean-space-agency-future.html. Accessed May 2021.

4.4 Programmes and infrastructure

4.4.1 Resources and infrastructure

The budget allocated to CONAE has increased in the past few years. In 2021, the budget of CONAE will account for 7458 million pesos. In 2020, the budget accounted for 3748 million pesos.[336]

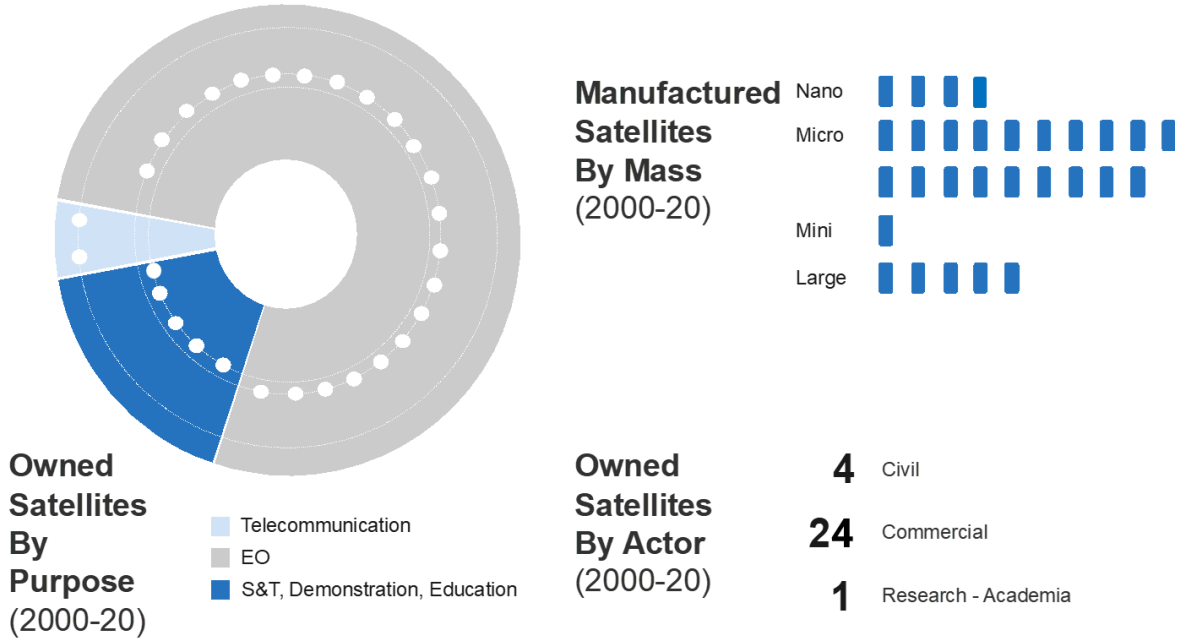

Figure 22: Argentina's space infrastructure overview (ESPI database)

4.4.2 Space programmes and activity

Telecommunication

Aside from Argentina's early satellites, the majority of telecommunication satellites are owned and operated by ARSAT, the Argentinian government-owned telecommunications company.[337] Through the PSGA and the *Plan Conectar*, ARSAT is granted the mandate to conduct activities relating to satellite telecommunications in Argentina through the ARSAT satellite constellation.[338] The ARSAT 1 and ARSAT 2 satellites were launched in 2014 and 2015, respectively. ARSAT 1 focuses on providing data, telephone, and television transmission services for Argentina, Chile, Uruguay, Paraguay, and Bolivia.[339] Construction of ARSAT 3 was halted in 2016 due to financial reasons, but the programme was resumed in 2020 with the announcement of the ARSAT-SG1 satellite. [340] This satellite is planned to be launched in 2023 and is based on a platform developed by the GSATCOM joint venture between INVAP and the Turkish Aerospace Industry.[341] The satellite will provide broadband connectivity to all of Argentina, including 200,000 homes

[336] Alonso, Matias. "Reactivación espacial". 2020. UNSAM. Available at: https://www.unsam.edu.ar/tss/reactivacion-espacial/. Accessed May 2021.
[337] Lopez, A., Space Policy (2018), http://doi.org/10.1016/jspacepol.2018.06.001
[338] "Satellite Industry Development Law". 2015. Marval O'Farrell Mairal. Available at: https://www.marval.com/publicacion/ley-n-27208-de-desarrollo-de-la-industria-satelital-12709&lang=en/. Accessed May 2021.
[339] "ARSAT 1". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/arsat-1.htm. Accessed May 2021.
[340] "ARSAT retoma desarrollo de su tercer satélite". 2020. ARSAT. Available at: https://www.arsat.com.ar/arsat-retoma-desarrollo-de-su-tercer-satelite. Accessed May 2021.
[341] "ARSAT-SG 1". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/arsat-sg-1.htm. Accessed May 2021.

in rural areas, and parts of Argentina's neighbouring countries, as well.[342] [343] So far, all ARSAT satellites have been constructed by INVAP.[344]

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit & Mass	Customer	Purpose
ARSAT 01	INVAP	Arianespace	2014	GEO, 2985 kg	ARSAT	Ku-band. Data, telephone, TV services. Covers Argentina, Chile, Uruguay, Paraguay, Bolivia
ARSAT 02	INVAP	Arianespace	2015	GEO, 2975 kg	ARSAT	C-band, Ku-band. Data transmission, internet & TV services. Covers the Americas.

Table 16: Argentina telecommunication satellites (ESPI database)

Earth Observation

Satellogic has been responsible for the majority of Argentina's EO satellites through its Aleph-1 constellation, consisting of the ÑuSat satellites. Aleph-1 will consist of up to 90 satellites, and 18 have been launched so far. The majority of the satellites have been launched using Chinese launch services, however the launch of ÑuSat 6 was provided by Arianespace.[345]

CONAE also develops EO satellites. SAC-C was developed through a partnership between CONAE and NASA, and includes instruments from France, Italy, Brazil, and Denmark, as well. SAC-C was part of the Morning Constellation for Earth Observation (along with Landsat 7, EO 1, Terra, SAC-C) SAC-C was launched from Vandenberg Air Force Base in 2000. [346]

The SAC-D/Aquarius satellite was launched in 2011 and was also the result of collaboration between CONAE and NASA. The mission was focused on measuring sea surface salinity. [347] The SAOCOM constellation consists of two L-band SAR satellites which are part of the SIASGE joint project between CONAE and ASI aimed at providing information for emergency management.[348] The project ultimately encompasses six satellites, Argentina's two SAOCOM satellites and Italy's four COSMO-SKYMed satellites. SAOCOM1A and SAOCOM1B were launched in 2018 and 2020, respectively.[349] Two SAOCOM2 satellites are also planned.[350]

[342] "El ARSAT-SG1". Government of Argentina. Available at: https://www.argentina.gob.ar/jefatura/innovacion-publica/ssetic/conectar/el-arsat-sg1. Accessed May 2021.
[343] "ARSAT-SG 1". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/arsat-sg-1.htm. Accessed May 2021.
[344] Lopez, A., Space Policy (2018), http://doi.org/10.1016/jspacepol.2018.06.001
[345] "ÑuSat 1, ..., 98 (NewSat 1, ..., 98, Aleph-1 1, ..., 98)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/nusat-1.htm. Accessed May 2021.
[346] Comob, F.R., et al. "SAC-C Mission and the Morning Constellation." 2002. Harvard University. Available at: https://ui.adsabs.harvard.edu/abs/2002iaf..confE.888C/abstract. Accessed May 2021.
[347] "Aquarius / SAC D (ESSP 6)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/aquarius.htm. Accessed May 2021.
[348] "SAOCOM-1" Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/saocom-1.htm. Accessed May 2021.
[349] *Ibid.*
[350] *Ibid.*

CONAE designated the technology and services company, VENG, the task of bringing SAOCOM products to market through the creation of an online platform which allows user to search SAOCOM imagery.[351]

The SABIA-Mar constellation is currently under development and will provide data on sea and coastal areas. The project was initially envisioned as a joint project between CONAE and AEB, but ultimately CONAE took full responsibility for SABIA-Mar 1 and SABIA-Mar 2 became AEB's project. SABIA-Mar is scheduled to launch in 2023.[352]

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit & Mass	Customer	Purpose
SAC-C	INVAP	ULA	2000	LEO, 485 kg	CONAE	Remote Sensing. Observation of land and coastal water and internal waters to study geomagnetic fields and the atmospheric structure.
SAC-D/ Aquarius (ESSP6)	INVAP	ULA	2011	LEO, 1600 kg	CONAE, NASA	Remote Sensing. Gather climate information from salinity measurements and get an idea of circulation and mixing processes in the ocean.
ÑuSat 1 & ÑuSat 2	Satellogic	CASC	2016	LEO, 37,5 kg	Satellogic	Commercial real-time Earth imaging and video, 1 m resolution
ÑuSat 03, ÑuSat 4, ÑuSat 5	Satellogic	CASC	2017-2018	LEO, 37,5 kg	Satellogic	Commercial real-time Earth imaging and video, 1 m resolution
SAOCOM 1A, SAOCOM 1B	INVAP	SpaceX	2018, 2020	LEO, 3000 kg	CONAE	SAR L-Band. Soil moisture measurement and emergency applications (oil spill detection at sea, flood monitoring, etc.)
ÑuSat 7, ÑuSat 8	Satellogic	CASC	2020	LEO, 37,5 kg	Satellogic	Commercially available real-time Earth imaging and video
ÑuSat 6	Satellogic	Arianespace	2020	LEO, 37,5 kg	Satellogic	Test sub-meter imaging technology and improve R&D of EO capabilities.
ÑuSat 9-18	Satellogic	CASC	2020	LEO, 41 kg	Satellogic	Commercial real-time Earth imaging and video, 1 m resolution

Table 17: Argentina EO satellites (ESPI Database)

[351] "Official website for the marketing of SAOCOM® products". VENG. Available at: https://saocom.veng.com.ar/en/. Accessed May 2021.
352 "SABIA-Mar". CONAE. Available at: https://www.argentina.gob.ar/ciencia/conae/misiones-espaciales/sabia-mar. Accessed December 2020.

Additionally, CONAE seeks to meet the increased demand for EO data by developing new satellites and instruments through the project, *Arquitectura Segmentada*. Programmes include the plans for the development of improved communication systems, cluster navigation technologies, and new payloads.[353]

S&T, Education

Argentina has also deployed a number of technology demonstration, and education satellites.

The Cubebug satellites were launched as technology demonstration missions for a new cubesat design for universities and research institutions to use. The Argentinian Ministry of Science, Technology, and Productive Innovation, INVAP, Satellogic, and Radio Club Bariloche sponsored the project. The first mission tested the components for BugSat EO satellites and then entered a new mode to provide science data downloads and a digital repeater for the amateur radio community.[354]

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit	Customer	Purpose
PehuenSat1	AATE, UNC, AMSAT Argentina	Antrix Corporation	2007	LEO, 6 kg	AATE, UNC, AMSAT Argentina	Provide experience in manufacturing and operating a small satellite. Give learning opportunity to students.
CubeBug-1 (Capitán Beto)	Satellogic	CASC	2013	LEO, 2 kg	Satellogic	Technology demonstration for new cubesat platform design. Amateur radio.
CubeBug-2 (Manolito)	Satellogic	ISC Kosmotras	2013	LEO, 2 kg	Satellogic	Technology demonstration for new cubesat platform design. Amateur radio.
BugSat1 (Tita)	Satellogic	ISC Kosmotras	2014	LEO, 22 kg	Satellogic	Prototype satellite for ÑuSat's. Amateur radio.

Table 18: Argentina S&T, education satellites (ESPI database)

PehuenSat 1is a nanosatellite project undertaken jointly by the AATE (Asociacíon Argentina de Tecnología Espacial), UNC (Universidad Nacional del Comahue), and AMSAT Argentina (Asociación Argentina de RadioAficionados por Satélites).[355] The satellite had educational, technological, and scientific purposes.[356]

In March 2021, the privately developed Argentinian test satellite, PocketQube, DIY 1 was launched to test a variety of different technologies.[357] Additionally, Technical School No. 5 in Mar del Plata is developing

[353] "Programas de Desarrollo". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/misiones-espaciales/arquitectura-segmentada/programas. Accessed May 2021.
[354] "CubeBug 1, 2 (El Capitán Beto, Manolito) / LUSAT-OSCAR 74 (LO 74)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/cubebug-1.htm. Accessed May 2021.
[355] "PehuenSat 1 (PO 63, PehuenSat-OSCAR 63)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/pehuensat.htm. Accessed May 2021.
[356] "PEHUENSAT 1". N2YO. Available at: https://www.n2yo.com/satellite/?s=29712. Accessed May 2021.
[357] "DIY 1 (ArduiQube)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/diy-1.htm. Accessed May 2021.

and building PocketCube, SatDuino. SatDuino will be the first Argentinian satellite built by public technical school students. The goal of this initiative is to introduce aerospace in technical schools and promote careers in STEM. Additionally, this project launches the National Programme, EduAR-Sat, which aims at providing similar opportunities for schools across the country.[358]

Space Transportation

Argentina's space journey started with space transportation. In 1947, Argentina started to develop small tactical rocket with liquid-propellant motors. In 1954, it started to develop rocket engines with solid propellant. The CNIE and the IIAE of the Air Force develop sounding rockets and missiles in the 1960s. In 1961, CNIE and NASA signed a cooperation agreement on sounding rockets for space research.[359] In 1961, Argentina used space platforms in Chamical to test the Beta and Gamma rockets-probes as well as stratospheric balloons.[360] In 1965, the Centaur rocket was launched from the Matienzo Base in Antarctica. In 1966, Argentina launched the Orion II rocket from Antarctica. Argentina became the first Latin American country to launch an object into space and the only country to have achievement significant development in the field of launchers.[361] [362]

In the 1960s, the U.S., France, and Argentina cooperated and launched 16 French Centaure rockets from Argentinian soil. In the 1960s and 1970s, CNIE develop several rockets, including the Alpha, Beta, and Gamma, Orion II, Castor, Canopus I and II, Rigel, and Clag I and II rockets.[363]

Argentina's efforts in developing launchers were closely related to the military and its missile programme. In 1979, Argentina started to develop the Condor I rocket due to border issues with both Chile and Great Britain.[364] However, the Condor I missile had a limited range of 100 km. During the Falklands War, the Condor I missile could not reach the Falkland Islands and Argentina could not use other missiles such as the French Exocet missiles it imported due to a French embargo. Therefore, Argentina decided to develop the Condor II rocket, which had a longer range capable of reaching the Falkland Islands.[365] [366] The Condor II programme was enabled by the imports of technologies from France, Italy, and Germany as well as funding from Egypt and Iraq.[367] At that time, Argentina was also developing its civil nuclear program. This led to concerns that Argentina was exporting missile and space-based technologies to Egypt and Iraq and contributing to Saddam Hussein's ballistic missile capabilities. In 1993, the Condor II programme was discontinued due to American pressure.[368] After that, Argentina stopped the development of launchers and redirected its activities towards civilian purposes.

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[358] "SatDuino". Argentine Technical Schools. Available at: https://satduinot5t1.wixsite.com/satduino?lang=en. Accessed May 2021.
[359] "Argentina Missile Chronology". NTI. 2010. Available at: https://media.nti.org/pdfs/argentina_missile.pdf. Accessed May 2021.
[360] Froehlich et al. 2020. "Space Supporting Latin America, Latin America's Emerging Space Middle Powers". ESPI; Springer.
[361] "Argentina". Astronautix. Available at: http://www.astronautix.com/a/argentina. Accessed May 2021.
[362] De Leon, Pablo. "The Condor Project". 2016. University of North Dakota. Available at: https://www.researchgate.net/publication/308890406_THE_CONDOR_PROJECT.
[363] Argentina Missile Chronology". NTI. 2010. Available at: https://media.nti.org/pdfs/argentina_missile.pdf. Accessed May 2021.
[364] Tollefson, Scott. El Condor Pasa: "The Demise of Argentina's Ballistic Missile Program" in *The International Missile Bazaar.* 1994. Routledge. Available at: https://www.taylorfrancis.com/chapters/edit/10.4324/9780429311932-11/el-condor-pasa-demise-argentina-ballistic-missile-program-scott-tollefson
[365] Long, William. "Argentina Abolishes Missile Program with Iraq: Military: It turns over 'missing' parts, and in return wants to buy sensitive U.S. technology". 1993. *Los Angeles Times.* Available at: https://www.latimes.com/archives/la-xpm-1993-09-26-mn-39403-story.html. Accessed May 2021.
[366] Bilnder, Daniel. "Towards an Argentine Space Policy". Centro de Estudios sobre Ciencia, Desarrollo y Educacion Superior. Available at: https://www.redalyc.org/pdf/924/92438580003.pdf. Accessed May 2021.
[367] "Missile Programs". Federation of American Scientists. 2012. Available at: https://fas.org/nuke/guide/argentina/missile/index.html. Accessed May 2021.
[368] Long, William. "Argentina Abolishes Missile Program with Iraq: Military: It turns over 'missing' parts, and in return wants to buy sensitive US technology". 1993. Los Angeles Times. Available at: https://www.latimes.com/archives/la-xpm-1993-09-26-mn-39403-story.html. Accessed May 2021.

Today, Argentina is developing launchers with the Tronador series in an effort to develop its industry by building autonomous capabilities. The Tronador I rocket was a suborbital rocket, which was successfully launched in 2007. The Tronador II is a small satellite launcher. The Tronador III is a launcher with a range of 600 km and a payload capacity of 1 ton.[369] The progress of Tronador III has been significantly slowed down due to fluctuations in public spending.[370]

Additionally, space start-ups Lia Aerospace and TLON Space have started working on the development of micro-launchers, (Procyon and Aventura-I).

Finally, Argentina established three launchpads on its soil:

- The Teófilo Tabanera Space Centre (CETT), located in the province of Cordoba. It hosts several facilities such as a mission control centre, a testing laboratory, the Mario Gulich Institute, etc.[371]
- The Manuel Belgrano Space Centre (CEMB), located in the province of Buenos Aires, within the Puerto Belgrano Naval Base. It is the selected launch pad for the Tronador II and Tronador III.[372]
- The Punta Indio Space Centre (CEPI), located in the province of Buenos Aires.[373]

Launch Vehicle	Manufacturer Launch provider	Characteristics	Performance (kg)	Launch Year (maiden)	Launch site
Tronador I	VENG	Suborbital 1 stage	60 kg	2007	Belgrano Space Centre
Tronador II	VENG	Orbital 2 stages	250 kg in LEO	2020	Belgrano Space Centre
Tronador III	VENG	Orbital 2 stages	750 - 1000 kg in LEO	> 2025	Belgrano Space Centre
VLE	VENG	Orbital 2 stages	80 kg in LEO	> 2023	Belgrano Space Centre
Aguila IV	CITEDEF	Orbital 4 stages	60 kg in LEO	> 2025	Belgrano Space Centre
Zenit	Lia Aerospace	Suborbital 1 stage	30 kg	> 2022	N/A
Procyon	Lia Aerospace	Orbital 2 stages	150 kg in LEO	> 2024	N/A
Aventura I	TLON Space	Orbital 2 stages	25 kg in SSO (500-800 km)	N/A	N/A

Table 19: Argentinian launch vehicles

[369] Froehlich et al. 2020. "Space Supporting Latin America, Latin America's Emerging Space Middle Powers". ESPI; Springer.
370 "VLE, nuevo enfoque de CONAE". 2020. *latamsatelital*. Available at: http://latamsatelital.com/vle-nuevo-enfoque-de-conae/. Accessed December 2020.
[371] "Centro Espacial Teofilo Tabanera". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/centros-y-estaciones/centro-espacial-teofilo-tabanera. Accessed May 2021.
[372] "Centro Espacial Manuel Belgrano". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/centros-y-estaciones/centro-espacial-manuel-belgrano. Accessed May 2021.
[373] "Centro Espacial Punta Indio". Government of Argentina. Available at: https://www.argentina.gob.ar/ciencia/conae/centros-y-estaciones/centro-espacial-punta-indio. Accessed May 2021.

4.5 Key takeaways

4.5.1 Argentina's space ambitions

Argentina's space efforts were first driven by military objectives and space capabilities were mostly developed by the Air Force. However, after the dismantlement of the Condor II programme, Argentina had no choice but to redirect its space development efforts towards civilian and peaceful purposes.

Since then, the main driver for pursuing space activities in Argentina has been socio-economic benefits. These goals are clearly highlighted in the National Space Plans, public speeches, and space projects. For instance, Argentina tries to uptake space-based data to provide citizens with information on health issues such as dengue or Chaga's disease through CONAE's Geoportal. CONAE is also cooperating with the Ministry of Health to organize courses on the use of EO data to monitor such disease and create risk maps. CONAE and other academic institutions are trying to analyse the link between the environment and the emergence of some diseases.[374]

Additionally, in the field of telecommunications, reducing the digital divide is one of the main objectives of the government. Argentina increasingly views SATCOM as a way to provide connectivity to rural areas without setting up complex and costly terrestrial networks.[375] In 2020, the government unveiled the Connectivity Plan, which aims at improving network capacities and providing connectivity in rural areas through fibre optics and satellites. The plan includes the development of the ARSAT SG1 telecommunication satellite.

Since the early 2000s, the Ministry of Defence has started to pursue space-related activities again. However, the use of space to meet national security objectives is rarely highlighted by policymakers. In addition, soft power and prestige are rarely mentioned in space policies and the space sector does not seem to be the object of a strong governmental communication campaign. Therefore, socio-economic benefits are the main driver for pursuing space activities in Argentina.

4.5.2 Space ecosystem highlights

Since the 1950s, the Argentinian space journey underwent several advancements and setbacks due to economic and political crises. Nonetheless, Argentina managed to develop space capabilities and reached key milestones, making it an emerging spacefaring nation.

Politics

Argentina signed all the UN space treaties, except for the Moon Agreement. It is a member of UNOOSA and UNCOPUOS.

At the national level, Argentina established its space agency in 1992. Since 1995, Argentina has adopted and regularly updated space policies. Argentina's main policy document is the National Space Plan, which defines objectives for the development of space activities and capabilities. The NSP focuses on EO, the peaceful use of outer space, and the development of space technologies. The NSP is being implemented by CONAE with the support of state-owned companies such as ARSAT or INVAP. However, while the NSP

[374] "Responses to the set of questions regarding policies, experiences and practices in the use of space science and technology for global health- Note by the Secretariat". *Committee on the Peaceful Uses on Outer Spaces- UNOOSA*. 2021. Available at: https://www.unoosa.org/res/oosadoc/data/documents/2021/aac_105c_1/aac_105c_1119add_2_0_html/V2007380.pdf. Accessed May 2021.
[375] "La conectividad en el medio rural". Ministerio de Agricultura, Ganadería y Pesca. Available at: https://www.magyp.gob.ar/sitio/areas/cambio_rural/boletin/conectividad.php. Accessed May 2021.

covering the 2016-2027 period has been approved by CONAE, it has not been approved by the government and has not been made public.[376] As a result, the scope, evolution, and ambitions of the space policy can hardly be assessed. Argentina's space budget has been increasing over the last few years. From 2020 to 2021, CONAE's budget went from 3748 million pesos to 7458 million pesos.[377] Yet, political changes and budget fluctuations often delay long-term space projects.

The national space ecosystem also relies on entities which provide training and education such as the University of Comahue, the National University of San Martin (UNSM), the University of Cordoba (UNC), and the National University of la Plata (UNLP). Several universities have contributed to national space missions.

Programmes

Argentina managed to develop capabilities in the field of Earth observation, telecommunications, and launchers. Argentina was the first Latin American nation to launch an object into space. In 1990, Argentina launched its first satellite (LUSAT-1). Since then, Argentina has developed manufacturing and design capabilities for GEO telecommunication satellites, and LEO Earth observation satellites by taking advantage of the technical progress in the nuclear sector. The first indigenous satellite, ARSAT-1, was launched in 2014.[378] Argentina has been developing indigenous launching capabilities with the Tronador III but has not yet launched an object into orbit.

[376] Lopez, Andres & Pascuini, Paulo & Ramos, Adrian. 2018. Climbing the Space Technology Ladder in the South: the Case of Argentina. Space Policy. 46. Available at: https://www.researchgate.net/publication/325926349_Climbing_the_Space_Technology_Ladder_in_the_South_the_Case_of_Argentina

[377] Alonso, Matias. "Reactivación espacial". 2020. UNSAM. Available at: https://www.unsam.edu.ar/tss/reactivacion-espacial/. Accessed May 2021.

[378] https://eu.usatoday.com/story/news/nation/2014/10/17/argentina-satellite-launch/17396753/

5 South Korea

5.1 National space history

In South Korea, space activities first started with the establishment of the Korea Astronomy and Space Science Institute in 1974. The first space-related legislation was adopted in 1987 (the Aerospace Industry Development Promotion Act) and the Korea Aerospace Research Institute (KARI) was founded in 1989. Those factors created the conditions to foster space activities and develop satellites and rockets. In 1992, South Korea launched its first satellite, KISAT-1, in cooperation with the University of Surrey (UK). In 1993, South Korea launched its first scientific sounding rocket, KSR 1.

Since then, South Korea has achieved key milestones by sending the first South Korean astronaut to the ISS, building a spaceport, and launching the Naro-1 rocket (previously known as KSLV-I) into orbit in 2013. Today, the country also seeks to improve its military capabilities, increasingly acknowledging the importance of space as a strategic domain and successfully launching its first military communication satellite in 2020.

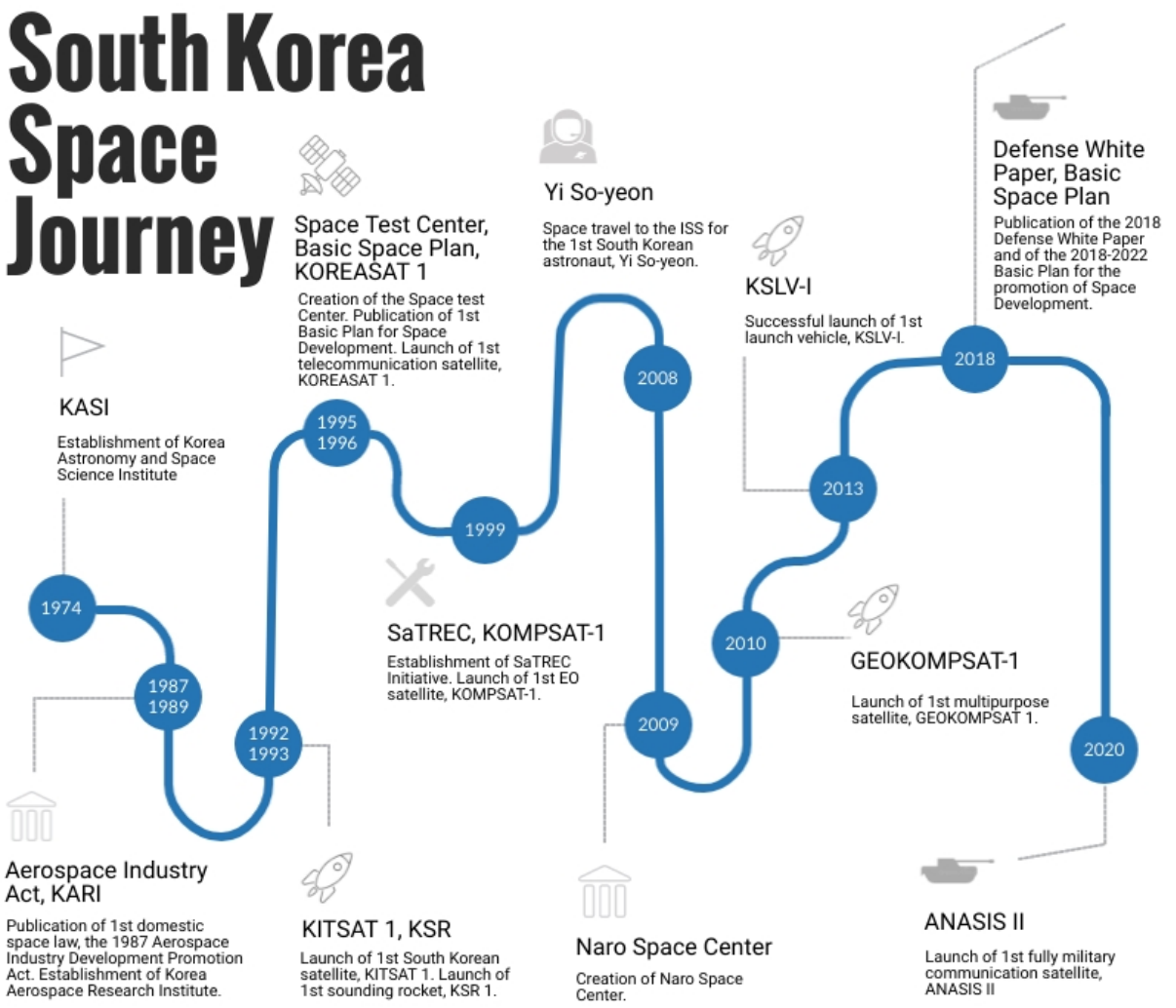

Figure 23: Timeline of South Korea space journey

5.2 Space sector governance

5.2.1 Institutional framework

Different governmental entities engage in the conduct of space activities in South Korea and their respective involvement is reviewed in the table below.

Entity	Involvement in space
National Space Council	Supreme decision-making body chaired by MSIT gives overall direction to national space activities and set-up basic space plan
Ministry of Science and ICT (MSIT)	Main authority: supervises S&T policies and promotes R&D and cooperation; promotes IT industry & country's informatization; enacts space laws and policies through the relevant specialized bodies
Ministry of Trade, Industry & Energy	Promotes space industry development; enacts space industrial strategy
Ministry of National Defense (MND)	Enacts defence white papers containing space security measures; supervises the activities of ADD
Korea Aerospace Research Institute (KARI)	Supports the implementation of national aerospace policies; develops and executes space missions.
Korea Astronomy & Space Science Institute (KASI)	Carrying out research activities on optical, radio, and theoretical astronomy, space science, and in SSA.
Korea Institute of Geoscience and Mineral Resources (KIGAM)	Planetary geology, GIS mapping, RS payload development, geophysical exploration, electronics, resource extraction, and resources utilisation
Electronics and Telecommunications Research Institute (ETRI)	Carries out research and development activities on information, communications, electronics, broadcasting, and convergence technologies
Agency for Defence Development (ADD)	Carries out defence-related space activities.

Table 20: South Korea institutional framework (adapted from KARI and Korea Space Forum)

MSIT oversees over civil space activities and according to the 2005 Space Development Promotion Act, grants different national entities with competences that fit their area of expertise.[379] In other words, there is no "centralized space agency" covering all areas of research, but rather several specialized institutions that will contribute to space development to the extent dictated by MSIT. Defence-related space activities are mainly carried out by ADD under the supervision of the Ministry of National Defence (MND). A more detailed overview of these specialized bodies is provided below.

[379] Law no. 7538, *Space Development Promotion Act* (2005), amended by Act No. 15243 (2017), art 7.

Korea Aerospace Research Institute (KARI)

Established in 1989, KARI acts as a S&T-focused national space agency. It conducts R&D in eight main areas: aerospace, satellites, space launch vehicles, convergent technology (such as AI, microsatellites, 3D-printing, *etc.*), utilisation of satellite images, unmanned vehicles, lunar exploration, and satellite navigation.

The main function of KARI is to contribute to the development of the South Korean economy and improve the living standards of all South Koreans through technological advancements, developments and dissemination of space science and technology. To achieve this, KARI has been granted four main missions:

- R&D in systems, core technologies for aircraft, satellites and launch vehicles,
- Support national space policies and raise awareness on space technology,
- Share testing facilities with the industry, academia, and research and collaborate with SMEs,
- R&D cooperation and technical outsourcing activities with public and private entities, and training of human resources.[380]

KARI's Space Test Center is a facility for analysing, testing, and assembling satellites and launch vehicles.[381]

While KARI is a research centre, it is worth mentioning that it is seen by most foreign actors as the country's space agency. South Korea does not have a space agency per se.

Korea Astronomy & Space Science Institute (KASI)

Established in 1974, the Korea Astronomy & Space Science Institute (KASI) is the national research institute conducting research activities on optical, radio, and theoretical astronomy, space science, and SSA.

KASI has acquired the core technology necessary to develop space surveillance capabilities through the establishment of the OWL-Net optical space surveillance program in order to build a radar surveillance system for SSA.[382]

KASI's functions are the following:

- Performing a key role in astronomy and space science,
- Developing and operating research facilities for astronomy and space science,
- Developing technologies related to space situational awareness,
- Managing national astronomical almanac and Korean Standard Time,
- Performing public outreach & citizen science for astronomy and space Science,
- Collaborating on R&D projects with public and private sectors,
- Fostering R&D manpower and establishing policy for astronomy and space science.[383]

Agency for Defence Development (ADD)

Established in 1970, ADD is the South Korean national agency for research and development of defence technologies, including space-related technologies. It supports the improvement and autonomy of the national defence industry through research, development, and testing of weapons and equipment.[384]

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[380] "Major Functions". KARI. Available at: https://www.kari.re.kr/eng/sub01_02.do. Accessed December 2020.
[381] "Space Test Center. KARI. Available at: https://www.kari.re.kr/eng/sub03_02_05.do. Accessed December 2020.
[382] "Space surveillance technology overview". KARI. Available at. https://www.kasi.re.kr/eng/pageView/322. Accessed May 2021.
[383] "Vision and function". KARI. accessed December 2020, https://www.kasi.re.kr/eng/pageView/51.
[384] "Who We Are, Mission and Vision". Agency for Defense Development. Available at: https://www.add.re.kr/board?menuId=MENU02258&siteId=SITE00003. Accessed May 2021.

Its strategy includes the reinforcement of advanced science and technology (S&T) capabilities for national defence to lead the Fourth Industrial Revolution, which has a strong focus on space:

- Space technology (Space technologies for military reconnaissance satellite constellations, military satellite communication and micro/ nano satellites),
- Sensor technology (Advanced radar such as Active Electronically Scanned Array Radar, Over-The-Horizon Radar, Photonic Radar, advanced navigation system, high-performance seeker, and underwater acoustic sensor technologies),
- Laser technology (High-energy laser weapon technology),
- Quantum technology (Quantum radar technology).[385]

ADD also conducts R&D on the following areas:

- Surveillance and Reconnaissance Systems (infrared cameras for satellites and multi-sensor/ multi-source imagery),
- Command and Control/Information Warfare Systems (Joint Tactical Data Link System),
- Space Technologies (Space-based surveillance and reconnaissance System, small satellite system, and military communication systems),
- Core Technologies (anti-jamming satellite navigation systems, star tracker, GNSS jamming, rocket propulsion),
- Future technologies (quantum and terahertz technology).[386]

5.2.2 Space industry and economy

In the 1970s, South Korea outlined a vision for entering the space sector, which was centred on space-related technology in order to develop a high-tech economy and a skilled workforce within the defence industry at a time when South Korean industries mostly consisted of low-cost labour. Then, in 1985, the South Korean government released the "Long-Term Plan for the Development of Science and Technology towards the 2000s", which viewed the space sector as a sector that would reinforce the competitiveness of the economy and enable South Korea to catch up with industrialised and developed economies. In 1996, the First Basic Plan on Mid-to-Long-Term National Space Development aimed at placing South Korea among the world's top ten space industries in the world by 2010 through the independent development and launch of a rocket and a satellite from Korean soil.[387] Since 2018, socio-economic benefits generated by space have become important goals for South Korea. The Third Basic Plan outlined "public safety and quality of life" as major objectives.

As New Space emerged, South Korea is looking to transition its space industry and economy from an area governed mostly by the state to one led by the private sector.[388] To this end, KARI increasingly transfers activities and capabilities to the private sector. However, it still remains the main driver of space manufacturing activities in Korea.[389] The OECD assessed that South Korea has capabilities in most space industry segments, including space vehicle and equipment manufacturing, satellite launch, satellite operations, and downstream applications.[390] In terms of manufacturing capacities, South Korea can manufacture light, medium, and heavy systems for both national and international customers. The South

[385] "Who We Are, Mission and Vision". Agency for Defense Development. Available at: https://www.add.re.kr/board?menuId=MENU02258&siteId=SITE00003. Accessed May 2021.
[386] "Space Technologies". ADD. Available at: https://www.add.re.kr/board?menuId=MENU02258&siteId=SITE00003. Accessed December 2020.
[387] Hyoung Joon An. South Korea's Space Program: Activities and Ambitions. Asia Policy. Volume 15. No 2. 2020. 34-35
[388] *Ibid.* 36
[389] "Korea", in OECD, The Space Economy in Figures: How Space Contributes to the Global Economy. 2019.
[390] "Korea", in OECD, *The Space Economy in Figures: How Space Contributes to the Global Economy*. 2019.

Korean company Satrec has provided six satellites to foreign actors, mostly other emerging spacefaring nations: DubaiSat1 and DubaiSat 2 (UAE), Deimos 2 (Canada), RazakSat (Malaysia), and X-Sat (Singapore).

The South Korean space industry employs over 6000 people and generated some KRW 2.7 trillion (USD 2.4 billion) in revenue in 2016. The space sector continues growing and generated around KRW 3.2 trillion (USD 2.9 billion) in revenue in 2018.[391] According to Sangwoo Shin, Senior Researcher at KARI, the government developed a Space Industry Strategy, which aims at expanding the space industry to KRW 3.7 trillion in revenue by the end of 2021 by expanding the private sector, creating new industries, and strengthening competitiveness.[392]

The industrial landscape is diversified, with relevant capabilities in most segments, including satellite and launch vehicle manufacturing, ground infrastructure, satellite operations and downstream services applications[393]. An overview of the most relevant companies is provided in the table below.

Capability	Examples
Launch systems /components manufacturers	Dongyang A.K. Korea, Korea Jig&Fixture Ind., Nexcoms, Turbo CAM Technology, JoilAero, Anh Structure, Korea Aerospace Industries (KAI), Perigee.
Space system /components manufacturers	NARA Space Technology, Korea Composite Inc. (KCI), Navcours Co., Songwol Technologies, Qnion, JoilAero, Hanwha systems, Genohco, Satrec, KAI, Innospace, Asia Pacific Satellite Inc. (APSI).
Operators	KT Corporation
Applications and VAS	Gaonsoft, SK Telecom, LG Uplus, APSI, Intellian, Ace technologies, Lig nex 1, Almac, Aeromastercorp, Ewha Defense Technology

Table 21: South Korea space industry (adapted from Korea Aerospace Industry 2020-2021)

[391] ESPI. New Space in Asia.
[392] ESPI. New Space in Asia.
[393] "Korea", in OECD, *The Space Economy in Figures: How Space Contributes to the Global Economy*. 2019.

KOREA AEROSPACE INDUSTRIES, LTD.

Foundation

1999

Core Business

Aerospace & Defense

Activities/ Products/ ?

- CAS500
- GEOKOMPSAT
- KOMPSAT
- KSLV-II

SATREC INITIATIVE

Foundation

1999

Core Business

Satellite systems, Electro-optical payloads, Ground systems, Defense products

Activities/ Products/ ?

- SpaceEye series
- Star Tracker
- EOS series
- Mission Control System, Image Receiving Processing System
- Secure Satellite Imaging Platform

PERIGEE

Foundation

2018

Core Business

Micro launch systems, Propulsion systems, Orbital & sub-orbital systems

Products & Services

- Blue Whale 1

kt sat

Foundation

2012

Core Business

Telecommunication, Satellite operator

Products & Services

- Kumsan Satellite Service Center
- Yongin Satellite Control Center
- Busan Maritime Business Center
- KOREASAT series

5.2.3 Research & Academia

Space research in South Korea is diversified, with research and academic institutions contributing to space activities in many ways and domains, including satellite manufacturing, geological research, electronics and telecommunications, and astronomy.

Space-related research activities are carried out in government research agencies (e.g., KARI, KASI, ETRI), as well as many universities that offer space engineering and space science programmes. Several universities also have satellite manufacturing capacities. Among those, Korea Advanced Institute of Science and Technology (KAIST), Korea Aerospace University (KAU), Seoul National University (SNU), Yonsei University, Chungnam University, Chosun University, and Kyung Hee University (KHU), have each manufactured one or multiple small satellites in the past twenty years. Fourteen academic satellites were launched between 2017 and 2020.[394] KAIST seeks to bring a global contribution in these fields and

[394] "KAIST", KAIST. Available at: https://www.add.re.kr/board?menuId=MENU02258&siteId=SITE00003. Accessed December 2020,

transition into an increasingly entrepreneurial university.[395] KAIST houses many specialized centres such as the Microsatellite Constellation Research Centre, the Radiation and Nuclear Engineering Research Centre, the Combustion Engineering Research Centre, the Satellite Technology Research Centre, the MARS AI Research Centre, and the Perigee-KAIST Rocket Research Centre.[396]

The Korea Institute of Geoscience and Mineral Resources (KIGAM) is contributing to space exploration by investigating the surface of planetary bodies. Building on a century of expertise in Earth geology, it has expanded its research into several space-fields such as planetary geology, GIS mapping, RS payload development, geophysical exploration, electronics, resource extraction, and resources utilisation.[397] One of its current focuses is on lunar science and exploration.[398]

The Electronics and Telecommunications Research Institute (ETRI) develops and distributes technologies in information, communications, electronics, broadcasting, and convergence technologies.[399] It hosts the Telecommunication & Media Research Laboratory, which is working on developing network technologies and 5G mobile communication, or radio-satellite research.[400]

[395] *Ibid.*
[396] "Centers, Institutes, and Labs: Research Organizations". KAIST. Available at: https://www.kaist.ac.kr/en/html/research/040301.html. Accessed December 2020.
[397] Kyeong Ja Kim. "KIGAM's new direction for lunar science and exploration in conjunction with lunar and planetary ISRU". 2019. KIGAM, at *Horizon 2061 Workshop*.
[398] Kyeong Ja Kim. "KIGAM's new direction for lunar science and exploration in conjunction with lunar and planetary ISRU". 2019. KIGAM, at *Horizon 2061 Workshop*.
[399] "Overview". ETRI. Available at: https://www.etri.re.kr/engcon/sub1/sub1_02.etri.Accessed December 2020.
[400] "Introduction". ETRI. Available at: https://www.etri.re.kr/eng/sub6/sub6_0101.etri?departCode=7. Accessed December 202.

5.3 Policy and legal framework

Early on, South Korea developed instruments to frame, regulate, and direct space activities. Space policies are embedded in space laws as they mandate the establishment of public policies. The key legal instruments cover industrial development, space activities development, and telecommunication. Modifications or amendments are often used to ensure that instruments are in line with the political and socio-economic context as well as the government's priorities.

5.3.1 Space policies and strategy

South Korean space policies are based on the Short, Middle and Long-Term National Space Development Basic Plan, which were first adopted in 1995 and revised in 2000, 2013, and 2018.[401]

The Basic Plan for Promotion of Space Development 2018-2022

The Basic Plan elaborates on mid- and long-term policy objectives and covers particular matters prescribed by the Promotion Act.[402] It sets the strategy and organisational structure, as well as implementation plans for space development in South Korea. It also outlines investment plans and training plans, as well as guidelines for promoting space projects.[403]

The Basic Plan aims at generating socio-economic benefits and contributing to national security. It is centred around four objectives:[404]

- Inspiring People (return asteroid samples by 2035),
- Fostering industry and employment (develop government satellites through private channels by 2030),
- Advancing strategic areas (provide private launch services for small satellites by 2030),
- Addressing challenges and national interest (develop Korean PNT System by 2034).

The plan arranges six missions to achieve its goals, focusing on domestic launch capabilities, satellites and their applications, space exploration, a national positioning system, space innovations systems, and space industry and employment.

[401] ESPI report New Space in Asia.
[402] Law no. 7538, *Space Development Promotion Act (2005)*, amended by Act no. 15243 (2017), art. 5.
[403] Law no. 7538, *Space Development Promotion Act (2005)*, amended by Act no. 15243 (2017), art. 5.
[404] Park, Seejeong. "National Space Policy in Korea". 2019. Space Policy Practitioners Workshop ESPI-APRSAF.

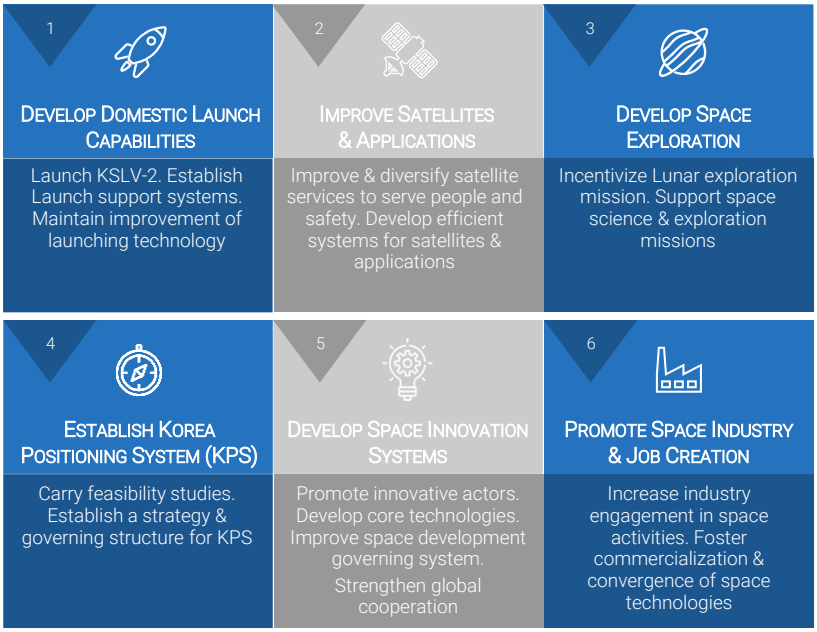

Figure 24: South Korea space plan missions (Promotion of Space Development Basic Plan)

Future Vision 2050

In 2019, KARI announced its plan for South Korea's aerospace development in the next 30 years, called Future Vision 2050. Future Vision 2050 is a set of 19 strategic goals to advance four areas of space activities: [405]

- space transportation (e.g., developing launchers, establishing a spaceport, etc),
- space exploration for science and research (e.g., lunar missions, cosmology, observation, and deep space research, etc),
- aerospace capabilities to respond to environmental changes (e.g., EO satellite network, NEO monitoring systems, and photovoltaic power generation system and other eco-friendly aerospace technologies, etc),
- space for socio-economic benefits and "prosperity of mankind" (e.g., PNT data and EO for improving living standards, creating a sustainable aerospace industry, creation satellite applications for the big data economy, etc).

As a result, this strategy highlights socio-economic benefits as a strong driver for pursuing space activities in Korea.

2018 Defense White Paper – Defense Reform 2.0

In 2018, South Korea released its 2018 Defence White Paper, revising the Defence White Paper of 2013. The policy document assesses the global security environment, as well as the developments of military powers in Northeast Asia. It presents both the National Security Strategy and the National Defence Policy.[406]

[405] "Future Vision 2050". KARI. Available at: https://www.kari.re.kr/eng/sub01_06.do. Accessed May 2021.
[406] Ministry of National Defense. 2018 Defense White Paper. 2018.

The White Paper introduces the Defence Reform 2.0, which aims at creating a military capable of taking initiative in responding to omnidirectional security threats, having an elite military powered by advanced technologies (including space), and having a military managed in a way that benefits the country. It is about developing and strengthening sovereign defence capabilities, exploiting the scientific and technological advancements of the Fourth Industrial Revolution to overcome human resource shortage, and adapting the defence apparatus to the future of warfare, as well as gaining public support and restoring public confidence in the Armed Forces after cases of corruption in the defence industry.[407]

Regarding space defence capabilities, the Defence White Paper outlines two priorities:

- Strengthening the Foundation for the Development of Space Defence Capabilities by updating the existing legal, institutional and policy framework, which governs space activities in South Korea. This framework enabled the Ministry of National Defence to establish a space organisation within the ministry, develop space defence capabilities, and operate the ROK-U.S. space defence cooperation channel. In addition, the government updated the "Basic Plan for the Promotion of Space Development", which enabled the Ministry of National Defence to acquire reconnaissance satellite and SST capabilities. The "Basic Plan for the Development of Space Défense Power" has also been revised and recommends pursuing the development of space defence capabilities by developing an operating system, establishing a space force, and increasing international cooperation.
- Development of an Alliance-Based Space Defence Cooperation by increasing cooperating with the United States, mostly through the ROK–U.S. Alliance. Since 2013, the two countries have been meeting within the Space Cooperation Working Group. South Korea and the U.S. signed cooperation agreements on Space Situational Awareness Service and Information Sharing in 2014. This agreement led the ROK Air Force to establish a space intelligence centre in 2015 in order to process and disseminate SSA data. In 2017, the Ministry of National Defence and the U.S. DoD conducted a military exercise to identify potential space risks on the Korean Peninsula.[408]

In 2018, outer space did not seem to be officially considered a warfighting domain equivalent to land, sea, air, and cyber. However, the White Paper outlines that the Air Force will be "reorganized to have a structure capable of strategic deterrence and aerospace operations" and that a Satellite Surveillance Control Unit, as well as an electro-optical satellite surveillance system will be established to monitor satellites orbiting over the Korean Peninsula.[409]

5.3.2 Legal and regulatory instruments

South Korea has enacted space-related legislation and regulatory measures that cover industrial development, space activities development, and telecommunications. Other laws can be identified such as the "Astronomy and Space Act" regulating the activities of people working in the field of astronomy, and the "Young Astronaut Korea Support Act" which aims at encouraging the youth to pursue careers in STEM.[410]

1987 Aerospace Industry Development Promotion Act

The purpose of this first space related law was: "to facilitate the peaceful use and scientific exploration of outer space and to contribute to national security, the sound growth of the national economy, and the

[407] *Ibid.*, 49-51.
[408] *Ibid.*
[409] *Ibid.*, 116.
[410] "Young Astronauts Korea Support Act". KLRI. 2015. Available at: https://elaw.klri.re.kr/eng_mobile/viewer.do?hseq=48724&type=part&key=18. Accessed May 2021.

betterment of citizen's lives by systemically promoting the development of outer space and by efficiently using and managing space objects." [411] Therefore, South Korea has always viewed space as an important domain for national security, industrial development, and socio-economic benefits.

The Act mandates the Government to establish a "master plan for aerospace industry development" and to adopt policies related to a series of projects such as the development and advancement of test technology for spacecraft, either directly or through other entities. [412] Overall, the content focuses on national needs and economic ambitions/plans and does not really address international aspects. [413]

Articles 14 and 15 established the "Aerospace Industry Development Policy Council", which is chaired by the Minister of Trade, Industry, and Energy, and is responsible for drafting a Master Plan for Aerospace Industry Development, coordinating relevant activities between ministries, and supervising space R&D. According to Article 3, this Master Plan is supposed to cover matters concerning goals and direction, implementation structures, strategies, and plans for the development of the aerospace industry; a comprehensive research system, as well as budgets for research and development of aerospace science and technologies; details on necessary funds, skills, and workforce to develop the industry; the creation of a specialized complex for the industry as well as details on international industrial cooperation.[414]

2005 Space Development Promotion Act & 2007 Act on Compensation for Damage caused by Space Objects

The Promotion Act works to facilitate and develop space activities, and contribute to national needs, such as security, economic growth, and improved living standards.[415] To this end, the Act mandates MSIT to establish three plans and their "action plans":

- Basic Plan and Action Plan for Promotion of Space Development (five years),
- Master Plan and Action Plan for Utilization of Satellite Information (five years),
- Basic Plan and Action Plan for Preparing against Dangers in Space (ten years).

To that end, MSIT will support projects and catalyse investment in the private sector through different measures such as forming human resources and providing tax support. An emphasis is put on the importance of fostering private initiatives.

The National Space Committee was established under Article 6 and chaired by MSIT. It has decision power on space development matters, formulation of plans, coordination of policies, designation of institutions, and permission for launch.[416]

Article 14 on Liability for Damage caused by Space Accidents implicitly introduces the 2007 Compensation Act which addresses compensation for damage, measures to be taken by the government in case of accident, and limitation of liability. The aim is to ensure both the protection of the victims' interests and the efficient development of space activities.[417]

Telecommunication Acts

Through relevant sub-entities, the Ministry of Science and ICT have enacted several acts to regulate telecommunications such as:

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[411] Law no. 8852, *Aerospace Industry Development Promotion Act* (1987), amended by Act no. 14116 (2016), art. 1.
[412] Law no. 8852, *Aerospace Industry Development Promotion Act* (1987), amended by Act no. 14116 (2016), art. 3, 4.
[413] Ahn, Youngshin. "Recent Developments in the Republic of Korea's Space Policy: An Overview of Space Activities and National Laws". 2019. *Air and Space Law* 44, no. 2.
[414] "Aerospace Industry Development Promotion Act". KLRI. 2016. Available at: https://elaw.klri.re.kr/eng_mobile/viewer.do?hseq=43106&type=part&key=28. Accessed May 2021.
[415] Law no. 7538, *Space Development Promotion Act* (2005), amended by Act No. 15243 (2017), art 1.
[416] Law no. 7538, *Space Development Promotion Act* (2005), amended by Act No. 15243 (2017), art 6.
[417] Law no. 8714, *Compensation for Damage Caused by Space Objects Act* (2007), amended by Act no. 14839 (2017), art. 1.

- The 2013 Telecommunications Business Act,
- The 2015 Framework Act on Broadcasting Communications Development,
- The 2015 Internet Multimedia Broadcast Services Act,
- The 2015 Radio Waves Act,

These laws do not solely focus on space-related technologies or activities, but rather cover telecommunication infrastructures at large.

5.3.3 International affairs

International and regional cooperation

At the international and diplomatic level, South Korea has ratified the OST, the Rescue Agreement, and the Liability Convention, and has acceded to the Registration Convention. The country is also a Party to the Nuclear Test Ban Treaty, the Convention on the Distribution of Programme-Carrying Signals Transmitted by Satellite (BRS), ITSO Agreement, IMSO Convention, and the ITU Constitution and Convention. South Korea is a member of UNOOSA and UNCOPUOS and is very active in these forums.

At the bilateral level, the United States is a strategic partner for South Korea. The two countries have been long-time partners and cooperate in various fields, especially defence and security. In 1953, the US-ROK Alliance was established as part of the US-ROK Mutual Defence Treaty to provide South Korea with a security guarantee in the aftermath of the Korean War.[418] In this framework, South Korea and the U.S. DoD conducted exercises to identify potential space threats across the Korean Peninsula. Since 2014, the two countries signed an MoU on "SSA Service and information Sharing". In 2021, South Korea and the U.S. agreed to increased cooperation in space in order to ensure effective joint response against emerging threats.[419] Additionally, South Korea and the U.S. cooperate in the field of space exploration. In 2021, South Korea announced its intent to join the Artemis Programme.[420] NASA and KARI also cooperate on the Korea Pathfinder Lunar Orbiter, which is planned to be launched in 2022. The Lunar orbit will carry five instruments, including one from NASA, which was developed by Arizona State University and Malin Space Science Systems.[421] The Korean Meteorological Administration also collaborates with NOAA as part of the KMA-NOAA Protocol on Cooperation in the Field of Atmospheric Science and Technology.[422]

Additionally, South Korea has a longstanding partnership with Russia. The two countries mostly cooperated in the field of launchers. Indeed, the missile test and attempted satellite launch of a North Korean satellite in 1998 prompted South Korea to accelerate the development of launchers.[423] In 2002, it partnered with Russia to build the Naro rocket (formerly known as KSLV-1), which consisted of a Russian first stage and a South Korean second stage. The rocket was successfully launched in 2013. Today, South Korea is looking to independently develop rockets (KSLV-2 or Nuri).[424] The two countries still cooperate in other areas. South Korea also signed cooperation agreements with CNES, DLR, JAXA, DTU, etc.

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[418] "Excerpt: The US-South Korea Alliance". Council on Foreign Relations. Available at: https://www.cfr.org/excerpt-us-south-korea-alliance. Accessed May 2021.
[419] "U.S.-ROK Leaders' Joint Statement". The White House. Available at: https://www.whitehouse.gov/briefing-room/statements-releases/2021/05/21/u-s-rok-leaders-joint-statement/. Accessed May 2021.
[420] Si-soo, Park. "South Korea to join NASA's Artemis project: reports". 2021. *SpaceNews*. Available at: https://spacenews.com/south-korea-to-join-nasas-artemis-project-reports. Accessed May 2021.
[421] "NASA Selects 'ShadowCam' to Fly on Korea Pathfinder Lunar Orbiter". 2017. NASA. Available at: https://www.nasa.gov/feature/nasa-selects-shadowcam-to-fly-on-korea-pathfinder-lunar-orbiter. Accessed May 2021.
[422] "Some of the International Satellite Data Shared with NOAA". NOAA Satellite and Information Service International and Interagency Affairs Division. Available at: https://www.nesdisia.noaa.gov/developingpartnerships.html. Accessed May 2021.
[423] Joon An, Hyoung. South Korea's Space Program: Activities and Ambitions. Asia Policy. Volume 15. No 2. 2020. 34-35.
[424] "Korea Space Launch Vehicle- KSLV (South Korea)". Krunichev State Research and Production Space Center. Available at: http://www.khrunichev.ru/main.php?id=73&lang=en. Accessed May 2021.

Figure 25: South Korea international cooperation (adapted from KARI)

International and regional competition

The development of South Korea's space capabilities should also be understood in a geopolitical context. Recent developments in the Asia Pacific region characterized by rising tensions between China and the United States, territorial disputes, religious and ethnic divides in Northeast Asia, as well as military build-ups in neighbouring countries. This state of affairs affects South Korea's strategic environment.[425]

In addition, North Korea is continuing to develop its nuclear program. According to Todd Harrison, et al, "North Korea's space intentions are closely tied to its ballistic missile aspirations".[426] Indeed, DPRK established two launch pads (Tonghae Satellite Launching Ground and the Sohae Satellite Launching Ground).[427] It developed several ballistic missiles such as the Hwasong-12, the Hwasong-10, and the Hwasong-14. The latter is estimated to have a range of approximately 10,000 km, thereby making it

[425] Ministry of National Defense. 2018 Defense White Paper. 2018.
[426] Harrison, Todd et al. *Space Threat Assessment 2021*. 2021. CSIS Aerospace Security Project. Available at: https://bit.ly/3frU5S9. Accessed May 2021.
[427] Tae Joo, Jeong. "North Korea readies deployment of new GPS jamming device/ Link to funeral prep- Daily NK & IBT". 2020. Resilient Navigation and Timing Foundation. Available at: https://rntfnd.org/2020/05/01/n-korea-readies-deployment-of-new-gps-jamming-device-link-to-funeral-prep-daily-nk-ibt/. Accessed May 2021.

capable of reaching LEO and MEO.[428] North Korea has six space systems in orbit, including one operational EO satellite (Kwangmyongsong-4), which was launched in February 2016.[429] However, nothing indicates that North Korea is currently developing counterspace weapons except for GPS jamming devices.[430]

In this context, South Korea, which mostly relies on the United States for monitoring the Korean Peninsula, initially planned to independently develop five reconnaissance satellites by the end of 2020 in order to better monitor the DPRK's military activities. However, the project has been delayed partly due to technological difficulties. In 2020, South Korea and the United States revised their joint missile guidelines to enable South Korea to develop rockets with solid fuel engines and develop a military reconnaissance satellite to by launched by the end of the 2020s.[431] [432] Additionally, ANASIS-II, South Korea's first military communications satellite was launched from Cape Canaveral by SpaceX's Falcon 8 rocket in July 2020.[433]

[428] Weeden, Brian; Samson, Victoria. *Global Counterspace Capabilities- An Open Source Assessment.* 2021. Secure World Foundation. Available at: https://swfound.org/media/207162/swf_global_counterspace_capabilities_2021.pdf. Accessed May 2021.
[429] *Ibid.*
[430] Harrison, Todd et al. *Space Threat Assessment 2021*. 2021. CSIS Aerospace Security Project. Available at: https://bit.ly/3frU5S9. Accessed May 2021.
[431] "Revised missile pact with US to facilitate Seoul's monitoring of Korean peninsula via satellite". 2020. *The Straits Times.* Available at: https://www.straitstimes.com/asia/east-asia/revised-missile-pact-with-us-to-facilitate-seouls-monitoring-of-korean-peninsula-via. Accessed May 2021.
[432] *Ibid.*
[433] Erwin, Sandra. "SpaceX Falcon 9 launches South Korea's Anasis-2 military satellite". 2020. *SpaceNews.* Available at: https://spacenews.com/spacex-falcon-9-launches-south-koreas-anasis-2-military-satellite/. Accessed May 2021.

5.4 Programmes & Infrastructure

5.4.1 Resources and infrastructure

In February 2021, MSIT announced the allocation of KRW 615 billion (USD 553 million) to the space programme in 2021.[434] The budget allocated to civil space activities in 2020 reached USD 537 million.[435]

Space-related infrastructure

Between 2000 and 2020, South Korea launched 31 satellites. South Korea has EO and telecommunications, but the majority of its satellites are dedicated to research. Most of South Korea's satellites are civil. While South Korea first focused on international cooperation, as well as the purchase of foreign technologies, it progressively built up its capacities and now focuses on developing satellites more independently.[436]

To manage its national space infrastructure, Korea has built a National Satellite Operation & Application Center, which operates governmental satellites and processes the space-based data they generate. It also conducts research and development based on satellite data and develops satellite operating technologies.[437] The centre is now upgrading the satellite data distribution and utilisation system and promoting the satellite data utilisation service to facilitate the use of government satellite data in public and private sectors.

The Satellite Operation Building is responsible for "monitoring the function and performance of satellite systems; planning the operation of satellite systems; making decisions on satellite system orbits and position control and the prediction, adjustment and management of orbit; monitoring communication between the satellite system and the ground system; and receiving earth observation images and weather images".[438]

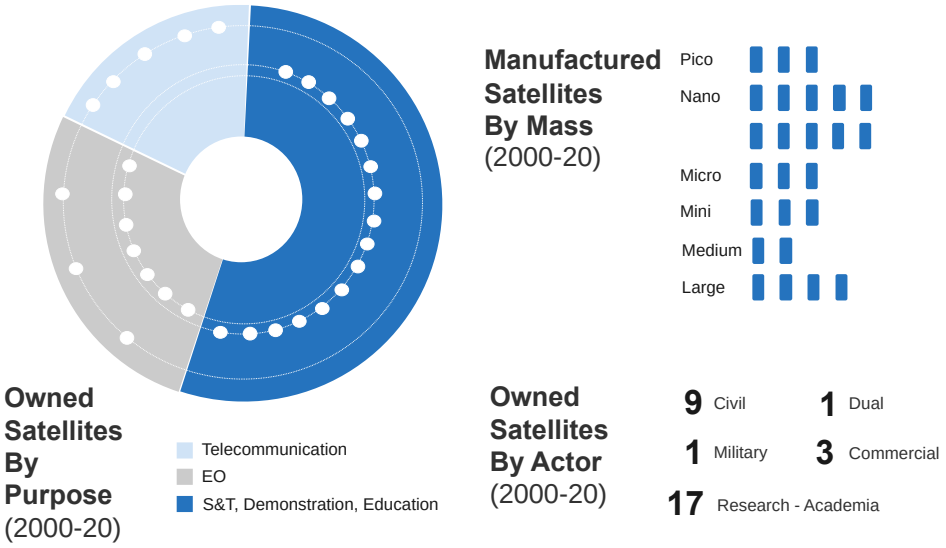

Figure 26: South Korea's space infrastructure overview (ESPI database)

[434] Si-soo, Park. "South Korean to spend 553 million on space projects in 2021". 2021. *SpaceNews*. Available at: https://spacenews.com/south-korea-to-spend-553-million-on-space-projects-in-2021/. Accessed February 2021.
[435] Korea Aerospace Industries Association, *Korea Aerospace Industry 2020-2021* (2020), 8-9.
[436] Joon An, Hyoung. South Korea's Space Program: Activities and Ambitions. Asia Policy. Volume 15. No 2. 2020
[437] "Utilization of Satellite Images". KARI. Available at: https://www.kari.re.kr/eng/sub03_05.do. Accessed May 2021.
[438] "Utilization of Satellite Images". KARI. Available at: https://www.kari.re.kr/eng/sub03_05.do. Accessed May 2021.

5.4.2 Space programmes and activity

Telecommunication

Civil telecommunication services are mainly provided through the Koreasat series of telecommunication satellites operated by KT Corporation, South Korea's sole satellite communication operator. There are currently four operational Koreasat satellites. Through Koreasat 5, the first dual communication system, the country has been developing its military communication capabilities. The military part of the system, called ANASIS I (Army, Navy, Air Force Satellite Information System I), is operated by the ADD.[439] In 2020, ANASIS II, South Korea's first entirely military satellite was launched.[440]

Spacecraft	Manufacturer	Launch Service Provider	Launch Year	Orbit & Mass	Customer	Purpose
Koreasat 5 (ANASIS I)	Thales Alenia Space	Sea Launch	2006	GEO, 4465 kg	KT Corp., ADD	Ku-Band, Ka-Band, SHF-Band, transponders. Dual satellite for broadband, digital TV, and military communications
Koreasat 6	Thales Alenia Space	Arianespace	2010	GEO, 2622 kg	KT Corp.	Ku-Band transponders. Provides HDTV, 3DTV, UHD, *etc.* Covers Korea.
Koreasat 7	Thales Alenia Space	Arianespace	2017	GEO, 3680 kg	KT Corp.	Ku-Band, Ka-Band transponders. Extends & improves coverage over Korea, Philippines, Indochina, India, Indonesia. Provides DTH broadcasting, VSAT networks, *etc.*
Koreasat 5A	Thales Alenia Space	SpaceX	2017	GEO, 3500 kg	KT Corp.	Ku-Band transponders. Replaces Koreasat 5. Covers Korea, Japan, Philippines, Guam, Indochina, South Asia. Provides DTH broadcasting & improves maritime coverage.
ANASIS II	Airbus Defence & Space	SpaceX	2020	GEO, 5500 kg	ADD	Military communication. Complements Koreasat 5/ANASIS I satellite.

Table 22: South Korea telecommunication satellites (ESPI database)

[439] "Koreasat 5 (Mugunghwa 5, ANASIS 1)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/koreasat-5.htm. Accessed May 2021.
[440] "ANASIS 2 (KMilSatCom 1, URC-700K, Koreasat 116)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/anasis-2.htm. Accessed May 2021.

Earth Observation

South Korea first developed EO capabilities through an international partnership with the University of Surrey (UK) and benefited from knowledge transfer programmes in which Korean engineers went to the UK to receive training and assist in the development of South Korea's first satellites KITSAT-1 and KITSAT-2.[441] Then, South Korea developed its own capacities.

In 2006, KOMPSAT-2, a lightweight EO satellite developed by KARI, was launched from Plesetsk, Russia on a Rokot-KM. The satellite is still operational today and aims at monitoring climate change and provides imagery for land use and disaster management. While KOMPSAT-2 is a civil satellite, it also provides South Korea with high-resolution images of the Korean peninsula, including North Korean military activities.[442] The Korean Multi-Purpose Satellite series consists of eight satellites, six currently in orbit and two planned to be launched in 2021.

The Geostationary Earth Orbit Korea Multi-Purpose Satellite (GEOKOMPSAT) series monitors the environment and the ocean.

The Compact Advanced Satellite 500 (CAS500) series consists of two EO satellites with Advanced Earth Imaging Sensor System.[443] While CAS500-1 was jointly developed by KARI and industry (mostly Korea Aerospace Industries), CAS500-2 is mostly developed by industry and KARI only carried out the technical audit and provided technical support.[444] This is part of a broader policy to transfer activities and capabilities to the private sector. In the future, KARI plans to transfer most of the responsibilities and activities to the private sector for the development of 500-kg class satellites in order to focus on areas that still need the government's support.[445]

The ADD is developing four SAR reconnaissance satellites as part of the 425 Project. The project is being developed by KEI and Hanwha Systems Corps and the SAR payload will provided by Thales Alenia Space. It will serve the Korean authorities for surveillance, intelligence, and control of specific areas of interest.[446]

Spacecraft	Manufacturer	Launch Provider	Launch Year	Orbit	Customer	Purpose
KOMPSAT 2	KARI	Eurockot Launch Services	2006	LEO, 800 kg	KARI	Uses a high-resolution multi-spectral camera for land management, disaster & risk mitigation, *etc.*
GEO KOMPSAT 1	Airbus	Arianespace	2010	GEO, 2500 kg	KARI	Provides 24/7 weather and ocean monitoring, satellite communication, broadcasting, *etc.*

[441] Moerman, M.J.M. "Overall Programmes at the University of Surrey". Available at: https://core.ac.uk/download/pdf/32553509.pdf. Accessed May 2021.
[442] "KOMPSAT 2 (Arirang 2)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/kompsat-2.htm. Accessed May 2021.
[443] "CAS500 1, 2". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/cas500-1.htm. Accessed May 2021.
[444] "CAS500 (Compact Advanced Satellite 500)". KARI. Available at: https://www.kari.re.kr/eng/sub03_02_03.do. Accessed May 2021.
[445] Si-soo, Park. "With CAS500, South Korea launches journey toward private-led satellite development". 2021. *SpaceNews*. Available at: https://spacenews.com/with-cas500-south-korea-launches-journey-toward-private-led-satellite-development/. Accessed May 2021.
[446] "425 Project radar satellite 1, ..., 4". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_sdat/425-project-sar.htm. Accessed May 2021.

KOMPSAT 3	KARI	Mitsubishi Heavy Industries	2012	LEO, 980 kg	KARI	Uses a sub-meter resolution electro-optical camera for stereo and broadband recording.
KOMPSAT 5	KARI	ISC Kosmotras	2013	LEO, 1315 kg	KARI	Provides all-weather observation of Earth (SAR). Complements KOMPSAT 3 & 3A. Used to detect flooding, oil spills, drought, *etc.*
KOMPSAT 3A	KARI	ISC Kosmotras	2015	LEO, 1100 kg	KARI	Uses an optical resolution and IR sensor to observe high-temperature phenomena, *e.g.*, forest fires, nuclear facilities.
SNUSAT 2	SNU	SpaceX	2018	LEO, 3kg	SNU	Provides early scanning for disaster monitoring. Test star tracker and earth sensor.
Geo-Kompsat 2A & 2B	KARI	Arianespace	2018	GEO, 3400-3500 kg	KARI	Space meteorology, marine environmental observation. 2A observes ground and space meteorological conditions. 2B monitors the oceans
CAS500-1, CAS500-2	KARI	Glavkosmos	2020	LEO, 500kg	KARI	Caters to public sector needs in high-resolution satellite imagery.

Table 23: South Korea EO satellites (ESPI database)

S&T, Education

Science and technology demonstrations hold an important place in South Korea. Most Korean satellites have been launched for academic or technological demonstration purposes. These missions have been mostly developed by KAIST to create a path for future missions and demonstrate indigenous skills.

South Korea is also part of an international consortium to operate a nanosatellite science mission called CINEMA, launched between 2012 and 2013. KHU contributed to two of the four CubeSats, CINEMA 2 and 3, also branded as KHUSAT 1 and 2.[447] In the future, several new missions are envisioned, including:

- In space science, with the KASISAT series developed by KASI,
- In technology, with MIMAM by Yonsei University, Snuglite 2 by SNU, and NEXTsat 2 by KAIST.

447 "CINEMA 1, 2, 3, 4 (KHUSAT 1, 2)", Gunter's Space Page.

Spacecraft	Manufacturer	Launch Provider	Launch Year	Mass & Orbit	Customer	Purpose
STSat 1	KAIST	Cosmos International	2003	LEO, 100kg	KAIST	Technology, Astronomy. Carries space science research & develop tech for future missions.
STSat 2C	KAIST	KARI	2013	LEO, undue 100kg	KAIST	Technology demonstration (study near-earth environment, test new technologies)
STSat 3	KAIST, Satrec	ISC Kosmotras	2013	LEO, 150kg	KAIST	Science, EO, technology demonstration. Provides astronomical imagery of galaxy, infrared & hyperspectral imagery to monitor Earth's environment, water, and land.
LINK	KAIST	ULA	2017	LEO, 2kg	KAIST	Technology, thermospheric research. Measures ions & atoms.
SNUSAT 1 & 1B	SNU	ULA	2017	LEO, 2 kg	SNU	Technology, thermospheric research. Studies lower thermosphere and
CANYVAL-X1& X2	Yonsei University, NASA	Antrix Corp.	2018	LEO, 1-2,7 kg	Yonsei University, NASA	Technology demonstration. Tests a vision alignment system and a virtual telescope system.
CNUSail 1	CNU	Antrix Corp.	2018	LEO, 4kg	CNU	Technology demonstration. Conducts solar sail experiments to deploy the craft in LEO & perform de-orbiting using a "drag-sail" technique.
KAUSAT 5	KAU	Antrix Corp.	2018	LEO, 4kg	KAU	Technology demonstration. Uses IR camera & measures radiation levels around LEO.

SIGMA	KHU	Antrix Corp.	2018	LEO, 4kg	KHU	Space Science. Measures magnetic fields & radiation.
STEP Cube Lab	Chosun U	Antrix Corp.	2018	LEO, 1 kg	Chosun U	Technology demonstration. Rates national academic technologies for future missions.
K2SAT	KAIST	SpaceX	2018	LEO, 3 kg	KAIST, Korea AF Academy	Technology demonstration. Tests satellite imaging & transfer, and voice repeating.
NEXTSat1	KAIST	SpaceX	2018	LEO, 100 kg	KAIST	Technology demonstration. Creates standardized platform for small satellites, conducts in-orbit verifications, carries geo-environmental and astronomical monitoring.
SNUGLITE	SNU	SpaceX	2018	LEO, 2 kg	SNU	Technology demonstration. Tests a dual frequency GPS receiver and a measuring system for magnetic fields.
VisionCube	KAU	SpaceX	2018	LEO/SS 0,2 kg	KAU	Thermospheric research. Studies transient luminous events in upper atmosphere.

Table 24: South Korea S&T, education satellites (from ESPI database)

Positioning Navigation and Timing

Korea is reinforcing its PNT infrastructure, with KARI working on two PNT projects, the Korea Augmentation Satellite System (KASS), and Korea Positioning System (KPS).[448]

KASS is a Satellite Based Augmentation System that will deliver more accurate GPS positions. The system should be operational in 2022, making South Korea the seventh country to have such capabilities.[449] In 2021, the United States announced that it will provide support to South Korea for the development of KASS.[450]

[448] "Satellite Navigation, SBAS: more accurate GPS". KARI. Available at: https://www.kari.re.kr/eng/sub03_06.do. Accessed December 2020.
[449] *Ibid.*
[450] Messier, Doug. "U.S., South Korea to Deepen Space Cooperation Through Artemis Accords, Satellite Navigation System". 2021. *Parabolic Arc.* Available at: http://parabolicarc.com/2021/05/23/u-s-south-korea-to-deepen-space-cooperation-through-artemis-accords-satellite-navigation-system/. Accessed May 2021.

KPS will respond to the needs of the Korean Peninsula by using seven systems, three GEO navigation satellites and four oblique navigation satellites.[451] KPS is being developed in order to reduce reliance on foreign GNSS systems, whose access depends on political and geopolitical developments. It is also aimed at accelerating the Fourth Industrial Revolution and enable self-driving cars, drones, and other connected objects.[452] KPS should be completed by 2035.[453]

Space Situational Awareness

At UNCOPUOS in 2021, South Korea recognized that space was "becoming increasingly congested, contested, and competed by a number of actors and objects." South Korea assessed that an arms race is currently occurring in space and that it could escalate towards potential weaponization of space and aggressive actions. In this context, South Korea advocated for an approach based on observable behaviour through transparency and confidence building measures as well as better space situational awareness in order to identify threats and intent behind some space activities.[454]

In terms of capabilities, South Korea's efforts in SSA are led by both civil and defence stakeholders. While most of its SSA data relies on its partnership with the U.S. Department of Defence, civil capabilities are developed within KASI and can be categorized in six lines of activities:

- Radar surveillance technology,
- Optical surveillance technology,
- Orbit analysis & estimation,
- Risk analysis and space catalogue,
- Asteroid characteristics and risk analysis,
- OWL-Net development.

The OWL-Net (Optical Wide-field patroL Network) is an optical space surveillance system which monitors satellites in LEO.[455] The system is based on a network of telescopes that operate completely autonomously and is able to take several images of passing satellites and to follow them. There are two observatories, one in Mongolia and the other in Morocco, both controlled by the Site Operating Server (SOS).[456] Besides KASI, ADD is developing several space based SSA capabilities, such as infrared cameras and multi-sensor/multi-source imagery fusion.[457]

Space exploration and human spaceflight

The core of South Korea's space exploration plans lies with KARI's Korean Lunar Exploration Programme. It aims at building the first lunar probe, named Korea Pathfinder Lunar Orbiter (KPLO), which is scheduled to be launched by 2022. The project will be divided in two phases:

- Phase 1 will be conducted in partnership with international actors (mostly NASA) in order to secure the necessary core technologies for space exploration, establish a deep space telecommunication

[451] "Satellite Navigation, SBAS: more accurate GPS". KARI. Available at: https://www.kari.re.kr/eng/sub03_06.do. Accessed December 2020.
[452] Satellite Navigation, SBAS: more accurate GPS". KARI. Available at: https://www.kari.re.kr/eng/sub03_06.do. Accessed December 2020.
[453] "South Korea to build its own Korean Positioning System". 2018. *Geospatial World*. Available at: https://www.geospatialworld.net/news/south-korea-build-korean-positioning-system/. Accessed May 2021.
[454] "Republic of Korea's National Report on the UNGA Resolution A/Res/75/36". 2021. Available at. https://front.un-arm.org/wp-content/uploads/2021/05/210503-National-Submission-Republic-of-Korea_75_36.pdf. Accessed May 2021.
[455] "OWL-Net development". KASI. Available at: https://www.kasi.re.kr/eng/pageView/325. Accessed December 2020.
[456] *Ibid.*
[457] "Infrared Camera for Satellites". ADD. Available at: https://www.add.re.kr/board?menuId=MENU02881&siteId=SITE00003. Accessed December 2020,

network, and develop the five payloads that will be carried by the probe (a 5m high-resolution camera, a wide-field polarized camera, a magnetic field sensor, a gamma ray sensor, and space internet test equipment).

- Phase 2 will see the development of the unmanned lunar orbiter and lunar lander, which are planned to be launched by a Korean launch vehicle.[458]

Regarding human spaceflight, the Korean Astronaut Programme was carried out between 2006 and 2008. It led Yi So-yeon to become first South Korean astronaut to visit the ISS. This programme aimed at developing manned space technologies and conducting space experiments, as well as engaging the general public and raising awareness on space. KARI, as part of the Manned Space Experiment, is also conducting research on manned space technologies that could serve the U.S. Lunar Gateway or manned Mars missions.[459] In 2021, South Korea signed the Artemis Accords, which will increase cooperation on space exploration with the U.S and the nine other signatories. It remains to be seen how the Artemis Accords will impact space exploration and human spaceflight programmes in South Korea.[460]

Space transportation

South Korea has progressively been building autonomous launching capabilities. South Korea started to develop sounding rockets in the 1990s. In 1998, the North Korean Taepodong missile test and attempted launch of their satellite Kwangmyŏngsŏng-1 pushed South Korea to accelerate the development of launch vehicles.[461]

In 2002, South Korea did not have the necessary technological capabilities and know-how to develop a rocket independently by 2005. Therefore, it decided to partner with the Khrunichev State Research and Production Space Center in Russia to build its first rocket (Naro-1, formerly known as KSLV-1). Naro-1 consisted of a Russian first stage, which was identical to the Angara rocket, and a South Korean second stage. In 2003, South Korea started to build the Naro Space Center, a spaceport located in Bongrae-myeon, Goheung-gun, Jeollanam Province, also in cooperation with Russia.[462] However, South Korea did not manage to launch its first rocket by 2005. The launch was delayed due to technological transfer issues between Russia and South Korea and failed launch attempts.[463] In 2009, the first launch was conducted, but the payload failed to separate properly. In 2010, a second launch was conducted but also failed to reach orbit.[464] In 2013, Naro-1 was successfully launched from the Naro Space Center in South Korea.

Building on the knowledge and expertise developed thereupon, KARI began developing a second series of launchers, KSLV-2 (also called Nuri). It will be the first fully indigenous launch vehicle when completed in 2021. Its payload capacity will have a significant increase in comparison to KSLV-1, going from 100kg to 1.5 tons for KSLV-2. Although the main target is the domestic market, its services should also be commercialized internationally. KAI has been designated the main system integrator since 2014. In 2018, KSLV-2-TLV test launch was successfully conducted. The maiden flight is scheduled for 2021.[465] Cooperation between South Korea and Russia did not stop after KSLV-1, but took on a different form, as Russian expertise was brought into the development of KSLV-2 ground infrastructure. According to

[458] "Korean Lunar Exploration Program". KARI. Available at: https://www.kari.re.kr/eng/sub03_04_01.do. Accessed May 2021.
[459] "Convergent Technologies: Intelligence and advancement of state-of-the-art aerospace technologies". KARI. Available at: https://www.kari.re.kr/eng/sub03_07.do. Accessed December 2020.
[460] Messier, Doug. "U.S., South Korea to Deepen Space Cooperation Through Artemis Accords, Satellite Navigation System". 2021. *Parabolic Arc.* Available at: http://parabolicarc.com/2021/05/23/u-s-south-korea-to-deepen-space-cooperation-through-artemis-accords-satellite-navigation-system/. Accessed May 2021.
[461] Joon An, Hyoung. South Korea's Space Program: Activities and Ambitions. Asia Policy. Volume 15. No 2. 2020.
[462] "Naro Space Center". KARI. Available at: https://www.kari.re.kr/eng/sub03_03_04.do. Accessed May 2021.
[463] Joon An, Hyoung. South Korea's Space Program: Activities and Ambitions. Asia Policy. Volume 15. No 2. 2020.
[464] "Naro-1 (KSLV-1)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_lau/naro-1.htm. Accessed May 2021.
[465] "Nuri (KSLV-2)". Gunter's Space Page. Available at: https://space.skyrocket.de/doc_lau/kslv-2.htm. Accessed May 2021.

Hyoung Joon An, the KSLV program was significant in establishing South Korea as an emerging spacefaring nation and contributed to the prestige and soft power of the country abroad.[466]

Furthermore, KARI improved its infrastructure at the Naro Space Center with the construction of a second launch pad. KARI plans to develop more launchers in the future, namely KSLV-2A, a reusable KSLV-2A, a small launch vehicle (SSLV), KSLV-3, and KSLV-4. SSLV is supposed to be an opportunity for the private space sector to build on KSLV experience.

In parallel to these developments, private companies have been also targeting the development of micro-launchers. The most notable efforts are led by Perigee with its Blue-Whale project. Blue-Whale 1 is Korea's first privately developed micro-launcher. It consists of two stages for a total of 8.5 meters and 1.8 tons.[467] While detailed information has not been released, it was announced in 2019 that the launch services would be provided by Southern Launch from the Whaler's Way Complex, Australia. Perigee plans to expand its capabilities in the future with ambitions to carry up to 300 kg into LEO before 2025.[468]

Launch Vehicle	Manufacturer/ launch provider	Characteristics	Performance range (kg)	Launch Year	Launch site
KSLV-1 (Naro)	KARI, Khrunichev	Orbital rocket 2 stages 33.5m	100kg in LEO	2009, 2010 Failure 2013, Success	Anheung test site (Taean)
KSLV-2-TLV	KARI, KAI	Suborbital rocket 2 stages 25,8m	200km (dummy upper stage)	2018	Naro Space Center
Blue-Whale 1	Perigee Aerospace	Orbital rocket 2 stages 8.5m	50 kg to 500 km SSO, 63 kg to 500 km LEO	>2020	Whaler's Way, South Australia
KSLV-2 (Nuri)	KARI, KAI	Orbital rocket 3 stages 47,2m	1.500 kg in LEO (800km SSO)	> 2021	Naro Space Center

Table 25: South Korean launch vehicles (adapted from KARI and Perigee)

[466] Joon An, Hyoung. South Korea's Space Program: Activities and Ambitions. Asia Policy. Volume 15. No 2. 2020.
[467] Henry, Caleb. "Backed by Samsung, South Korean startup Perigee aims for 2020 maiden launch". 2019. *SpaceNews*. Available at: https://spacenews.com/backed-by-samsung-south-korean-startup-perigee-aims-for-2020-maiden-launch/. Accessed December 2020.
[468] *Ibid.*

5.5 Key takeaways

5.5.1 South Korea's space ambitions

South Korea's efforts in the space sector have been driven by different objectives over the years, mostly industrial development, defence, and security, as well as socio-economic benefits. These drivers were already outlined in the 1987 Aerospace Industry Development Promotion Act, which are defined as, "national security, the sound growth of the national economy, and the betterment of citizen's lives" as key objectives.

In the 1970s, South Korea started to pursue space activities for industrial development purposes. Space was seen as a way to catch up with developed and industrialised economies, improve the country's competitiveness, and develop new technologies with a skilled workforce. Today, South Korea seeks to develop more autonomous industrial and technological capabilities.

In the last two decades, socio-economic benefits have taken a more important place in South Korea's space policies. The contribution of space in improving living standards, contributing to public safety, solving social problems, and generating ripple effects in other sectors of the economy is often mentioned. KARI is primarily tasked to "contribute to the development of the national economy and the improvement of the quality of life for people by developing world-class aerospace science and technology." [469]

Furthermore, South Korea is pursuing space activities for defence and security purposes in order to ensure national security objectives and monitor North Korean military activities in the region. Several developments in the space sector have been pursued or accelerated following North Korea's space and nuclear developments. For instance, the development of launching capabilities was accelerated following the failed North Korean launch of Kwangmyŏngsŏng-1. South Korea launched its first military satellite in 2020 and is expected to further develop its military space capabilities now that the U.S. has lifted restrictions on solid fuels.

Finally, prestige and soft power have been traditionally given less consideration. Nonetheless, ongoing and planned developments in the field of exploration and navigation suggest a progressive consolidation of this driver as well. South Korea's communications efforts rarely target an international audience but rather focus on South Korean citizens. According to the Global Soft Power Index 2021, South Korea is ranked as the 11th most influential nation in the world. While some space developments have surely contributed to South Korea's soft power (e.g., South Korean first astronaut or KSLV-1), its influence abroad mostly comes from pop culture, the tech sector, and gastronomy.

5.5.2 Key achievements

Over the last four decades, South Korea has developed its space activities and capabilities and reached key milestones, making it an emerging spacefaring nation.

Politics

At the international level, South Korea signed four UN space treaties and is a Member State of UNOOSA and UNCOPUOS. At the bilateral level, South Korea signed numerous cooperation agreements and partnerships with foreign space agencies and space companies. It developed cooperation with the United

[469] "Outcome of R&D Investments". KARI. Available at: https://www.kari.re.kr/eng/sub01_07.do. Accessed December 2020.

States and Russia, which provided knowledge and technology transfers that enabled South Korea to build indigenous capabilities.

At the national level, several institutions were established early on to supervise space activities. KASI was established in 1974 to conduct scientific research and KARI was established in 1989. While KARI is not a full-fledged space agency, it is generally recognized by international partners as the country's space agency. Space development programmes are planned and managed by the Ministry of Science and ICT, but other ministries are also involved in space activities, namely the Ministry of National Defence; the Ministry of Oceans and Fisheries; the Ministry of Land, Infrastructure, and Transport; and the Ministry of Foreign Affairs. In addition, the country is home to many universities providing space-related curriculums. Korea's share in scientific publications in the OECD "Space literature" dataset has consistently increased over the past 20 years, and it now ranks among the top countries in space-related patent applications.[470] In addition, laws and regulations have been adopted since 1987 to enable and regulate space activities, including commercial ones. Several space policies have been adopted, such as the Basic Plans and Defence White Papers, which are regularly updated.

As a result, South Korea has developed a comprehensive policy and legal framework to enable and regulate space activities and established national institutions to implement the country's objectives.

Programmes

At the programmatic level, South Korea has developed capabilities in various areas. It launched its first satellite in 1992. South Korea has mature capabilities in telecommunications, Earth observation, science and technology, as well as launching infrastructures. South Korea is currently building a navigation system and developing autonomous launching capabilities. These two latest developments will play an important role in enhancing South Korea's strategic autonomy.

South Korea is now looking to expand its activities to space exploration with the Korea Pathfinder Lunar Orbiter. Additionally, South Korea signed the Artemis Accords to facilitate cooperation with NASA and other signatories in the field of exploration. This will enable South Korea to develop its know-how in this field and acquire core technologies for space exploration and deep space communications.

In terms of manufacturing, South Korea can manufacture light, medium, and heavy satellites for both national and international customers. Several universities, as in the case of KAIST, KAU, SNU and KHU, contribute to the country's activities and have manufacturing capacities, with 14 academic satellites launched between 2017 and 2020. At the moment, KARI and ADD remain the main drivers of space manufacturing activities in Korea. However, now that the South Korean space industry has mature capabilities for large satellites, South Korea is looking to transition its space industry and economy from a sector governed mostly by the state to being led by the private sector. To this end, KARI is progressively transferring responsibilities to the private sector for the development of 500-kg class satellites to focus on areas that still need the government's support.

[470] OECD, *The Space Economy in Figures: How Space Contributes to the Global Economy* (2019).

6 Europe and Emerging Spacefaring Nations

6.1 Emerging spacefaring nations: pursuing autonomy for different objectives

The selected case studies show that the concept of an "emerging spacefaring nation" encompasses very different actors with varying sets of technical capabilities, resources, focus areas, and ambitions.

Some commonalities among emerging spacefaring nations can however be identified, particularly in relation to the pursuit of technical and political autonomy, which is a central driver for the development of their national space activities. Emerging spacefaring nations have rising national space ambitions, but often possess limited domestic capacities. Closing this gap, including for critical areas of their national programmes, is a shared concern among emerging spacefaring nations. These countries seek to build on a mix of international partnerships, technology transfers, and capacity-building programmes to achieve a greater level of autonomy.

Their national ambitions are shaped by several drivers, which are common across the spectrum of space actors, but influence developments in individual emerging spacefaring nations to varying degrees:

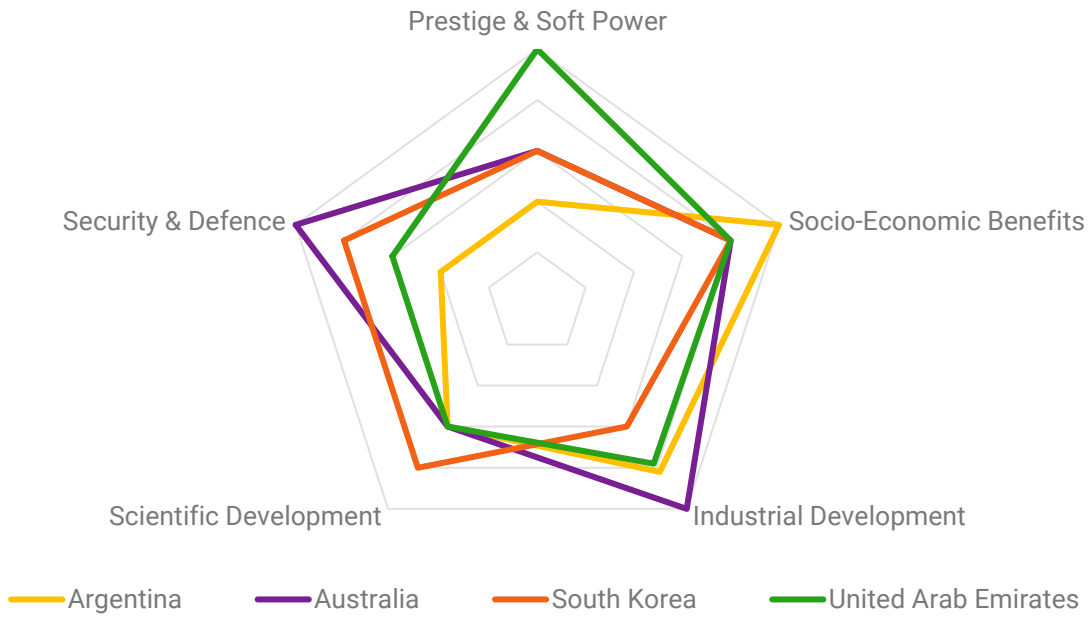

Figure 27: Mapping drivers of the four analysed emerging spacefaring nations

Industrial development: the space industry is often either set-up through international cooperation and knowledge transfers or established by adapting expertise and capabilities from other sectors (e.g., nuclear sector, defence sector).

Socio-economic benefits: space is increasingly integrated in the economy and society of emerging spacefaring nations at large. It provides opportunities for economic growth and economic diversification, which are often acknowledged and promoted in policies and public speeches.

Security and Defence: space is used to pursue national security objectives and support military operations. Emerging spacefaring nations often rely on foreign and/or commercial systems for security and defence purposes. Also, space is sometimes recognized as an operational domain.

Scientific development: universities and schools often play an important role in the space ambitions and programmes of emerging spacefaring nations, in terms of education and research as well as manufacturing, assembly, and testing.

National prestige and soft power: space contributes to national stature on the international scene and inspires national unity and pride in a country's achievements. Space is perceived as a foreign policy tool and emerging spacefaring nations are rather active in international discussions to communicate their vision of space and promote their positions.

All four selected countries are looking to generate significant socio-economic benefits, recognizing the multitude of ways space-based systems and space-derived data can contribute to national development, while supporting governmental policies and the wider economic landscape. Governments also often publicise socio-economic benefits in order to create public support for public spending. Regarding security and defence, space systems are often dual purpose and civilian satellites can also contribute to national security objectives of emerging spacefaring nations. Space-related defence policy objectives can vary from one country to another depending on geopolitical contexts, strategic culture, and perceptions of space as an operational domain. The importance of other drivers such as scientific and industrial development or prestige and soft power also varies according to the broader political, economic, and diplomatic priorities of the country.

Irrespective of the specific commonalities and differences, the emergence of new actors in the space arena can be expected to have implications for the international space community and, hence, also for European stakeholders, both at the European and the national level.

6.2 State of affairs: a wide-ranging engagement

Europe has cooperated with emerging spacefaring nations both at the national and the pan-European level. This cooperation has taken place on various planes, in different frameworks, and across various space fields, including satellite telecommunications, remote sensing, launch services, and science and exploration. Cooperation with Europe played a role in the emergence of some countries on the space scene, as many cooperation agreements included know-how and technology transfer.

6.2.1 Cooperation with ESA: pursuing programmatic goals

International cooperation activities have been on the agenda of the ESA Council since its creation in 1975.

Historically, ESA's approach to international space cooperation has been driven by the potential for programmatic opportunities, rather than a clearly defined foreign policy agenda. In recent decades, ESA has built a reputation as a reliable partner for cooperation with both third countries (USA, Russia, Japan, India, China, etc.), as well as international organizations (The World Bank, Asian Development Bank, etc.) in all areas of ESA's activities. The specificities of cooperation are varied, and can include global development assistance, technological support, leveraging synergies, sharing costs in resource intensive missions, and reliance on third country infrastructures, services, and know-how, for example.

ESA has worked with many of the identified emerging spacefaring nations and their national space agencies since the inception of their programmes. This has enabled ESA to gain a better understanding of their motivations and to tailor engagement with them. This also benefits Europe at large, especially in the form of industrial exports and the development of infrastructures in third countries.

Overall, ESA´s cooperation with third countries has undergone different historical phases of development, which have been summarised below.

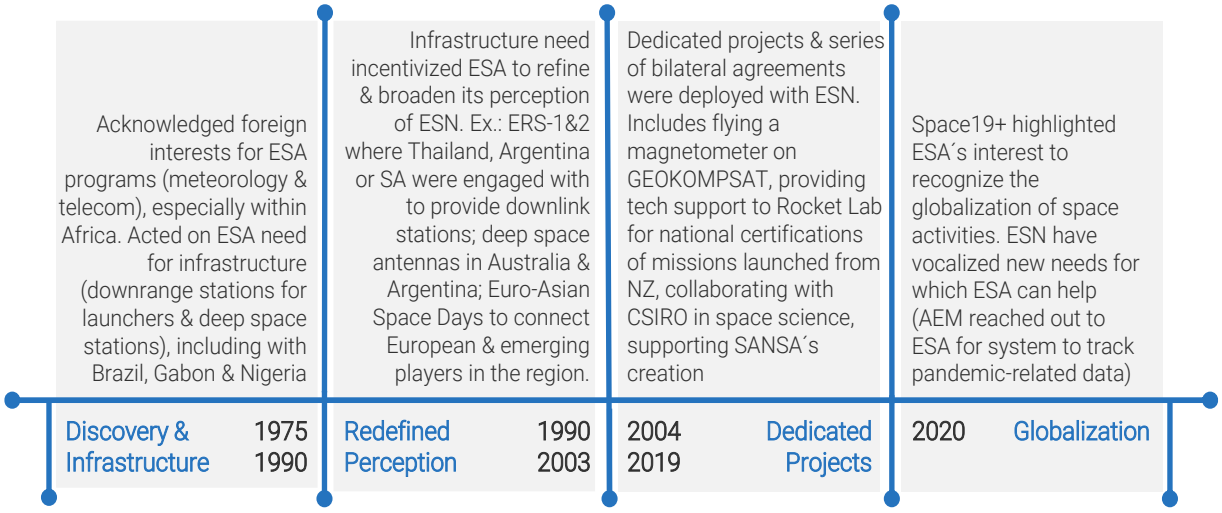

Figure 28. The evolution of ESA cooperation with emerging spacefaring nations and other third countries

Looking at more recent relations, ESA is involved in many international initiatives with emerging spacefaring nations, including Australia, New Zealand, South Korea, Argentina, Brazil, Mexico, South Africa, and the UAE.

With regard to the four analysed case studies of this report, recent activities are summarised below:

Country	Cooperation activity
Australia	Joint Statement of Intent with ASA on expanding bilateral cooperation and identifying joint projects. Implementation of Copernicus MoU and Agreements with CSIRO and Geoscience for EO cooperation. Construction of third deep space tracking station in New Norcia based on agreement with the Federal Government, to be supported by CSIRO.
Argentina	Organisation of Jordana Espacial with the Buenos Aires Planetarium showcasing presentations from ESA and CONAE to a group of students. Kick-off meeting for a project to use Argentina's Antarctic bases as a ground-based analogue to train for human space exploration. Continued discussions about the Malargüe deep space antenna and improvements to be made around the premises. Letter of Intent with the Buenos Aires Planetarium to have teachers in the country access the CESAR teacher-training programme. Awareness actions on ESA presence in Argentina.
South Korea	The Atomic Clock Ensemble in Space (ACES) Investigators Working Group agreed to the Korea Research Institute of Standards and Science (KRISS) hosting a microwave link ground terminal for ESA to connect their clocks to the ACES network, at the financial expense of KRISS. Request from KARI to use the ESTRACK network for their lunar mission. Ground station support to Korean infrastructure in order to benefit ESA's deep space ground station network.
UAE	Support activities to implement a memorandum of Intent signed with MBRSC and prepare Hazza Al Mansoori for spaceflight. Collaboration in space education.

Table 26: Selected major ESA-ESN cooperation

6.2.2 Cooperation with the EU: multiple engagements

International relations in space at the EU level are addressed by the European Commission and the European External Action Service (EEAS). Other actors are also regularly solicited to support specific dialogues or initiatives including ESA, EUMETSAT, the GSA (soon to be EUSPA), the European Environment Agency (EEA), the ED, and the European Union Satellite Centre (EU SatCen).[471]

Notably, the EU already engages in space relations with emerging spacefaring nations, such as Australia, Brazil, South Africa, and South Korea. EC and EEAS engagement with these countries has been driven by a mix of programmatic and political objectives. These include:

- Contributing to the implementation of European space programmes (EGNOS, Galileo, and Copernicus), their market uptake and extension of EGNOS,
- Supporting European research and innovation, while opening up markets abroad for European space-related technology and services,
- Promoting dialogue to facilitate institutional and industrial cooperation and regulatory convergence on topics ranging from safety and security to commercialisation and education through various channels and events,
- Reducing safety and security risks to keep outer space accessible to all, for its sustainable usage.

Relations with emerging spacefaring nations are more broadly embedded in the context of the 2016 Space Strategy for Europe and its overarching ambition to "promote [Europe's] position as a leader in space, increase its share on the world space markets, and seize the benefits and opportunities offered by space". These international ambitions are promoted through three main tools and mechanisms:

- Space dialogues and economic diplomacy to accompany European companies on global markets,
- Cooperation in EU flagship programmes (namely Copernicus and EGNSS),
- Participation in EU Framework Programmes for Research and Innovation.

Space Dialogues

Since 2005, space dialogues have been established with selected countries by the European Commission and the EEAS to advance European space objectives and contribute to the EU's overall external policy priorities.[472] Although space dialogues have been mainly established with existing space powers (the United States, Russia, China, and Japan), the European Commission has been increasingly eager to include emerging spacefaring nations in dialogues to discuss EO, navigation, space exploration and security-related issues. Recently, the Commission has established space dialogues with Australia and South Africa, with meetings taking place on an annual basis.

Through these dialogues, international partners are encouraged to promote responsible and peaceful behaviours in space. The 3SOS initiative was founded to raise international awareness on the consequences of an increasingly congested, contested, and competitive space environment and on the fact that global action is needed to ensure that space remains safe and accessible for all.

Cooperation in EU Flagship Programmes

EU Flagship Programmes EGNSS and Copernicus also provide an important framework for cooperation. Copernicus is used as a cooperation tool based on a "full, free and open data" policy, and as a way to

[471] "Internal Market, Industry, Entrepreneurship and SMEs: International Aspects", European Commission, accessed December 2020, https://ec.europa.eu/growth/sectors/space/international-aspects_en.
[472] Other actors are also closely involved in the dialogues, including ESA, EUMETSAT, and EU agencies.

establish global best practices and international standards. In turn, this should lead to the optimization of EU investments (e.g., in development aid), streamlined data integration, and access to European EO products on the international market. Arrangements made under this scheme have involved Australia, Brazil, and the African Union, among others. Similarly, EGNOS and Galileo have been instrumental in the creation of a navigation centre in Brazil, and GSA has advocated for EU interests in Asia.

Applications stemming from these services are a key focus area for both Europe and emerging spacefaring nations. The EU has already envisaged important measures (e.g., the expansion of the EU Space Prizes to target countries, including many emerging spacefaring nations), to encourage Galileo and Copernicus-based innovation and market uptake.

EU Framework Programmes

Entities from a number of emerging spacefaring nations are also eligible to receive funding through grants within the EU's Framework Programmes for research and development (7th Framework Programme and Horizon 2020). Organisations from Australia, New Zealand, South Korea, Brazil, and Argentina have participated in several space-related calls under FP7, and more recently Horizon 2020.

Among the various cooperation themes, calls have covered designing Copernicus-based downstream applications (DT-SPACE-06-EO-2019 including Brazil and Australia), Galileo-related awareness raising and capacity building (SPACE-EGNSS-4- 2019 including South Korea), and research on space weather (SU-SPACE-22-SEC-2019 including Australia), for example.

Moreover, through its framework programmes, the EU has also provided support to space-related infrastructure development in African, Latin American, and Asia-Pacific countries. Examples include:

- Investing in the Optical Infrared Coordination Network for Astronomy (OPTICON) involving the Australian Department of Industry under Horizon2020,
- Enabling Virtual Access to Latin-American Southern Observatories (EVALSO) under FP7 through which the RedCLARA network was built, connecting Tijuana to other cities.[473]

[473] "Optical Infrared Coordination Network for Astronomy", CORDIS, accessed December 2020, https://cordis.europa.eu/project/id/730890; https://cordis.europa.eu/project/id/609574; "Enabling Virtual Access to Latin-american Southern Observatories", CORDIS, accessed December 2020, https://cordis.europa.eu/project/id/212891; "EVALSO: Enabling Virtual Access to Latin-America Southern Observatories", EVALSO (2008), http://www.evalso.eu/evalso/wp-content/uploads/2008/08/jra2_spie08_poster.pdf.

6.2.3 Industry: satellite exports and launch service provision

At the industrial level, Europe's relations with emerging spacefaring nations have mainly taken place in the area of satellite exports. Although over the past two decades Europe's top customer has been the United States, Europe exported a total of 33 satellites to Brazil, Turkey, Egypt, Saudi Arabia, the UAE, South Korea, Indonesia, and Thailand since 2000. Demand from these countries has occurred mostly in the context of export contracts usually involving technology transfer and often part of broader commercial and diplomatic agreements.

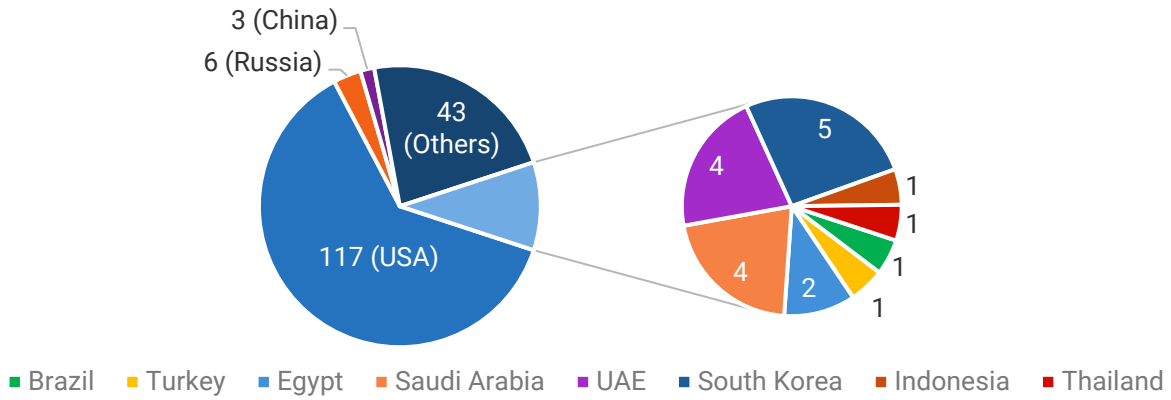

Figure 29: European satellite export by destination (Source: ESPI database)

Other countries rely on available commercial solutions or purchase systems from the United States, Russia, China or Japan. The manufacturing contracts in Europe were mainly handled by Airbus and Thales Alenia Space, and to a lesser extent by SSTL (UK) and Telespazio.

Besides satellite exports, Europe has also provided launch services to the UAE, South Korea, Argentina, and Australia as well as other emerging spacefaring nations. Between 2000 and 2020, Europe launched 53 satellites for emerging spacefaring nations out of 202. Europe is the top launch service provider, followed by the United States (46), Russia (32), and China (25). Satellite export contracts may directly include a pre-negotiated launch service.

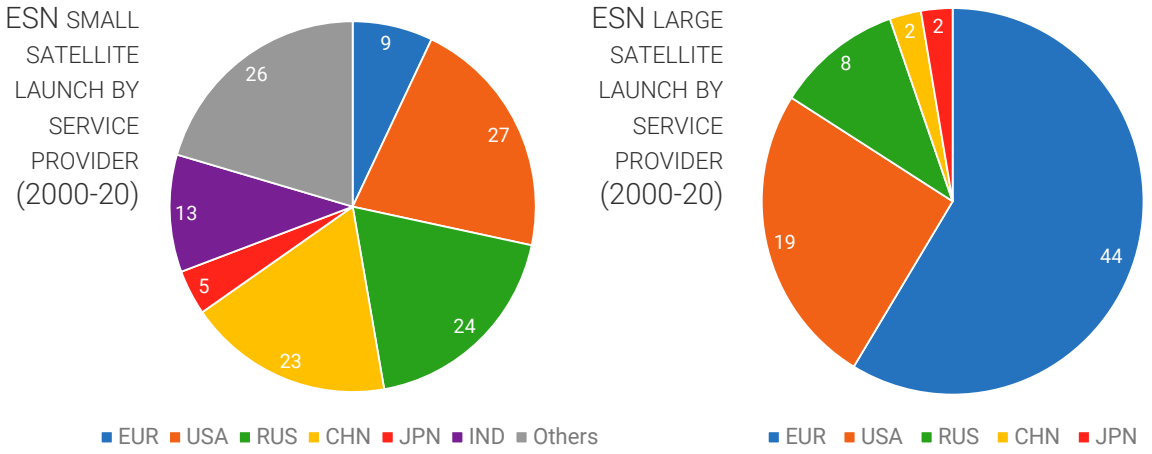

Figure 30: Satellites launched for emerging spacefaring nations 2000- 2020 (ESPI database)

Other types of commercial and industrial relations between Europe and emerging spacefaring nations such as cross-border investment, joint-ventures, establishment of local offices and factories, or other industry-to-industry cooperation arrangements have been limited so far.

6.3 Implications for Europe: new opportunities and challenges

The emergence of new spacefaring nations will have a variety of implications for Europe associated to new cooperation needs and expectations from these countries as well as to a more diverse, globalized, competitive and contested space environment. In order to discuss trends, opportunities and challenges, and evaluate potential scenarios stemming from the emergence of new spacefaring nations, ESPI organized a dedicated workshop where European stakeholders (EU, ESA, industry) were asked to identify possible challenges and opportunities associated with emerging spacefaring nations and sort the identified trends by likelihood of occurrence and relevance for Europe. The results of this exercise were then aggregated and are summarised in the figures below.

Figure 31: Mapping potential opportunities by relevance and likelihood (source: ESPI)

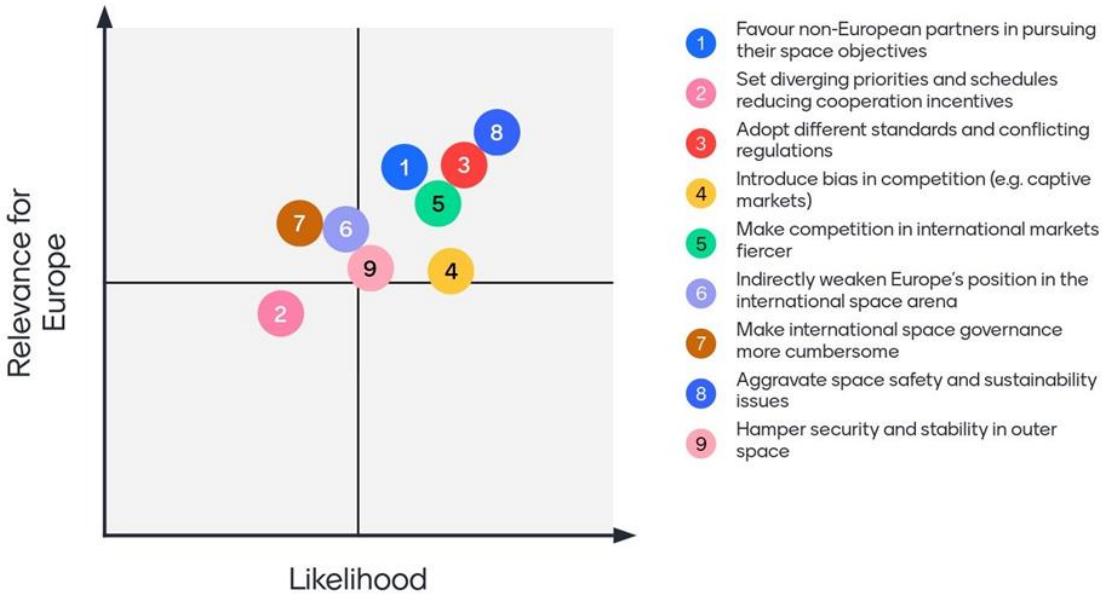

Figure 32: Mapping potential challenges by relevance and likelihood (source: ESPI)

Some of the identified challenges and opportunities are characteristics of the broader globalisation, diversification, and intensification of space activities and are not only related to the emergence of new state actors in the space sector.

Implications for Europe of the emergence of new spacefaring nations can be grouped into several core areas:

- Programmatic implications,
- Industrial and commercial implications,
- Diplomatic and political implications,

Security and defence implications are not discussed here.

Programmatic implications

The first set of implications is related to programme cooperation. The emergence of new actors on the global space scene offers the opportunity for Europe to develop new cooperation arrangements with emerging spacefaring nations. This prospect may offer more options to foster synergies, share mission costs and/or enhance mission value with hosted payloads, instruments, or experiments. Conversely, the development of increasingly advanced space missions by emerging spacefaring nations will also offer the possibility for Europe to benefit from reciprocal opportunities for hosted payloads, instruments, and data access and services, etc onboard foreign exploration missions for example.

Furthermore, Europe could also benefit from increased synergies in space data exploitation. As emerging spacefaring nations develop operational systems, in particular remote sensing satellites, new opportunities for data sharing will likely arise. EO data generated by their systems could benefit the Copernicus programme for example (e.g., cooperation on data processing, integration of third-party data into the Copernicus data system, data assimilation into models and products of the Copernicus services).[474] Emerging spacefaring nations will also provide Europe with an opportunity to encourage Galileo and Copernicus-based innovation and market uptake.

Closer partnerships could facilitate European efforts to gain access to specific territories for ground segments and infrastructure (e.g., in the southern hemisphere). According to John J. Klein, Assistant Professor at the Space Policy Institute at George Washington University, geography is also an important aspect of space strategy as there are some strategic locations for ground infrastructures such as satellite ground stations, deep space antennas, or spaceports.[475] Some locations in emerging spacefaring nations can be considered "chokepoints" for ideal uplink or downlink transmissions and positioning of radars and antennas for Space Surveillance and Tracking.

Ultimately, cooperation with emerging spacefaring nations would provide Europe with opportunities to diversify its international partnerships and would allow Europe to promote common standards and best practices.

Industrial and commercial implications

New opportunities are also expected to emerge on the industrial and commercial fronts. European industry may benefit from increased foreign ambitions and resources as they could increase demand, at least in the short-term, offering additional commercial opportunities for exports and satellite launches. In

[474] Copernicus. International Cooperation in the area of Data Exchange. Available at: https://www.copernicus.eu/en/international-cooperation-area-data-exchange Accessed June 2021.
[475] John J. Klein. Les fondements de la stratégie spatiale. Magazine DSI Hors Série n°76. Février-Mars 2021. 24

the longer term, this demand may change as developments in these countries reach a point where local industry can satisfy a part of their domestic needs. Many countries have already adopted policies which give preferences to national industries and companies to satisfy demand in the space sector, which could lead to captive markets from which European companies would be excluded. Such prospects will likely impact the satellite manufacturing market first and then the launch service market. The emergence of industrial competitors in emerging spacefaring nations may become a challenge in the longer term. Therefore, potential long-term implications must be considered on a case-by-case basis when agreeing to the transfer and sharing of strategic or specific know-how, expertise, and technologies. Europe should therefore continue making efforts to ensure that cooperation with emerging spacefaring nations is carried out on the basis of reciprocity.

Regarding downstream applications, emerging spacefaring nations also provide interesting market opportunities for European companies, in particular in countries seeking to boost socio-economic benefits from space. Space-based applications for smart agriculture, road safety, connectivity, telemedicine, disaster management, and others are increasingly used in these countries (e.g., UAE, Argentina, Australia, etc.). As the needs of these countries might be different than those of European customers, it also provides European companies with the opportunity to broaden their service portfolio.

Most emerging spacefaring nations seek to attract foreign direct investment and promote the establishment of local branches of foreign companies. The UAE, for example, has established "free zones", boasting business-friendly regulations and tax exemptions. As the results of the case study demonstrate, many companies have taken advantage of these environments and established offices in the UAE. The context offers interesting opportunities for European companies to establish local offices and develop their business in these regions. Conversely, the attractiveness of such business-friendly environments may raise challenges for Europe in offering similar conditions. It should be noted, however, that companies' internationalisation policies are rarely reduced to tax considerations and that other incentives may draw them to Europe (e.g., skilled workforce, market size, political stability, EU internal market).

Besides a few major European industrial actors, the development of partnerships with local industries and the opening of branches of European companies in emerging spacefaring nations is rather limited.

Diplomatic and political implications

Another set of implications relates to the development of a new diplomatic and political landscape as a consequence of new state actors raising their ambitions and actively participating in international dialogues and negotiations with potentially different perspectives on issues at stake.

Many emerging spacefaring nations perceive space as a foreign policy tool and are rather active in international discussions to communicate their vision of space and promote their positions. This is certainly a positive development to ensure that international agreements take into consideration a more comprehensive national representation, in line with the principles of the Outer Space Treaty. However, the emergence of new actors may contribute (although it is certainly not the main factor) to make international consensus more difficult to achieve on a number of pressing issues such as space sustainability, STM, space resources, RPOs, ASAT testing, etc. While emerging spacefaring nations do not share the same views on these issues, they are usually mindful of international agreements that could affect their free access to space or that would hinder their capacity to develop space activities.

Space diplomacy is becoming increasingly important for Europe, as is the need to establish appropriate diplomatic relations with third countries. Establishing appropriate relations with emerging spacefaring

nations would likely support European diplomatic efforts, for example to promote responsible behaviour in outer space for a safe, sustainable, and secure space environment. There is a need for complementarity between bilateral and multilateral relations: developing appropriate relations at bilateral level would significantly support the capacity of Europe to gain support in multilateral negotiations.

Increased cooperation could likewise be conducive to gaining support and reinforcing future Europe-led diplomatic initiatives, or even forming coalitions on common interests in order to progress towards the establishment of joint frameworks for space activities.

Some emerging spacefaring nations might have different views than European countries on issues such as space resources and could influence international negotiations. For instance, the UAE has adopted a legal framework that allows and enables the commercial exploitation and appropriation of space resources – a topic on which European countries have largely remained undecided. In 2019, the UAE submitted a resolution on Space Resources Utilization, which mostly aimed at establishing a working group that would analyse the status quo, as well as current practices of Member States on space resources utilization and define recommendations and principles on the issue.

At the same time, a challenge may arise from the possibility that emerging spacefaring nations will choose to build partnerships with other partners instead of Europe. Some emerging spacefaring nations have established strategic relationships with the United States (e.g., Australia, South Korea). They also have already started establishing regional partnerships in order to pool resources and enhance manufacturing capacities (e.g., Pan-Arab Space Group, Latin American Space Agency).

Emerging spacefaring nations are actively developing their approach to international cooperation and partnerships. Therefore, it is essential to position Europe as a partner of choice with strong diplomatic relations.

6.4 Enhancing European engagement with emerging spacefaring nations

Shifting the focus to the global space environment at large, it can be observed that the drivers and goals pursued by emerging spacefaring nations are similar to those of established spacefaring nations and space powers such as the US, Russia, and China. Europe and emerging spacefaring nations have similar interests and objectives which provides opportunities for increased cooperation and support to European efforts at the diplomatic, programmatic, and industrial levels.

It would be critical that future EU diplomatic engagement towards emerging spacefaring nations is based more extensively on common positions shared by all European stakeholders. Specifically, it would be essential that the posture and action of the major European constituencies (ESA, the EU, and their Member States) are not only coordinated, but also mutually enforcing and able to establish proper links between programmatic, industrial, and political objectives. Achieving concerted policy actions among all European constituencies is a challenge given the fragmentation of European efforts. This would imply appropriate processes and coordination schemes to formulate consistent diplomatic positions and initiatives and would contribute to enhancing Europe's influence in international negotiations with the ultimate objective to promote and safeguard Europe's interests. This is actually a broader challenge for Europe that goes beyond relations with emerging spacefaring nations and concerns the way Europe engages in space diplomacy at large.

The EU does not need to have a dedicated strategy for emerging spacefaring nations. Each emerging spacefaring nation is different and has a different type of relationship with both the EU and ESA based on past and current economic, political, geopolitical, and military cooperation. In addition, their status as emerging spacefaring nations is temporary, which would make a dedicated strategy inadequate. However, European cooperation with emerging spacefaring nations has to be consistent with the EU foreign policy. In terms of policy documents, the EU would rather need an EU space industrial strategy and an EU space security policy, which would provide a vision, principles, and guidelines for cooperation with foreign actors, including emerging spacefaring nations.

The need for these two EU policies is broadly recognized by institutional and industrial stakeholders alike and reflections are ongoing. As also articulated in ESPI Report 75, these two policy frameworks should themselves be drafted to consider not only "internal", but also "external" aspects, including:

- Relevant external actions to promote European positions and protect European interests on the international stage,
- Appropriate mechanisms to promote a coherent diplomatic engagement by:
  - enhancing the coordination between European stakeholders
  - ensuring consistency between internal and external actions
- Mandates to ensure appropriate representation in relevant forums with appropriate initiatives.

Overall, embedding European "external actions" within a more coherent European space diplomacy, as well as a Europe-wide policy framework for space industry and space security matters will be an essential condition to effectively seize the manifold opportunities and address the inherent challenges raised by the emergence of new spacefaring nations in the international arena.

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