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EXPLORING INSIGHTS FROM EMERGING SPACE AGENCIES

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EXECUTIVE SUMMARY

Since the turn of the century, technological innovation and reduced launch costs have lowered many conventional barriers of entry to space, giving way to a more diversified space-faring community. From commercial companies and civil space organizations to military space programs and partnerships between all three, more nations are benefitting from the use of outer space than ever before. In the past six years alone, sixteen nations established national civil space agencies for the first time. While there are benefits to establishing a new space agency in this more expansive new space age, developing space nations face new and unique challenges associated with a more congested, competitive, and contested space environment.

With the goal of providing practical knowledge for emerging space nations to develop successful strategies, this research explored the best practices and lessons learned in the development of newly formed space agencies established between 2014 and 2019. The research featured two core sections: a general assessment of comprehensive literature reviews that profiled defining characteristics and rationales for

establishing these space agencies, and a case study section that entailed a deeper dive into two nations selected from the list, Luxembourg and the United Arab Emirates. From the general assessment, the research found that the driving rationale for the creation of space agencies during this time was economic, attesting to the increasing importance of commercial space activities for emerging space nations. Using interviews with representatives from the Luxembourg Space Agency and the UAE Space Agency, the case studies further explored and analyzed the formation, rationales, roles, frameworks, and key projects of these agencies. Based on the general assessments and case study nations, this paper concluded in providing recommendations for emerging space nations looking to establish their own space agencies and for established space nations seeking to engage with emerging space nations.

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INTRODUCTION

Space Agencies in Context

Civil space agencies are public bodies, funded by national governments to promote domestic space capabilities. There is no single universal model for developing a space agency. Instead, they have been assigned many distinct purposes and roles by different governments over the years. The history of civilian space agencies began on October 1, 1958, with the establishment of the National Aeronautics and Space Administration (NASA), just one year after the launch of the world's first artificial satellite by the Soviet Union [1]. The creation of NASA was directly related to the Cold War space race and resulted from a careful examination by the U.S. Government of two alternative organizational paths for the nascent space program: (1) to conduct all activities within the U.S. Department of Defense, or (2) to create a separate dedicated civilian space agency focused on science and exploration. The latter was selected as a way to demonstrate the peaceful purposes of the American space program and to ensure that due priority would be given to scientific, non-military missions [2].

Overall, the early space age was characterized by the technological competition between the United States and the Soviet Union, and by the near monopoly on space enjoyed by the two superpowers. Unlike the United States, however, the Soviet space program was not organized under a designated space agency. Decision-making was diffused and poorly coordinated, but the lack of central authority did not prove to be an impediment for the accomplishment of remarkable achievements [3]. During this phase, national governments were the main actors in the use and exploration of outer space. The associated costs constituted a burden that only nation states could bear, and space activities were considered of scientific and technological interest rather than of social and economic benefit. National security and prestige were, for the most part, the main rationales.

With the end of the Cold War, national space ambitions largely changed towards the exploration of deep space and a more sustainable presence off-planet, notably through the establishment of the International Space Station. Increased costs, reduced budgets, and a shift away from previous rationales prompted NASA to seek partnerships and to collaborate with other nations in space. This demanded changes in the Agency’s cultural values, relational approaches, and technology strategy [4]. Nevertheless, missions were still centered around science and technology goals, and space was still limited to a small number of states with large-scale space programs, and a few large private enterprises.

Today, over sixty years after the establishment of the first space agency, the space sector is vastly different. Technological development and reduced costs have lowered the barriers of entry to space and have given way to a more diversified space-faring community. The 21st century, and the last decade in particular, has seen a rapid expansion in both the quantity and variety of space activities and organizations around the world. From small to medium sized space agencies and commercial

companies, military space actors, academia, and partnerships between all four, more people are benefitting from the use of outer space than ever before.

Between 2000 and 2018, over 600 private space companies were established [5], and while public investment continued to be a critical driving force, the number of privately funded space companies grew from two dozen in 2009 to 375 in 2019 [6], showing that increasingly more actors can and do participate in the space sector without the need for government support. The diversity in the commercial uses of space has also expanded. Building on traditional space applications for communications, Earth observations, and navigation, new markets are emerging for asteroid mining, space tourism, robotic satellite servicing, and other activities that were once consigned to the realm of science fiction. As a result of this rapid growth, the global space economy is already worth an estimated USD 360 billion and is expected to reach over USD 1 trillion in the next 20 years, according to different assessments [7, 8].

As the space sector evolves, so do space agencies' roles in it. The first space agencies were designed for a time in which space was largely a province of a few dominant governments. Their rationales were traditionally centered around national prestige, scientific research, technological development, international cooperation, and proposal and execution of space policies. While these goals are still relevant today, the creation of many modern space agencies has been closely associated with, and possibly a consequence of, the increasing commercialization of space. The emergence of private space sectors has made it possible for smaller and developing nations to implement space programs without the astronomical budgets of the past. At the same time, governments around the world are increasingly compelled to get involved in space to harness the economic potential and the multiple benefits that space activities offer to life on Earth. Over 70 nations are now operating space programs, and many more are beginning to explore the opportunities that space can provide [9].

In this context, space agencies are just one among many types of participants in national space sectors, and other actors are able to conduct space activities regardless of their involvement. In fact, both government and commercial actors are increasingly performing activities that used to be within the exclusive domain of space agencies, including the development of spacecraft and launch vehicles, lunar landers, and human spaceflight. In spite of these facts, no fewer than 72 national space agencies were in existence in 2019 [10]. Of those, sixteen have been established in the past six years alone, with at least three additional countries declaring plans to create their own space agencies in the near future.

Justification

The fact that so many nations have created or considered forming a space agency in recent years suggests that these entities have an important role to play in the emerging space age. There remain roughly 120 countries without a national space agency and, in the coming years, many of these

nations will be facing the same questions as they consider establishing a space agency. Why create a space agency in today's world? What is the role of a space agency in the emerging space age? These are the leading inquiries that led us to formulate the following research questions:

- What have been the specific motivations for standing up and investing in a national civil space agency in the past six years?
- What are the benefits and challenges associated with it?
- What roles have emerging space agencies assumed?
- What are the plans, goals, missions, and programs put in place by these organizations?
- What have been the impacts of newly established space agencies?
- How do they reflect, change, and characterize the new space industry of today?

Rapid growth in the global number of national space agencies has created a gap in knowledge of the emerging trends for these new space entrants. By addressing the above research questions, we hope to contribute to public understanding of the priorities and challenges for new space entrants as well as strategies for the development of modern space agencies.

It is our hope that the findings presented in this report will help emerging space nations achieve their goals in a more successful, cost-effective, and sustainable manner, maximizing the socioeconomic benefits of space sector investment in the short and long term. By laying out emerging trends in the sector, as well as different models of engagement with the global space sector, this report also aims to inform established space nations' governments and decision-makers' engagement efforts, promoting more fruitful means of cooperation in the peaceful uses of outer space. As such, the research results will provide the global space community with a valuable and unique resource, which we hope will be useful for years to come.

Objective

The main objective of this report is to provide new entrants into the space community with recommendations based on the experiences, best practices and lessons learned from nations that have established a space agency for the first time in the last six years. In particular, our investigation will identify the various rationales behind the establishment of these new space agencies as well as their roles, projects, organizational structure, goals for the future, and the challenges they have faced. Drawing on the identified trends, the report will then provide a set of recommendations on the major issues that emerging space nations will need to consider when developing a national space agency.

METHODOLOGY

For the purpose of this study, our team defined "emerging space agencies" as federal or national-level civil agencies dedicated to the development of space science and technology, the harnessing of space data and applications for governance and societal improvement, or the development of a commercial

space economy. Given our nine-month research project timeline, we decided to examine all such agencies formed within the most recent five-year research period at the outset of the study, starting in January of 2014 until the end of December of 2019.

We broke our research into two core sections: a general assessment profiling the characteristics of emerging space agencies, and a case study section entailing a deeper dive into two nations selected from the list.

PART I: General Assessment

For the general assessment, the team has conducted a comprehensive literature review of 14 emerging space agencies. This review utilized open-source data from articles, books, agreements between spacefaring organizations, government archives, and other publicly available sources. The results were then compiled to identify trends and draw general conclusions about the development of newly formed space agencies. The space agencies included in this general assessment are the African Union, Australia, Bahrain, Egypt, Greece, Kenya, New Zealand, Paraguay, Philippines, Poland, Portugal, Saudi Arabia, Turkey, and Zimbabwe.

PART II: In-Depth Case Studies (Luxembourg and United Arab Emirates)

After assessing all of the sixteen identified nations with space agencies formed since 2014, the team approached several space agencies from the identified list at the International Astronautical Congress (IAC) in Washington, D.C. in October 2019. The team then compiled a shortlist of nations based on the list of space agencies that expressed interest during IAC along with other agencies that could potentially be approached through client contacts. In order to narrow down the selection, the team determined that the two nations should meet the following criteria:

- Both countries should have two distinctly different focuses for their space agencies
- Both countries should be in different geographical regions
- Each country must have an officially established civil space agency organization
- Each country should have national civil space facilities for touring
- Each country should have publicly demonstrated ongoing investment in civil space programs

Following the assessment of the subset of countries that met the following criteria, along with the list of allowable travel destinations based on GWU requirements, the team chose Luxembourg and the United Arab Emirates (UAE) as the two final travel case study nations. These two nations' space agencies have been established due to different motivational factors, have varying strategic goals, and have different maturity levels. Therefore, conducting deep dives into these space agencies offered comprehensive yet unique perspectives to the overall general assessment. Additionally, the two selected case study nations were vetted by the team's clients; all clients expressed an interest in

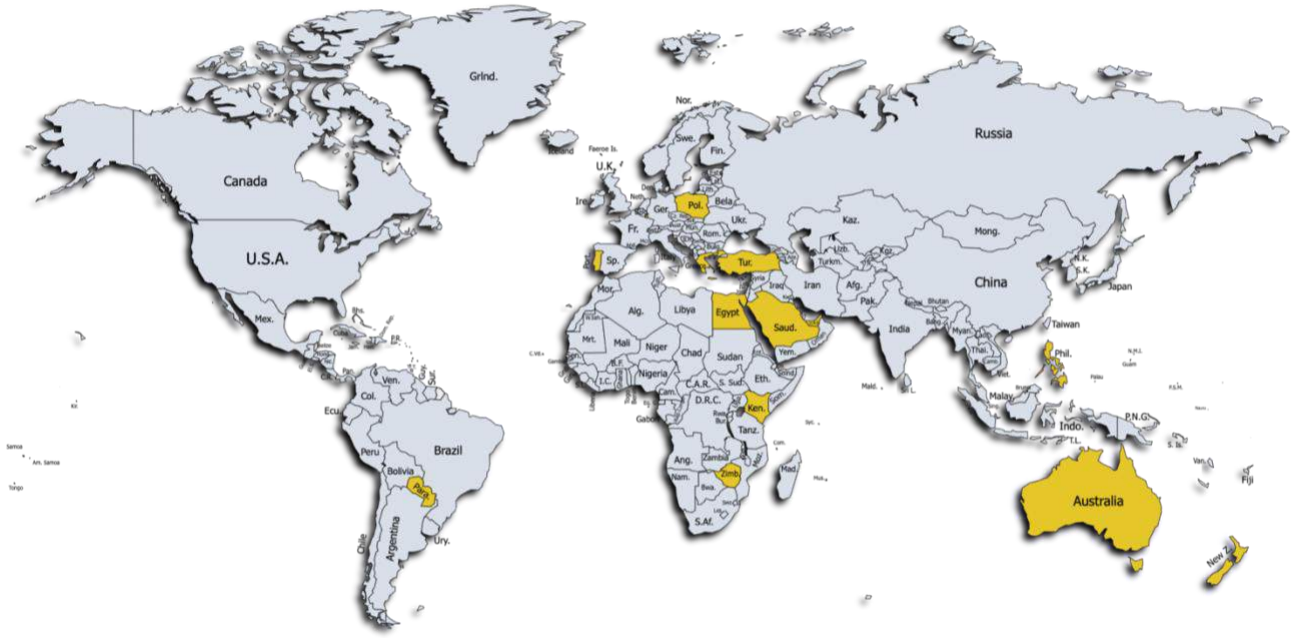
learning more about these recently established space agencies and also noted that findings from these agencies would add value to their organizations' understanding of emerging space nations.

The case studies began with a literature review of publicly available documents and included a number of targeted interviews with representatives of the LSA and UAESA, high-level officials and stakeholders, experts and representatives of the private space sector. For these in-depth case studies, qualitative in-person and virtual interviews were conducted. Through these interviews, first-hand accounts were collected on areas such as the context, motivations, challenges, political landscapes, and key factors that led to the establishment of these organizations. In addition, Luxembourg Space Agency national facilities used for the development of space technologies were toured to analyze the country's operations, infrastructure, and the coherence between their goals and capabilities.

PART I: GENERAL ASSESSMENT

Space Agencies Created Between 2014 and 2019

- African Space Agency (AfSA), African Union
- Australian Space Agency (ASA), Australia
- National Space Science Agency (NSSA), Bahrain
- Egyptian Space Agency (EgSA), Egypt
- Hellenic Space Agency (HSA), Greece
- Kenyan Space Agency (KSA), Kenya
- Luxembourg Space Agency (LSA), Luxembourg
- New Zealand Space Agency (NZSA), New Zealand
- Paraguayan Space Agency, Paraguay
- Philippine Space Agency (PhilSA), Philippines
- Polish Space Agency (POLSA), Poland
- Portugal Space, Portugal
- Saudi Space Commission (SSC), Saudi Arabia
- Turkish Space Agency (TUA), Turkey
- United Arab Emirates Space Agency (UAESA), United Arab Emirates
- Zimbabwe National Geospatial and Space Agency (ZINGSA), Zimbabwe



Findings by Country

The following section contains general overviews of each emerging space nation other than the two case study nations.

The Appendix contains comprehensive findings for each nation, including key rationales, the details surrounding the establishment of the agency, its primary role, and its organizational structure.

African Union (2018)

The African Union (AU) is a continental union, similar to the European Union, made of 55 nations located on the African continent. The AU has been working toward the establishment of a space agency since 2010. The AU Heads of State and Government adopted the first African Space Policy in 2016 and passed legislation and in 2017 the AU passed legislation establishing the African Space Agency (AfSA). Egypt was selected as the host nation for the agency and the AfSA and the agency is planned to be operational by 2023 [11].

Australia (2018)

The Australian Space Agency (ASA) differs from traditional space agencies, primarily in that its main objective is to promote the commercial space industry within Australia rather than to conduct its own missions and research. Though its civil space agency is young, Australia cannot be truly classified as an "emerging space nation;" it has a well-developed infrastructure across its government to utilize space data and services under offices such as the Bureau of Meteorology and Geosciences and the Bureau of Rural Sciences, among others. Australia is also a longtime partner with the United States in

astronomy and military space missions such as Space Domain Awareness (SDA). The primary roles of the ASA are to coordinate existing inter-agency civil space activities, grow the Australian commercial space industry to spur wider economic growth in the nation, and to provide national space policy and strategy to the government.

Bahrain (2014)

The National Space Science Agency (NSSA) of Bahrain is a civil space technology and science research organization, established in 2014. Its primary function, geared toward an overall 2030 Vision within the government, is to apply space technologies and applications towards sustainable development [12]. It has been active in directly tying its activities to the UN Sustainable Development Goals. It also serves to foster the development of a commercial space industry in Bahrain, working closely with the United Arab Emirates in many of its activities.

Egypt (2019)

The Egyptian Space Agency was established in August 2019 as an "upgrade" of the National Authority for Remote Sensing & Space Sciences (NARSS), with the aim of utilizing space for national development and security objectives to promote domestic welfare while participating in the global space economy. The Agency is one of the leaders in the African space sector through overseeing the country's proven satellite capabilities and establishing its long-term goals of deep space exploration, space resource utilization, and the setting of a new national space program and space law.

Greece (2018)

The Hellenic Space Agency was formed in 2018 but was abolished just over a year later and replaced by the Greek Space Center in 2019. The Agency's role included a desire to increase the competitiveness of the Greek economy, making use of space technology to boost other sectors, using satellite technology to improve Greece's defense capabilities, and providing an arena to partner with other, more technologically advanced nations.

Kenya (2017)

Kenya has been involved in space activities since 1964, when the Italian University of Roma "La Sapienza", with the support of NASA, established the Broglio Space Center (BSC) in Malindi, Kenya. In March of 2017, President Kenyatta signed a Gazette Supplement to establish the Kenya Space Agency (KSA), making Kenya the fourth African nation to have a space agency. The formation of the KSA was connected to UNOOSA's and Japan's KiboCUBE program, which enabled the launch of Kenya's first satellite. It is possible that part of the rationale for the development of the KSA was the need to ensure compliance with requirements for registration of space objects set forth by this partnership [13] [14] [15]. Ultimately, the establishment of Agency was mainly motivated by the benefits that space can have across many domestic industries. The Space Agency aims to use space to solve local problems, such as drought and communication gaps, as well as to grow Kenya's science and technology

expertise [16, 17]. The Agency's primary role is to enhance coordination between government, commercial, and academic organizations pursuing space activities as well as to implement Kenya's space policy and programs.

New Zealand (2016)

The New Zealand Space Agency was established in 2016 with a strong emphasis on reliance upon the commercial space industry and international partners. The Agency offers a unique case of a federal entity operating closely with the "New Space" sector, offering an attractive location and flexible regulatory framework for high-frequency, small launch capabilities. The New Zealand Space Agency is specifically responsible for the nation's policy, regulation, and business development of space-related activities, supporting rocket launches from New Zealand while providing policy recommendations to the government [18].

Paraguay (2014)

As one of the poorest Latin American countries, space has not been an immediate focus for Paraguay. However, this nation has recognized its lack of satellite presence, being one of the few Latin American countries without its own satellite. As a result, the country has been forced to lease satellite data from private companies, proving a costly effort. This need has driven the initial establishment of its space agency, the Agencia Espacial del Paraguay (AEP), as it continues to lay out a strategic plan forward and develop a domestic interest and workforce in the space sector. The AEP is specifically responsible for promoting and developing national space activities with a primary goal of generating scientific knowledge and technology through training of its personnel and fostering the youth's interest in astronomy and space [19].

Philippines (2019)

Though space activities in the Philippines date back to the 1960s, the Philippines' Space Agency (PhilSA) was only formally established in August of 2019. It acts as a centralizing agency for previously existing space science, technology, and industry capacity-building programs that were formerly operated by various agencies dispersed throughout the Filipino government. The majority of the Philippines' civil space efforts are dedicated to Earth observation missions such as disaster management and climate science.

Poland (2014)

Poland became a member of the European Space Agency (ESA) in 2012. The Polish Space Agency was established on September 26 of 2014 with the main purpose of better coordinating the national space sector internally and better representing its interest before ESA. The rationale was mainly economic, as the Agency was expected to boost the space sector's growth by bridging the gap between the scientific and the business sectors and by ensuring that they have access to funds and opportunities, both domestically and at the European level. Overall, the roles of the Space Agency are more

associated with the provision of services rather than the development of its own scientific missions or technology.

Portugal (2019)

Portugal became a member of the European Space Agency (ESA) in 2000. The Portuguese space agency, officially named Portugal Space, was created on March 13 of 2019. The agency is not tasked with building hardware, conducting experiments, or developing space missions of its own. Instead, it is a customer-oriented agency that was given the primary purpose of fostering the growth of the national space sector by stimulating entrepreneurial capacity. Portugal Space was also established as the first "ESA-hub," with responsibility over Portuguese-ESA budgets, relationship, and cooperation.

Saudi Arabia (2018)

Although Saudi Arabia's space agency, the Saudi Space Commission, was only established in 2018, Saudi Arabia has been involved in space activities since 1985. It has been one of the major space leaders in the Arab region and developed clear goals for its space sector development in support of the nation's broader Saudi Vision 2030, which include economic diversification, enhancement of society and quality of life, and development of a transparent governing strategy [20]. In general, the Saudi Space Commission is responsible for coordinating and producing the national space policy and strategy across the civil, commercial, and military sectors in close collaboration with other Saudi government entities [21].

Turkey (2019)

Prior to the formation of its space agency, Turkey had already had a well-established commercial sector composed of large defense contractors, several federally funded space-research centers, and a growing military space program. On December 13, 2018, President Recep Tayyip Erdoğan signed an executive order to establish Turkey's first space agency, Türkiye Uzay Ajansı (TUA). The establishment of the space agency was heavily influenced by the government's desire to build its first indigenous military satellite, develop a more independent space sector, and establish Turkey as a regional and global space power. The TUA has been tasked with managing all Turkish national space activities, including R&D, STEM education, international cooperation, and international representation [11]. The TUA also coordinates all space-related work being done by Turkish commercial companies and academic institutions, but the agency cannot control tasks carried out by the International Telecommunication Union (ITU) [11].

Zimbabwe (2018)

Zimbabwe became a member of the Group on Earth Observation (GEO) in 2015 [22]. The Zimbabwe National Geospatial and Space Agency (ZINGSA) was established on July 10 of 2018 as part of a wider reform which aims to turn Zimbabwe into an upper-middle-income economy by 2030 [23]. The new agency was created to foster economic development and help solve existing problems in Zimbabwe.

The roles of the new Space Agency include the promotion of research and innovation in geospatial science, the regulation of related activities, and international engagement. [24]

General Assessment Conclusions

Rationales for Establishing a Civil Space Agency

When examining the rationales that contributed to the formations of space agencies between 2014 and 2019, we identified six broad categories: economic, socioeconomic, coordination, centralization, geopolitical, and regulatory rationales.

- ***Economic:*** Growing the domestic space sector to grow the domestic economy and boost the GDP.
- ***Socioeconomic:*** Improving the domestic welfare and using space data and applications to enhance existing governance activities, such as agriculture, mapping, and climate science.
- ***Coordination:*** Facilitating and integrating activities across the domestic space academic, commercial, and government sectors.
- ***Centralization:*** Combining the activities of a dispersed government space sector into a single centralized agency.
- ***Geopolitical:*** Giving the government a platform to participate in the global space community, establishing the nation as a prominent space faring nation, or benefitting the nation's national security.
- ***Regulatory:*** Developing a regulatory framework to manage the space sector and comply with international law.

The most common rationale for the establishment of national space agencies created between 2014 and 2019 was economic. When looking into the roles and missions of these newly established space agencies, emphasis is often put on unlocking and supporting the growth of the national space industry as a means to promote economic development. This support, however, goes both ways. In the same way as emerging space agencies are fostering private sector growth, a large part of the reason why modern space agencies are being created in the first place is the commercialization of space dynamic, as the emergence of the "new space" sector has made it possible for smaller and developing nations to implement space programs without the astronomical budgets of the past.

A second rationale is socioeconomic. Governments around the world are increasingly compelled to get involved in space activities to harness the multiple opportunities that they can offer to enhance the wellbeing of their societies, ranging from climate and food security to educational and professional opportunities.

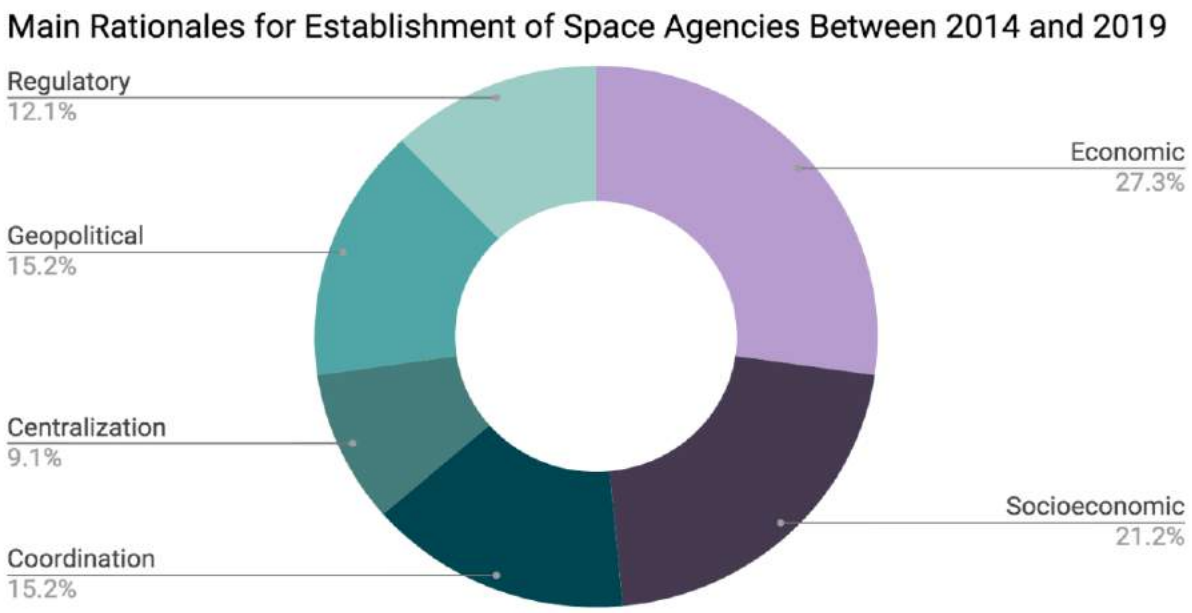


Figure 1: Main rationales for the establishment of space agencies created between 2014 and 2019

Another common reason why many countries decided to create a space agency in the last six years was to coordinate or centralize the administration of their existing various space programs and activities, previously spread across different segments of the government. Emerging space nations are rarely creating new space agencies as a first step in their involvement with space activities. More commonly, they have created space agencies after having already been engaged with space to varying degrees, including by launching satellites, promoting scientific research, or participating in international space organizations. By providing a more centralized structure to their space sectors, countries hoped to reduce redundancy, increase awareness of existing opportunities, stimulate participation, and enable a more efficient use of resources.

Although not as common of a rationale as in the past, a few of the emerging space agencies were still created to strengthen nations' geopolitical standings. Oftentimes, governments of emerging space nations seek to formalize their space activities through agencies to participate in the global space community and foster stronger international relations. Additionally, emerging space nations can utilize their space agencies as a means of establishing themselves as prominent spacefaring nations with clear goals, strategies, and policies. Being a leader in space can help emerging space nations signal political stability, financial security, societal development, and scientific and technological expertise to the larger global community. For space agencies that are involved in military space activities, these organizational bodies can also help promote national security.

Nation	Year Est.	Main Rationale
Egypt	2019	Socioeconomic, Centralization, Geopolitical
Philippines	2019	Centralization, Geopolitical
Portugal	2019	Economic
Turkey	2019	Coordination, Geopolitical
African Union	2018	Socioeconomic
Australia	2018	Economic, Coordination, Regulatory
Greece	2018	Economic
Luxembourg	2018	Economic
Saudi Arabia	2018	Economic, Socioeconomic, Coordination
Zimbabwe	2018	Socioeconomic
Kenya	2017	Socioeconomic, Regulatory
New Zealand	2016	Economic, Regulatory
Bahrain	2014	Economic, Socioeconomic, Geopolitical
Paraguay	2014	Socioeconomic
Poland	2014	Economic, Coordination
UAE	2014	Economic, Coordination, Centralization, Geopolitical, Regulatory

Table 1: Main rationales for the establishment of space agencies created between 2014 and 2019, in revers- chronological order, including each nation and the year of its space agency's establishment.

Lastly, some countries have created space agencies to regulate their national space activities. These nations typically have an established space sector already with players from across domestic industries. By establishing a space agency and designating it as a regulatory body, these nations have been able to streamline regulation frameworks and processes, such as licensing, while complying with international law.

The main roles assigned to these agencies were generally centered around the management of space activities rather than their execution, meaning that most emerging space agencies are tasked with the provision of services rather than the development of their own scientific missions or hardware. Among the different roles, the most common ones were the development and implementation of national space strategies and policies, and the promotion of international cooperation through agreements with other space nations and participation in international forums. These were followed by the roles of promoting growth and coordination of the national space sector, in alignment with the previously stated rationales. Additionally, some of these agencies were tasked with promoting research and

education, ensuring adequate regulatory framework, enhancing defense capabilities, applying space technologies towards national development, supporting launch programs, and guiding overall major research directions.

In conclusion, emerging space nations have been more commercially driven both in their rationales and roles, choosing to support private companies' space endeavors rather than pursuing their own. That is partially due to a fundamental shift in the logic of space programs that took place in recent decades, triggered by a new understanding of the potential benefits of space for life on Earth. The Cold War logic, which saw access to space as a means to showcase technological prowess and sovereignty, was slowly substituted by a more pragmatic approach, in which governments and citizens shifted their focus towards the potential of space for promoting sustainable socioeconomic development on Earth, mitigating exiting problems, and providing competitive advantages for business. This new logic has given way to new and more democratized opportunities for actors in the space sector.

> *"Space is no longer really seen as just countries wanting to show off their technological prowess and sovereignty. It's recognized as something that brings added value to society, and a competitive advantage for business"*
>
> *—Chiara Manfletti, to MIT Technology Review, 2019*

PART II: CASE STUDIES

Luxembourg Space Agency

General Overview

Luxembourg is among the smallest countries in Europe, with a population of only 600,000, yet it has a prosperous economy and a strong finance sector which attracts companies from all around the world. Recently, Luxembourg has combined its financial power and its experience in the space sector to establish a hub for the exploration and commercialization of space resources. The Luxembourgish Government has implemented a number of initiatives aimed at promoting space activities for economic returns through government support of commercial space companies. The Luxembourg Space Agency was created in 2018 in alignment with these goals, and its activities largely include partnerships with the commercial space sector.

History of the Luxembourg Space Sector

Luxembourg established itself early on as a hub for innovative space projects. It entered the space sector in 1985 through the establishment of Europe's first private satellite operator, the Société Européenne des Satellites (SES), which pioneered the use of fixed service satellite communication technologies to distribute television and radio programming via geostationary satellites [25]. SES launched its first satellite in 1988 [26]. In 2000, Luxembourg entered a cooperation agreement on ESA's Advanced Research in Telecommunications Systems (ARTES) program, and in 2005 Luxembourg took a significant step positioning itself in the European space sector by becoming the 17th Member State of the European Space Agency (ESA) [27].

In 2008, Luxembourg adopted its first National Action Plan for Space R&D, which outlined a course of action structured around three main axis: the promotion of Luxembourg's participation in ESA's programs, the establishment of a national research and development program specific to the space sector, and the advancement of bilateral and multilateral cooperation in space [28]. This plan was revised in 2012, 2016, and most recently in 2020 [29].

For three decades, Luxembourg's space activities have primarily revolved around the area of satellite communications, but that has begun to change in 2016 with the adoption of the Space Resources Initiative. In the promotion of both telecommunications and the exploration of space resources, the government chose to foster the activities of private companies rather than directly delving into those activities itself. The most recent milestone in the promotion of the Grand Duchy as a hub for innovative space companies was the establishment of the Luxembourg Space Agency (LSA) in 2018.

Economic Diversification

Luxembourg is a prosperous country, with high standards of living and one of the highest GDP per capita in the world [30]. However, that was not always the case. Only 160 years ago Luxembourg was one of the most impoverished nations in Europe, with an economy that was based on a scarcely profitable agriculture sector, limited by poor soil and a small labor force [31].

Luxembourg's economic growth in the mid 20th century was mainly driven by the steel industry, which was enabled by the discovery of rich iron ore deposits and the decision to open Luxembourg's borders to foreign workers. In the 1960s, the steel industry represented as much as 80 percent of the total value of the country's exports [32] and 30 percent of its GDP [33]. When the world demand for steel plummeted with the economic crisis in the mid-1970s, it brought Luxembourg's industry with it, revealing the vulnerabilities of a monolithic economy. Since then, however, the steel industry has been largely replaced by the financial sector as the new backbone of Luxembourg's economy, which now accounts for approximately one third of the country's GDP [34].

From its independence in 1839, the Luxembourgish economy has been characterized by periods of high dependence on one specific sector at a time, from agriculture, to steel, to finance. Luxembourg

has been described as a country in a constant state of transformation [35], having reinvented itself at different times during its short history as an independent nation in order to adapt to changes in global markets. Recognizing that the financial sector may lose its strength, and that this dependence makes Luxembourg vulnerable to market fluctuations and external shocks, the government began looking for the next "big thing" in order to expand and diversify the national portfolio of economic activities in Luxembourg.

The Luxembourg economic diversification effort is mainly a strategy to ensure the sustainability of the national economy, preventing another situation of economic dependence similar to that of the steel industry in the 20th century. While consensus around the need to diversify Luxembourg's economy has been growing since the 1980s, recent efforts in that direction were centered around investments in high-tech opportunities in more traditional sectors, such as health, logistics, and automotive. That is until Étienne Schneider joined the government as Minister of the Economy in 2012. In this new role, Mr. Schneider became aware that most other European nations were attempting to develop those same sectors, and concluded that in order for Luxembourg to be as successful as it had been with the development of the financial sector, it would need to find a new innovative niche in which no one else had been focusing on yet.

After a meeting with Dr. Pete Worden, who was the director of NASA's Ames Research Center at the time, Mr. Schneider became convinced that the exploration and commercialization of space resources – including the Moon and other near-Earth objects such as asteroids - could be that next "big thing" that Luxembourg was looking for. This conclusion was further encouraged by Luxembourg's previous successful experience taking risks in emerging space activities through the establishment of the pioneering SES in 1985. This was a controversial decision by the Luxembourgish government at the time, as many people strongly questioned the business case for private satellite communications. However, in retrospect, it has proven to be a good investment, as SES is today one of the world's leading companies in the field. In the same way, Luxembourg expects that a business case for the exploration of space resources will develop and that it will become a lucrative industry in the future.

In the meantime, the Grand Duchy has the financial stability to start developing the sector without the need to see immediate economic returns. In summary, Luxembourg aims to put in place the infrastructure needed to create a fertile ground for companies pursuing the exploration of space resources, so as to ensure that Luxembourg is prepared for the possibility that one day the financial sector might not be a good business anymore. When that day comes, Luxembourg wants to have an alternative already in place, preventing an economic turmoil similar to that of the 1970s.

The Space Resources Initiative

After numerous meetings with companies and other stakeholders involved in the exploration of space resources, Mr. Schneider introduced this new vision to the Ministry of the Economy. In order to unlock

the potential of this new market, the Ministry established a space resources strategy working along five pillars:

1. **The political promotion of the initiative**, including the development of communication strategies, international agreements, and participation in international forums;
2. **The establishment of a regulatory framework**, promoting clear domestic and international legal frameworks to encourage sector growth and responsible behavior;
3. **Workforce development**, creating a pipeline of talent and expertise through public support of research and education.
4. **Industry development**, promoting industrial R&D activities; and
5. **Long-term investment**, establishing mechanisms to finance commercial projects.

The development of a regulatory framework was identified as one of the first and most important steps for the implementation of what became known as the Space Resources Initiative, or SpaceResources.lu. The controversial nature of international discussions around space resources stems from the different understandings of Article II of the Outer Space Treaty, which states that "[o]uter space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means [36]," leaving room for an ongoing debate on whether or not companies are allowed to own and commercialize resources extracted from celestial bodies.

Acknowledging the need to secure property rights to space resources as a condition to build up the sector, and recognizing that legal disputes would be one of the first challenges that the SpaceResources.lu would be confronted with, the Department of Space Affairs, within the Ministry of the Economy, conducted a two-year study on the regulatory aspects of space resources utilization. Concerned about the public's reaction to this new initiative, the Department also spent approximately two months preparing the communications aspects of its announcement [37].

Mr. Schneider then approached Luxembourg's Council of Ministers for approval and to request EUR 200 million (USD 219 million) to kick-start the Initiative [38] [39]. Without too much reluctance, he obtained both. Although this capital has not been fully spent until today, it was important to signify that the Luxembourg Government was serious about the initiative it was undertaking. The Space Resources Initiative was officially launched in February of 2016, followed by the adoption of the Law on the Exploration and Use of Space Resources in July 2017, which stipulated that companies that are operating within the Grand Duchy's territory may legally own resources acquired from celestial bodies, turning Luxembourg into the first European country and second in the world after the United States to establish a legal framework for the ownership of space resources. This provided the legal

certainty needed for commercial space mining projects and investments, attracting extensive interest from international companies and opening new opportunities for development and cooperation for the national space sector.

Furthermore, Luxembourg's legislation differentiated itself from its American predecessor by providing a more flexible framework. While the US law requires companies to have more than 50 percent of US-capital, the Luxembourgish version places no such restrictions, extending its protection to companies that are mainly backed by foreign investment as well. This is an important distinction for new space companies that hope to leverage additional funding opportunities coming from Asia and other international markets, but risk losing their legal protection under the American law. By not limiting foreign investment, Luxembourg has become an especially attractive base for startups in the field.

Establishment of the Space Agency

The Luxembourg Space Agency was formally established on September 12, 2018 as the next major step within Luxembourg's wider strategy of economic diversification. Unlike previous legacy space agencies, the LSA was not created to engage in space exploration and scientific missions. Instead, it was created with the main purpose of promoting the economic development of Luxembourg's space industry by establishing an attractive and supportive ecosystem for new space ventures. This includes general guidance and support for companies to navigate the legal framework and to get access to funds and R&D grants. Although space activities were already being conducted in alignment with this strategy under the auspices of the Ministry of Economy's Department of Space Affairs, members of this Department came to the conclusion that their goals would be better served by the creation of a space agency. Through research and qualitative interviews with key stakeholders in this process, the present report identified four main rationales that led to this conclusion:

1. **Greater flexibility.** Under a department within the Ministry of the Economy, decisionmakers engaged in the promotion of the space sector were under the constraints of stricter rules and financing mechanisms. In contrast, an agency was expected to provide a greater degree of freedom and flexibility for officials to make decisions, sign contracts, and grant investments, allowing the government to better respond to the needs of emerging new space companies.

2. **Coordination of national space activities.** A space agency can serve as an umbrella body in which to group and manage the different initiatives and programs of a robust space sector, including partnerships, regulatory guidance, opportunities for research and education, and financing mechanisms. In a way, it was intended to create a "one-stop-shop" for companies and other organizations that wish to participate in or contribute to the Luxembourg space industry, facilitating access to opportunities.

3. **Increased visibility.** Government documents emphasize the importance of visible space activities for the national space policy, stressing that "access to activities is only possible if players are known and recognized by major established actors in this field [40]." The creation of a space agency was expected to give more visibility to Luxembourg's space activities and initiatives to develop the sector.

4. **Indication of commitment.** The creation of a space agency provides long-term sustainability for an initiative that otherwise reflects the vision of one particular statesman. By institutionalizing these efforts under a formal space agency, the government demonstrated that it was serious and committed to the cause, and that those activities would continue independent of who is in office.

Organizational Structure

The Luxembourg Space Agency (LSA) is currently a civil organization housed under the Ministry of the Economy. The LSA's organizational structure and activities are unlike traditional space agencies in several ways. First, LSA as an agency is not engaging in conducting its own research, building its own spacecraft or launch vehicles, conducting its own space science research, buying space data, or conducting human spaceflight missions. This represents a significant divergence from traditional space agency operations. Secondly, under the MoE, all of its activities are designed to stimulate the Luxembourgish economy. To achieve this, the LSA's activities largely include partnerships with commercial space companies who have established Luxembourg-based offices, academic institutions within Luxembourg, international finance organizations such as the European Investment Bank, and other non-traditional institutions to work towards goals usually considered secondary to a space agency's mission, such as the development of domestic workforce talent. Last, a large portion of LSA's work involves engaging with the wider Luxembourgish government as well as venture capital organizations to create funds of capital from which commercial space companies doing business in Luxembourg can pitch for investment. This is a highly unorthodox approach from a space agency, in keeping with its economy-driven rationale.

Another aspect currently distinguishing the LSA from other space agencies is its comparatively small team. The LSA is divided into two main directorships, one for Economic Development and one for International Affairs and the Space Resources initiative. The Economic Development team, led by Patricia Conti, supports individual projects with commercial companies partnering with LSA, while the International Affairs and SRI team, led by Mathias Link, engages in maintaining international partnerships across legacy and emerging space nations, as well as supporting legal and regulatory work, LSA's public research and education efforts, financial work, and the overall coordination of the Space Resources Initiative. Marc Serres, as CEO, coordinates across both teams, engages with the public, and manages the general workflow of the organization. Overall, there are less than 20 personnel comprising the LSA as it currently stands. Even considering the small population of the

nation itself, such a small staff is unusual for a federal space agency nearing the end of its second year of operation.

Funding and Budgets

All of the funding for LSA operations, staff salary, and administrative costs is built into the annual budget for the Ministry of the Economy, as is the case for other offices within the Ministry. However, for the commercial companies LSA partners with, the LSA invests a portion of its Ministry budget into a research and development scheme, which allows the government to allocate grants. These grants ensure that startups in the space business have a fully-fledged research development ground system in Luxembourg to develop their activities before applying for ESA programs and venture capital. In addition, as a Member State in the European Space Agency, Luxembourg also serves a role as the "middle man" between commercial space startups in Luxembourg and ESA programs seeking bids for contractors, coordinating bids for missions through the ESA's GeoReturn funding mechanism.

The European Space Agency utilizes its GeoReturn mechanism to fund cross-European space activities in an intergovernmental organization similar in structure to the EU. First, it takes annual fees from all ESA member states such as Luxembourg into a collective pool. Roughly 20% of that pool is dedicated to the core management and administrative functioning of ESA year-to-year. What remains is redistributed proportionally based on the offerings of industry and financial contributions of member states, with roughly that proportional amount remaining available for contracts from members of industry within the member state able to meet the requirements of a contract. Not all states that contribute to this process have a robust enough industry to support a 1-1 ratio of return for their annual contributions. Luxembourg's GeoReturn coefficient is over 1, meaning that Luxembourgish industry receives more contracts than they theoretically could receive from direct contributions from the LSA alone. Especially for such a small agency compared to other ESA member states' agencies, this is a distinct marker of the success LSA has built to coordinate and support Luxembourgish industry--which makes sense, as this is one of the core pillars of the LSA's rationale.

Investment Funds

As of the end of 2019, the LSA has invested with more than 50 commercial space companies and research laboratories employing more than 800 people, with the intention of providing economic return to Luxembourg and expanding Luxembourg's economy to include a wider range of new space activities [41]. Of these companies, a large number of them have been founded in or have offices based in Luxembourg itself, which they see as a major milestone reached towards their pillars. Each company has the opportunity to pitch for investment, bid on certain ESA programs via the GeoReturn mechanism, and apply for research grants from the Luxembourg government. The LSA has invested in commercial companies within the following core segments of the space industry:

In-Space Segment	Includes satellite and instrument manufacturers, system integration of small satellites, providers of electric propulsion for satellites, robotic payloads, in-space manufacturing companies, composites companies, radio frequency (RF) payloads, and field-programmable gate array (FPGA) providers.
Services Segment	Includes satellite-based media and telecommunications services, risk management services, satellite data analytics companies, providers of environmental applications and services, aeronautical information services, and builders of analytics platforms for satellite data.
Ground Segment	Includes satellite ground stations development, mechanical and electrical ground support equipment, communication networks, and mission operations providers.

A previous scarcity of interest in space-related startups from Luxembourgish investment community led the Ministry of Economy and the LSA to decide that the government should build means to invest and grow the sector. In an interview, former Deputy Prime Minister and former Minister of the Economy Etienne Schnieder explained that at the outset, the media attention on newly emerged space resource utilization start-ups such as Planetary Resources acted as catalysts for Luxembourg's contributions to investment funds. Because private financial institutions in Luxembourg were still hesitant to take risks on space start-ups, the LSA saw an opportunity for the government to help jumpstart investment, with the intention being that other investors would gain confidence from the government's demonstration of faith [42].

"LSA is firm in their belief that space resource utilization is the future of the space industry"

The inherent uncertainty in undertaking any venture capital investment is compounded for investments in companies forging new industries, such as the utilization of space resources. One of Luxembourg's first large investments, into space mining company Planetary Resources, was ultimately lost when the company failed to close subsequent rounds of funding in 2018, leading to the dismissal of most of its staff and acquisition by blockchain firm ConsenSys. This outcome put political pressure on the LSA, but Schneider has professed a positive outlook of the situation. Some initial failures, he explained, are a natural consequence of being an "early mover," comparable to any other venture capital fund, where on average, out of ten investments, only one or two will succeed dramatically. Governments can afford to put off direct returns for a decade or so to build out an entirely new industry from scratch--something private investors cannot do. LSA is firm in their belief that space resource utilization is the future of the space industry, so that will continue to be the priority for future investments.

The experience with Planetary Resources also helped to sharpen the ministry's experience in space investment, as well as its eye for what kinds of business plans and other criteria companies should meet before investment. Ultimately, a high-risk, high-reward system, Schneider explained, is why it should be the responsibility of the government first to take it on, with others to follow.

The Space Resources Initiative launched in 2016 introduced a massive commitment to its fourth and fifth pillars: industry development and long-term investment in the space sector. In the four years since its outset, three space-related venture capital funds have been established in Luxembourg, each with a distinct structure and with their own goals.

The first fund, a joint endeavor of the Luxembourg government and the European Investment Bank (EIB)'s European Investment Fund, has been named the Luxembourg Future Fund. The fund is a EUR 150 million (USD 165 million) venture capital pool, investing in both early and late-stage companies that contribute to the sustainable development of Luxembourg "strategic sectors," such as space and clean technology [43]. This fund is not exclusively dedicated to space but has already built space companies into its growing portfolio, including U.S.-based satellite data analytics company Spire [44]. The capital of the fund consists of EUR 120 million (USD 132 million) from the Luxembourg government via its public-law banking institution SNCI (Société Nationale de Crédit et d'Investissement), and EUR 30 million (USD 33 million) from the EIB via its European Investment Fund.

A second, space-focused fund is the result of a public-private partnership launched in January of 2020, focusing on early stage space start-up companies around the Series A mark. The fund, which is as yet still unnamed, recently completed a first closing at EUR 70 million (USD 77 million), with the Luxembourg government comprising 52% of that backing. It is expected to have a final closing around EUR 100 million (USD 110 million) in the near future, with the intent that the government will provide below 50% of the total capital forming the fund. The rationale behind the creation of this fund was to foster private investor confidence in space and ensure that the government over time makes up a smaller and smaller portion of total investment.

Lastly, a private-sector fund focused on space is on its way to being put in place in Luxembourg at the time of writing. Concentrating on space companies at the Series B and Series C stage, it is expected to complete its first closing at around EUR 200 million (USD 219 million), followed by a target final closing of EUR 500 million (USD 546 million). The Luxembourg government contribution to this third fund was written in by Etienne Schneider the day before he left his post, for EUR 10 million (USD 11 million). In an interview, he explained that even though it is a small proportion of the total expected closing, it was critical to get commitment from the Luxembourg government into this privately-run fund, again because it legitimizes their efforts and builds confidence for other investors. Though the fund will be located in Luxembourg, Schneider noted that governments such as the UAE have shown interest in investing in the fund as well.

Other Key Projects

Designed to support the SRI's third pillar of domestic space workforce development, the LSA worked with the University of Luxembourg to develop an Interdisciplinary Space Master (ISM) program. The ISM was also developed in partnership with the Interdisciplinary Centre for Security, Reliability and Trust (SnT), a department within the University well-known for its hands-on collaborative projects with the public sector and industry. In an interview, representatives for the LSA characterized the ISM program as a "building block" for Luxembourgish space activities generally, citing that a majority of the current space workforce in Luxembourg hail from out-of-country. Interest in the program among young Luxembourgish students is demonstrably high; in its first year of soliciting applications, the program received eight times as many applications as it was able to accommodate. Overall, the program will be used as a tool to foster a "talent pool of highly skilled engineers and innovative entrepreneurs... to create, shape and sustain leading commercial space enterprises and play an important role in the economy of the future [45]."

Even in its early years, LSA representatives observed the growing interest from smaller non- space faring nations in starting space-related research, development, and investment. In keeping with its first pillar, LSA recognized the importance of having a strong regulatory foundation within domestic law for space activities and utilization of space data. Under the auspices of the UN Office of Outer Space Affairs, it created a Space Law for New Space Actors program, in which it directly mentors less developed emerging space nations in "closing the gap" between vision and policy, to create national-level space policy, regulatory, and legal frameworks. This program incorporates staff from the Luxembourg Ministry of Foreign Affairs and encourages participation from students within the University of Luxembourg's ISM, as well.

> *"If anything, the LSA's success have proven that national civil space agencies can be more commercially-minded than ever before, and can also have a more specialized operational focus than a traditional space agency model."*

The LSA has also signed several formal partnership agreements to foster cooperation with other space agencies in developing commercial space activities, as well as allow Luxembourgish companies to gain access to international contracts. Notably, its first bilateral cooperative agreement that the LSA as an office signed was an MoU with the United Arab Emirates' Space Agency (UAESA), in 2017. The agreement covers "various aspects of space exploration, including space science, research, technology, remote sensing and navigation," and "encourages collaboration in space policy, law, regulation, and personnel training for space activities [46]."

Key Takeaways

There can be no doubt that the activities and rationale of the Luxembourg Space Agency are fundamentally different from the civil space agencies of traditional spacefaring nations. The LSA's five 'pillars' of its Space Resources Initiative that led to the formation of the LSA were tailored precisely to the broader historical context and national goals for Luxembourgish economic policy. While non-traditional, the LSA's operations have already resulted in something of a renaissance for European commercial space. On the regulatory and legal, financial, and industrial development fronts, Luxembourg is recognized internationally as a distinctly forward-leaning player in Europe. In only a few short years, it has built up its reputation as an attractive financial center for new commercial space companies to do business. Today, the space sector's contribution to the nation's GDP is among the highest ratios in Europe.

If anything, the LSA's successes have proven that national civil space agencies can be more commercially-minded than ever before, and can also have a more specialized operational focus than a traditional space agency model. Though convincing legislators, other space agencies, and governments that a commercial-focused model makes sense was a political challenge for LSA--especially in the face of early setbacks such as the failed Planetary Resources investment--identifying a long-term niche in space resource utilization, and sticking to it, ultimately proved to be an asset to their work. Synthesizing their efforts under a common SRI strategy with a long-term view followed squarely in keeping with Luxembourg's economic history. In our interviews with representatives of the LSA, each felt strongly that the commercial space economy, and the utilization of space resources in particular, will be the 'next big thing' for Luxembourg's economy--even if it requires a decade or more to come to fruition in terms of providing direct returns.

In sum, this study has identified three main lessons learned from Luxembourg's experience in developing a new space agency:

1. Luxembourg's political leadership first identified the need to diversify the national economy via space sector growth, and then decided that the creation of a space agency could support that goal. Thus, the purpose of the agency was determined before its creation;

2. Drawing on their previous experiences with the financial sector, Luxembourg officials decided to find a gap in the international space sector which they could fill. Rather than competing with other spacefaring nations in well-established activities, they chose to specialize and cooperate: the LSA fills in one gap and collaborates with other nations that are filling other gaps. This decision has brought growth to the Luxembourg space sector and benefited companies that were previously operating in a regulatory gap;

3. Unlike most legacy space agencies, Luxembourg has been willing to tolerate a significant amount of risk, particularly by investing in early stage companies in a still unproven segment

of the space economy. That has enabled the government to essentially build out an entirely new industry from scratch.

With these lessons in mind, it should still be noted that the Luxembourg model is an interesting case study, but not necessarily replicable in full for other emerging space nations, as it requires:

- A huge upfront dedication of capital
- Risky investments to start and the ability to lose some
- Long-term vision that is difficult to justify politically
- High interagency support (almost necessitates housing under another ministry such as the MoE, at least to start)
- Strict dedication to the long-term rationale (cannot pivot from space resources)

Luxembourg's direction--an economic-focused modern space agency with no self-conducted space missions underway--represents a fairly unique path compared to traditional actors. But it has emerged as a leader among its emerging space nation peers. Several factors unique to Luxembourg allowed for the LSA to take its current form, including its tolerance for risk, the availability of up-front capital and high levels of sustained funding, a strong political personality willing to advocate for it, and its small size, which allowed for low levels of bureaucracy and heightened flexibility. The LSA model is not the sole “non-traditional” approach for an emerging space nation to take; it has one of many rationales for modern-day agencies.

United Arab Emirates Space Agency

General Overview

The United Arab Emirates (UAE) is a federal presidential elected monarchy made up of seven emirates, each with autonomous local governments [47] [48]. Despite being founded less than 50 years ago, it has established itself as a global leader in the oil industry and is solidifying its global space presence. Backed by strong support from the UAE government and with a desire to diversify the economy, the domestic space sector has experienced significant progress and innovation over the past three decades, with a major goal of studying and ultimately sending humans to Mars. The UAE has taken a large role in leading and coordinating space activities for the larger Arab region and continues to collaborate internationally with other space nations, especially emerging ones.

The UAE Space Sector Prior to the Space Agency

Multiple players have been involved in the UAE’s space sector dating back to the late 1990s. Thuraya was founded in 1997 originally by Etisalat as an innovation project as the first UAE-based satellite operator [49] and is now owned by the Mubadala Investment Company, which is an Abu Dhabi state-owned sovereign wealth fund [50]. Ten years later, Al Yah Satellite Communications, or Yahsat, was

also established by the Mubadala Investment Company to offer a wide range of satellite communication services to the greater Arab region [51].

In terms of major space activities conducted by these players, Thuraya-1 was launched over the Pacific Ocean in 2000 by Thuraya. The satellite, manufactured by Boeing, marked a major milestone as the Middle East's first mobile telecommunications satellite [49]. Thuraya-2 and -3 were subsequently launched in 2003 and 2008 respectively, allowing Thuraya to expand its telecommunications services to the Asia-Pacific region [52]. Yahsat also launched its first satellite, Al Yah 1, in 2011, and together with Al Yah 2, its second satellite that was launched one year later, the two satellites have offered high-quality television streaming and satellite broadband coverage to areas across the Middle East, Africa, and Asia [53]. Mubadala, owned by Yahsat, ultimately acquired Thuraya in 2018, consolidating these two dominant satellite operators in the UAE under the full ownership of the Mubadala Investment Company [54].

Beyond commercial satellite operators, the UAE has had a strong foundation in space science technologies research and development through the Emirates Institution for Advanced Science and Technology (EIAST), which was established in 2006 by the Dubai government [55]. The EIAST functioned as the single federal actor in the UAE space sector prior to the establishment of the UAE Space Agency and was created to further enable the UAE to develop and utilize space science technologies and applications [56]. Among its major technological achievements, the EIAST collaborated with South Korean engineers to launch DubaiSat-1 and DubaiSat-2 in 2007 and 2013 respectively, representing the first two Earth observation satellites launched by a UAE-government entity [57] [58]. Eventually, the EIAST was restructured as the official entity of the Government of Dubai, the Mohammed bin Rashid Space Centre (MBRSC), in 2015 [55]. The MBRSC continues to lead the development and operations of UAE's federally-funded space science technologies projects and applications today.

Rationale for the Establishment of the Space Agency

As the UAE's space activities continued to expand, the government recognized the need to create a centralized, federal organization to oversee and facilitate the burgeoning space sector. Overall, the UAE identified several motivations for establishing such an agency and employed a specific approach that was tailored from its consultations with other established space agencies prior to 2014.

1. **Economic diversification.** The UAE firstly sought to diversify its economic activities away from its traditional reliance on hydrocarbons, which accounted for roughly 30% of the nation's GDP in 2014 [59]. The UAE saw the space sector as a unique economic opportunity, with its potential of attracting new businesses and technologies to participate in space activities within the UAE's borders and further stimulate the nation's economy. Additionally, the government sought to fill gaps in the international space industry and identify areas to

potentially specialize in, with the goal of reaping financial benefits while participating in the larger global economy.

2. **Geopolitical impact.** In the larger global landscape, the UAE saw space activities as a further opportunity to strengthen its geopolitical position. By establishing itself as a global leader in space, the UAE would be able to utilize its position as a means of contributing to stability for the larger Arab region. In a region that is often underscored by conflict and turmoil, the UAE could demonstrate to the rest of the world its steadfast ability to lead peaceful activities in space. By dispelling such instability, the UAE could strengthen its international partnerships to bolster its economy, develop human capital, and support future growth. Further, through these space activities, the UAE could also lead the Arab region by example. As the UAE's socioeconomic benefits of space activities such as financial opportunities and STEM education development became more apparent, other Arab nations' governments would likely seek to emulate the UAE's involvement in space activities, reinforcing the perception of stability in the region. Lastly, the UAE's involvement in the space sector could further develop capacity building, helping to foster more effective multilateral relationships with the international community.
3. **Consolidation of space activities.** As the space sector in the UAE grew, it became clear that the nation was lacking an identifiable "point of contact" for space activities both nationally and internationally. There are seven emirates within the UAE, each with autonomous local governments. Without an overarching Federal level entity overseeing and coordinating the space sector, the UAE found it challenging to advance interest on both the international and local levels with its counterparts and stakeholders. The country was lacking a unifying message on space to broadcast internationally and a single organization with a broad understanding as well as a clear plan for the entire domestic sector. The space sector was lacking a single body to facilitate coordination between the different UAE sectors involved in space as well as between operators and users. In the same vein, the space sector was also lacking an organizing body to facilitate collaborations at the regional and international levels. To make space a coordinated and federally driven project, rather than a disjointed effort driven by individual emirates, the UAE needed a unified point of contact for centralized visibility, coordination, and collaboration.
4. **Regulation of space activities.** Apart from radio frequency coordination and the Telecommunications Regulatory Authority, the UAE was lacking a regulatory body and national regulations related to space. This was workable when the majority of UAE space companies were "national operators" but, with a growing desire to encourage and enable a private sector to emerge and build an ecosystem within the space sector, the UAE needed a regulatory framework for non-governmental stakeholders to follow. Regulations are key to establishing transparency and ensuring compliance with international law. A clear and easy to

understand regulatory environment is also important for attracting businesses, inspire investor confidence, and, by establishing less aggressive regulations than other states, the UAE had the ability to leverage regulations to benefit their commercial space sector.

5. **Contribution to the global community**. Finally, the UAE sought to utilize space as a means of contributing to the larger global community. The national government prioritized environmental sustainability through its "UAE Vision 2021 National Agenda," committing to the sustainable development of infrastructure while preserving the environment [60]. The Agenda further highlighted the goals of clean and renewable energy solutions, water preservation, and air quality improvements, all of which can be tackled through the application of space-based Earth observation technologies. Beyond environmental issues, the UAE also possessed several strategic plans and initiatives focused on societal areas such as youth development and women empowerment, as highlighted in the UAE Centennial 2071 vision for long-term government goals, that could be enhanced through the expansion of STEM careers and workforce in the space sector. Most directly, the UAE also sought to contribute to the global scientific knowledge base with its space capabilities and applications.

Formation of the Agency

The UAE waited to form a space agency until it was clear that their space sector needed an organization to accelerate space activities and provide for an overarching Federal level entity to advance its interests, domestically and internationally. The UAE started this process by first clearly outlining their three goals for the agency: (1) not to overregulate the space sector; (2) to maximize the many economic, social, security, environmental, and political benefits of space; and (3) to sustain the growth of the space sector by ensuring the sustainability of the earth, space, the space projects and missions.

When forming their agency, the UAE found the lack of international guidelines and rapid changes in the space sector to be challenging. There were no existing space regulations in the UAE or surrounding region to use as a starting point for the space agency and the space sector has a very small number of treaties to use as guidelines, especially in comparison to other industries. The many unanswered questions about the existing legal framework in space was confusing for the UAE as new entrants into space. At the same time, the space sector and space economy was, and still is, in a state of rapid change with new players, new activities, and rapid growth.

Throughout the establishment of the space agency, the UAE studied the organizational models of existing space agencies to help determine a space agency framework that would best support their three goals. After completing this study, which included subject matter experts from the United States and other established space nations, the UAE concluded that none of the existing models fit what they were hoping to accomplish with their own space agency. Based on their three goals, the UAE

determined that the role of the agency would be a facilitator, rather than a producer, and it would utilize a "light," agile space agency approach to support the growth of the nation's space sector.

In 2014, the UAE Space Agency was established by the UAE's first space law, Federal Decree No. (1) of 2014. The law established the space agency, outlined its goals and mandate, and defined the role of the Agency's Board of Directors. No regulations were included in this first law. Instead, the newly formed UAESA was tasked with developing its regulatory framework.

Organizational Structure

The UAESA was established as a federal government authority. The decision was made to form an "Agency" rather than a new "Ministry" because UAE Ministries are purely political organizations and space agencies need to be more technically focused. For this reason, the UAESA does not have a seat in Cabinet of Ministries.

The UAE Space Agency is currently led by the Chairman, Dr. Ahmad bin Abdulla Humaid Belhoul Al Falasi, who also serves as the UAE's Minister of State for Higher Education and Advanced Skills, though it is not required that the Chairman also be a Minister. The UAE Ministry of Cabinet Affairs and the Future loosely oversees the UAESA, and the Agency reports its strategic objectives and key performance indicators to this Ministry and the Prime Minister's Office. The Chairman of the UAESA sits on the Board of Directors, which manages the Agency, and its members typically serve for roughly 3 years; however, this period can be extended as needed. The Board currently consists of a mix of individuals involved in federal, state-owned commercial enterprises, academia, and military UAE organizations [61], allowing for cross-sector communication and policy alignment. Beyond the Board of Directors, the Agency also possesses an Advisory Committee, featuring global civil space leaders and experts from the U.S., Saudi Arabia, Europe, China, India, Japan, Korea, and Russia [62]. The Advisory Committee initially helped establish the agency and continues to provide strategic guidance to the UAESA.

Due to the UAESA's involvement with the UAE Ministry of Cabinet Affairs and the Future, decisions are relatively easily flowed through the federal infrastructure. Proposals for new space-related projects are brought up through the Agency's Board of Directors and ultimately raised to the Chairman for approval. These proposals can then be presented to the Ministry or other relevant stakeholders by the Chairman. The UAESA's strategic and operational plans specifically are presented to the UAE Cabinet in the form of a memorandum once approved by the Agency's Board and Chairman. Though this decision-making process relies heavily upon the support and interest of the UAESA's leadership, one advantage that arises is the ability for a unified value proposition across multiple stakeholders, even outside of the Agency.

The UAE Space Agency is a small but agile organization, and it is able to grow and shrink in size depending upon its needs. Currently, there are about 60 staff members; roughly half of these staff fall under the core business function and the remaining are support services [63].

Agency Role

The UAE was aiming to achieve an agile and scalable space agency approach when determining the role of the UAESA. The Agency is primarily a coordinating, oversight, and regulatory body that serves to choreograph, convene, facilitate, promote, advise, and advance regulations and strategies for UAE space activities. The UAESA's responsibilities include proposing policies, strategies, regulations, and legislations related to the space sector; granting authorizations for space activities; contributing or participating in international space projects, suggesting international agreements with other entities in the space sector, and representing the UAE in international forums and programs; spreading awareness of the importance of the space sector; and financing or facilitating the financing of space activities [64].

A unique feature of the UAE is its strong political will for space activities. The UAESA has been given legal, financial, and administrative independence to enable the agency to carry out all actions and acts necessary to achieve the nation's goals and objectives for the space sector. The political support for the UAESA to exercise all powers, actions, and activities necessary has allowed the Agency to direct R&D spending and enable universities and Space Centers to take actions in space more quickly than other nations in the global space community [64].

UAESA is responsible for all licensing and regulatory activities related to the UAE space sector and have decided to adopt a "light," agile regulatory approach and will not push for new regulation until there is an obvious need. UAESA aims to only establish regulations that are essential for the space sector to function or will make it easier for entities to operate in their space sector. The UAESA does not want to hinder or impede the growth of their space sector by overregulating. Companies interested in pursuing space activities in the UAE are not inhibited by federal regulations that are often found in other nations, which makes the UAE an attractive opportunity for potential companies.

The primary purpose of the UAESA is not to execute technical work or directly invest in space activities, although its charter does not prevent it from contributing technical work or making financial investments [64]. The agency has actively sought to find ways to utilize existing resources and engage other sectors before taking direct action to fund or develop a capability. For example, rather than building a large research lab capability as part of the space agency, the UAE partnered with universities, including UAE University, Khalifa University, Sharjah University, and NYU Abu Dhabi, to build four new R&D centers. Most of the technical development for national space projects, like the Hope Probe, takes place at the existing Mohammed bin Rashid Space Centre while the UAESA is responsible for funding and supervising procedures [65].

Regulatory Framework

The UAE has produced a well-rounded set of laws, policies, and regulations since its formation in 2014. These policies have embraced an agile and scalable regulatory approach and have strived to remain technology neutral, meaning that the policies are not dependent on available current technologies. These two regulatory philosophies are critical for ensuring that the space sector remains attractive to private industry and does not become overregulated and developing a regulatory framework that is sustainable in the face of rapid technological changes.

The nation's regulatory framework can be broken out into two major parts, the leadership direction and the national law, as seen in the figure below. The leadership direction is based entirely on the UAE's 2016 National Space Policy and from this policy UAESA has developed a set of initiatives and programs, including the National Space Strategy, National Space Investment Promotion Plan, and Science, Technology & Innovation Roadmap. The other leg of the UAE's regulatory framework is the national law, which defines the rules and regulations that must be followed to achieve the goals laid out in the National Space Policy. Federal Law No. (12) of 2019 is the foundational law that guides the formation of actionable regulations to guide and control the space sector in the UAE.

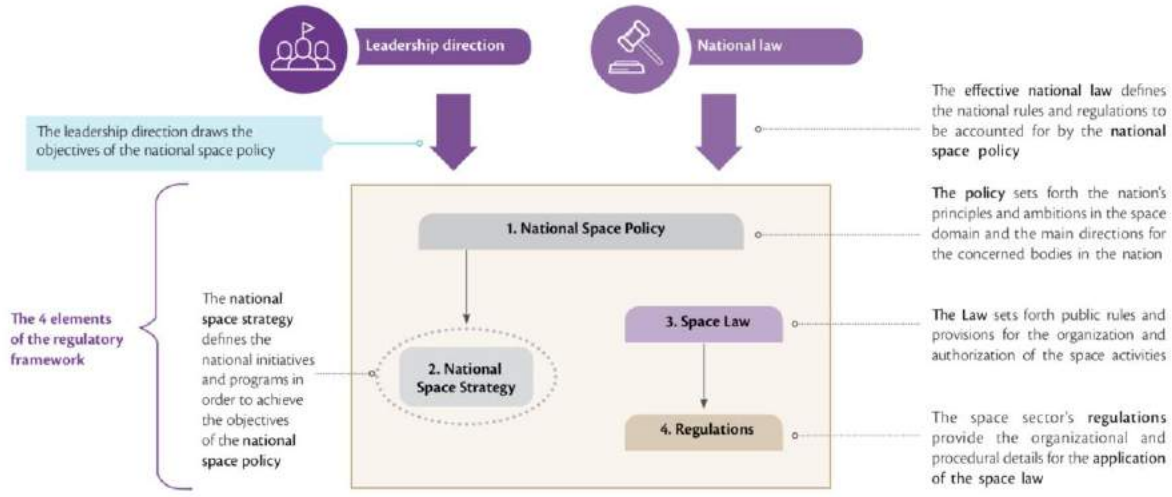


Figure 2: The regulatory framework of the UAE space sector from the UAE National Space Strategy Summary 2030

International Space Treaties

The UAE has ratified the Outer Space Treaty (1967), The Astronaut Rescue and Return Agreement (1968), the Liability Convention (1972), and the Registration Convention (1975). The only treaty that the UAE has not ratified is the Moon Agreement (1979).

Federal Decree-Law No. (1) of 2014

The UAE's first space law, Federal Decree-Law No. (1) of 2014 on the Establishment of the Emirates Space Agency, was announced by President His Highness Sheikh Khalifa bin Zayed Al Nahyan on July

8th, 2014 and served as the establishing law for the UAE Space Agency [64]. The decree laid out the agency's mandate, goals, and organizational framework. It is important to note that this decree was focused only on establishing the space agency and did not enact any regulations. This approach gave the UAE the opportunity to develop a greater level of space law expertise before drafting any regulations to ensure that the nation developed a strategic and attractive regulatory environment.

The decree established that the UAESA would be managed by a board of directors, maintain financial and administrative independence, and report directly to the nation's Cabinet. The mandate for the UAESA included managing the UAE's national space programs and missions as well as developing the policies, regulations, and enforcement mechanisms needed to regulate the space sector and accomplish the agency's objectives [66]. The agency's first five objectives, as outlined in the decree and translated by the UAESA, were to: (1) organize, support and guide the Space sector to serve the interests of the State; (2) encourage the development and use of Space science and technology within the State and provide advice in this area; (3) establish international partnerships in the Space sector so as to enhance the State's role and status in the Space sector; (4) contribute to the diversification of the national economy through a developed national Space sector; (5) raise awareness of the importance of the Space sector and the development of the qualified human resources in the Space field. These five objectives were used to inform the UAE's National Space Policy [67].

National Space Policy of the United Arab Emirates (2016)

In September of 2016, the UAESA released the UAE's first National Space Policy with the aim of articulating the government's intentions for the space sector by answering two major questions: (1) why should the UAE focus on space and (2) what are the UAE's ambitions in space? His Highness Sheikh Khalifa Bin Zayed Al Nahyan, President of the United Arab Emirates, was quoted saying that the aim of the policy was "to position the United Arab Emirates among the world's leading nations in space sciences before 2021."

The Policy was developed with inputs from relevant entities within the UAE government, commercial sector, academic sector, and international organizations. The Policy was also created in alignment with relevant international laws and treaties as well as with existing UAE policies and national strategies, including the UAE Vision 2021, the Higher Policy for Science, Technology and Innovation, and the National Innovation Strategy.

The National Space Policy is broken up into six sections, which included the principles for how space will contribute to the UAE's broader national goals, the goals and ambitions the UAE has for its space sector, the key enablers necessary to achieve those goals, the governance mechanisms needed to ensure success, and the role of the UAESA and other stakeholders in executing the policy. Each section of the policy informs the next, with the principles informing the goals and the goals informing the enablers.

The principles defining the UAE's reason for developing a space sector include (2.1) enhancing the lives of UAE citizens; (2.2) supporting the UAE's national interests; (2.3) encouraging the growth and diversification of the UAE's economy; (2.4) promoting national and international collaboration to support the UAE's status; and (2.5) respecting international laws and treaties. The UAE's goals for its national space program, as informed by these principles, are to (3.1) expand the utilization of space to contribute to areas of strategic national interest, like national security and disaster management; (3.2) develop a sustainable, competitive, and innovative commercial space industry; (3.3) conduct scientific space missions; (3.4) promote a safe and stable space environment by enhancing the sustainability of space activities; (3.5) establish and expand UAE's regional and international leadership in space. Finally, the enabling capabilities identified in the National Space Policy as necessary to achieve these goals are (4.1) an increased national awareness of the importance of space and its different uses; (4.2) an increase in the number of qualified UAE space professionals; (4.3) an effective and attractive space regulatory environment; (4.4) active management of radiofrequency spectrum allocation and satellite orbital assignments; (4.5) effective science, technology and innovation programs to conduct basic and applied space research; (4.6) national, regional and global collaborations, coordination and partnerships; (4.7) adequate investment and financial support for both government projects and domestic commercial space companies; and (4.8) the creation of the facilities and infrastructure necessary for development of space technologies.

Based on these principles, goals, and enabling capabilities, the UAESA determined four areas that are key to the successful implementation of the National Space Policy. The first is (6.1) the effective implementation, monitoring, and stewardship of the National Space Policy by the UAESA. One of the ways that the Policy directs to the UAESA to address this area is by developing a National Space Strategy and Implementation Roadmap to demonstrate how the National Space Policy will actually be implemented as a series of on-going space activities. Although it is not mentioned in the National Space Policy, the UAESA will also develop a National Space Investment Promotion Plan and Technology Investment Roadmap based on the National Space Strategy. The Policy also requires that the UAESA collect semi-annual progress reports from stakeholders and to provide annual reports on the status of the Policy to The UAE Cabinet. The UAESA is next tasked with establishing the National Committee for Oversight and Implementation of the National Space Policy to help address the second key factor, ensuring (6.2) active stakeholder involvement and coordination. The Policy also determines the importance of (6.3) identifying key gaps and opportunities in the space sector, so the UAESA is tasked with cooperating with other space actors to perform regular and comprehensive assessments of the space sector. The final success factor identified is (6.4) regular policy review and improvement. In response to this factor, a review of the National Space Policy is required every five years to ensure that the Policy remains up to date with the rapidly developing trends in space [67] [68].

Federal Law No. (12) of 2019 on the Regulation of the Space Sector

Five years after the establishment of its space agency, the UAE replaced Federal Decree-Law No. (1) of 2014 with an updated space law based on the objectives outlined in the 2016 National Space Policy. This new law, Federal Law No. (12) of 2019, was issued on December 19th, 2019 and includes the establishment of a regulatory framework for the space sector and an updated mandate and goals for the UAESA. Initially, the updated mandate and regulatory framework were drafted as two separate laws, but a decision was made to instead abrogate the original establishment law for the UAESA and merge the space sector regulations and the space agency's mandate into a single law. There were three major reasons for this approach. First, combining the laws made it easier for individuals outside of the UAESA to understand the space sector in the UAE. Referencing a single document is more efficient than having to reference and compare two highly related documents. Second, combining the laws made it easier for the UAE to make updates to the law in the future because the changes would only need to be reflected in one document, rather than two. Finally, the UAESA determined that other sectors in the UAE had also combined the establishment of the managing entity and the regulatory approach into a single law, so it would not be unprecedented to do the same for the space sector.

The stated objective of the Law is to (1) stimulate investment and encourage private and academic sector participation in space and space-related activities; (2) support the implementation of the necessary safety, security and environmental measures needed to enhance the long-term space stability and sustainability; (3) support the principle of transparency and the commitment of the UAE to implement the provisions of relevant international conventions and treaties. This Law contains the regulatory framework that was missing from the 2014 law establishing the space agency. The regulated activities included in the law are quite comprehensive, but it is clear that the regulations have been carefully formulated to support space sustainability and comply with the space treaties to which the UAE is a signatory, without discouraging participation in the space sector due to overregulation. The specific activities regulated by the law include the launch, re-entry, removal or disposal a space object from the orbit; the operation of space objects and satellite communication activities; providing logistical support services in outer space; the management of space data activities; and the collection or trade of meteorites that fall in the UAE [64].

National Space Strategy 2030

In March of 2019, the UAESA launched the National Space Strategy 2030 which translates the 2016 National Space Policy into a group of programs and initiatives that will be carried out by the public and private sectors from 2018 until the year 2030. The strategy includes 6 objectives, 21 programs and 79 initiatives and will involve more than 20 international space agencies and centers while benefiting more than 85 entities in the UAE. The UAESA will be overseeing the implementation of this strategy and coordinating activities between the many entities involved [69] [70].

National Space Sector Regulations

Based on numerous local and international studies as well as the legal framework established by Federal Law No. (12) of 2019, the UAE has identified five fundamental regulations that need to be enacted to effectively govern their space sector. These regulations are listed below [71].

1. Regulation on Registration
2. Regulation on Accident and Incident Investigation
3. Regulation on Authorizations
4. Regulation on Human Spaceflight Activities
5. Regulation on the Auditing Framework

The Regulation on Registration [72] and the Regulation on Human Spaceflight Activities [73] have already been established and the remaining three regulations are currently under consultation [71]. The Regulation on Registration is primarily focused on the registration of satellites for the UAE National Registry, which is maintained by the UAESA to inform the UN Office of Outer Space Affairs [72]. The Regulation on Human Spaceflight Activities is aimed at ensuring safety and requires that crew purchase an insurance policy and submit a declaration to waive UAE liability [73].

Funding and Budgets

The Agency has a basic operational budget that is appropriated by the UAE government and is based on the UAESA's strategic and operational plans [64]. The UAE Space Agency manages the funding of large flagship projects, such as the Emirates Mars Mission. As previously mentioned, the success of such ventures is directly related to the support and interest of the Agency's Board of Directors and the UAE Ministry of Cabinet Affairs and the Future. Once federal interest is established for a new space project, other sectors like the commercial, R&D centers, and academic sectors typically follow suit with their interest and involvement. The space agency is also responsible for facilitating alternative forms of funding for projects, commercial space companies, and startups through private investors. This strategy is laid out in the Space Investment Promotion Plan.

In short, the UAE government plays a large role in influencing the funding priorities and investments of the national space sector. With clear government interest and backing, decisions can also be made more rapidly to accelerate the execution of major projects. Moreover, the UAE government does not follow a cyclical term model, allowing for the continuity of support and funding for major space projects over an extended period of time.

Key Projects & Milestones

Though the UAE Space Agency has only directly responsible for the Emirates Mars Mission to date, the UAE's research centers and commercial partners have been and are working on a variety of projects, ranging from human spaceflight to satellite programs.

Mars Projects

A significant portion of the UAE's recent space activities has been focused on Mars, as the UAE government saw a clear value and importance of missions to the planet. It recognized that the national Mars vision could elicit inspiration and spark curiosity amongst its citizens, particularly for the younger generation. As a testament to this value, the UAE saw a 40% increase in the enrollment of STEM-related university majors after the announcement of the UAE's Mars Mission. Evidently, a vision set on Mars would motivate and stimulate the nation through scientific opportunity and intellectual curiosity. The UAE government is also seeking to utilize Mars missions as a mechanism to fill gaps in other space nations' architectures that are required to achieve a human presence in deep space.

The Emirates Mars Mission is a flagship project of the UAE that features the Hope Probe, a Mars orbiter, that successfully launched on July 19, 2020 from Japan [74]. The goal of the mission is to provide a comprehensive assessment of the Martian atmosphere, and the probe is ceremoniously scheduled to reach Mars by 2021 to mark the 50th anniversary of the UAE as a nation. The Hope Probe is the first planetary science mission led entirely by an Arab nation, making the UAE one of 9 nations to send a planetary mission to Mars. Of the over 100 Emiratis working on the Emirates Mars Mission, the average age of the team is 27 years old and women represent 30% of the engineers and scientists [75], attesting to the country's investment into the younger generation and women empowerment. Overall, the UAESA has played a role in the Emirates Mars Mission by providing funding and supervision of procedures and implementation of the project, while the MBRSC has been responsible for the execution and supervision of all stages of design, development, and launch of the Hope Probe orbiter [76]. The UAESA is also partnering with academic research centers at Arizona State University, the University of California, Berkeley, and the University of Colorado at Boulder [77].

An extension of the Emirates Mars Mission, the Mars 2117 vision was created with the goal of establishing the UAE's first habitable human settlement on Mars by the year 2117. The project was initiated in 2017 when the UAE Prime Minister and Vice President directed the MBRSC to lead the Mars 2117 project and devise a 100-year implementation plan [78]. Together with the Emirates Mars Mission, the UAE has challenged itself to achieve monumental endeavors that will solidify its position as a leader in space exploration [79].

Astronaut Program

One of the UAE's greatest space-related accomplishments thus far was its launch of the first Emirati astronaut, Hazzaa Al Mansoori, on September 25, 2019 to the International Space Station (ISS) [80].

While aboard the ISS, Al Mansouri conducted 16 experiments to demonstrate the scientific value of the mission to the larger UAE community. The interest in space amongst Emirati youth in particular significantly increased as the result of this mission, as it served as a source of inspiration for the next generation of scientists and engineers. On a larger scale, the UAE sought to showcase this mission as the first step towards the goal of developing a sustainable Emirati human spaceflight program. Currently, the MBRSC is leading the UAE Astronaut Program and recently completed its call for applications for the second batch of astronaut candidates. The Center noted a significant amount of interest through their campaigns at schools, hospitals, and government departments as the nation builds its momentum towards a sustainable human presence in space [81].

Satellite Program

Another of the UAE's major space accomplishments was the launch of the MBRSC's KhalifaSat in 2018, which was the first Earth observation satellite designed and built by an entirely Emirati team in collaboration with South Korean engineers [82]. In addition to KhalifaSat and the Center's earlier Dubai-1 and Dubai-2 satellites, Nayif-1 was also launched by MBRSC in 2017. Nayif-1 was the UAE's first nanosatellite built in collaboration with educational institutions as part of the sustainable space science knowledge transfer program [83]. The UAE is continuing to expand its satellite program, particularly with the development of nanosatellites. At the time of this report, the UAE has 10 functional satellites in orbit with 8 more in development, mainly of which are CubeSats. To enable the development of these CubeSats, the Yahsat Space Lab was launched in 2017 in partnership with Khalifa University to provide the facilities required to construct, test, and launch miniature satellites [84]. Through such commercial and academic partnerships, the UAE continues to expand its domestic satellite programs.

International Collaboration

Lessons Learned/Advice for Other Emerging Space Nations

The UAE has shared several lessons learned with other nations in the emerging space community, such as those in the Arab region, Australia, Azerbaijan, and Luxembourg. The UAESA has hosted workshops with these countries, beginning intensively over the course of the past 2 years, and continues to collaborate through these workshops today. Additionally, Australia and Luxembourg have "benchmarked" or "baselined" the UAE, engaging in exchanges with the UAESA to gain insights into its best practices prior to establishing their respective agencies. Both nations have framework agreements in place with the UAE, and through these agreements, lessons learned have continued to be shared amongst the countries [85] [86].

The UAESA's motivation for sharing such lessons learned is twofold: for nations in the Arab region, specifically, the UAE sought to spread its success to other nations and strengthen the region's geopolitical standing. Further, through open exchanges, the UAE could also continue to gain from lessons shared by other space nations to benefit the UAESA itself.

"The UAE approached formulating its regulations with flexibility in mind, allowing for regulatory procedures to be easily updated and to adapt to quickly evolving technologies."

The UAESA has compiled points of advice based on its direct experience and through its research of other established space nations. Firstly, the UAESA has strongly emphasized incorporating **flexibility** into policies and regulations when creating a space agency. It has advised nations to formulate policies that are deliberately vague in order to encourage technological innovation. The UAESA has found that rigid regulations led to the overregulation of the space sector, which in turn could create an innovation graveyard. In other words, innovation within these nations was stunted due to the restrictions imposed by regulators. Therefore, the UAE approached formulating its regulations with flexibility in mind, allowing for regulatory procedures to be easily updated and to adapt to quickly evolving technologies. Through such flexibility, the UAE has also been able to attract companies to participate in space activities within its borders and stimulate the nation's economy.

Furthermore, the UAESA has highlighted that regulations for space activities should be **technology neutral** rather than technology specific. In the case of other space nations, the UAE noted that several countries issued highly technology-specific regulations in environments where technologies were developing faster than the regulations themselves. As a result, the regulatory regimes were constantly struggling to keep up with the pace of technology changes, contributing to less effective regulations. Consequently, the UAE deliberately formulated regulations that were technology neutral to allow for a comprehensive framework that maintains flexibility in a rapidly changing environment.

UAE-Luxembourg Collaboration

The UAE and Luxembourg, the two case studies explored in this report, have collaborated heavily in their space activities given their commonalities. Both countries have had similar motivations for establishing their respective space agencies, greatly attributing economic diversification as a driving rationale. To draw a parallel, the Luxembourg government has strongly invested in SES within its country, just as the UAE government has financed Yahsat and Thuraya through the Mubadala Investment Company. UAE and Luxembourg leadership have similar views as well on the futures of their space sectors: both have set grandiose goals and objectives for their nations to achieve in space, such as UAE's Mars missions and Luxembourg's Space Resources Initiative. Both governments have been able to garner public support for these endeavors and galvanize their leadership, along with their space industries, to working towards such goals. These similarities in rationale and political support have lent themselves to strong collaboration amongst the space nations.

As mentioned previously, when establishing the Luxembourg Space Agency, the nation "benchmarked" the UAE Space Agency, specifically focusing on the UAE's space policies and regulatory framework. Given these countries' similarities, the UAESA was a natural model to consult in

when forming Luxembourg's agency. Even prior to the establishment of the LSA, Luxembourg and the UAE signed a memorandum of understanding (MoU) in 2017 to lay the foundation for bilateral cooperation on space exploration and the utilization of space resources. Both countries saw the MoU as an opportunity to align their strategic visions, foster closer cooperation, and exchange scientific knowledge. The UAE in particular recognized the benefit of collaborating with Luxembourg in promoting the peaceful exploration of outer space and pursuing the common goal of the betterment of humankind [86].

Beyond the 2017 MoU, the UAE and Luxembourg Space Agencies also hosted a joint UAE-Luxembourg Space Investor Forum Workshop in Abu Dhabi in January 2020. The purpose of the forum was to highlight the economic and political ties of the two nations as well as discuss their common interest in investment opportunities within the commercial space industry. The UAESA has been particularly interested in learning from Luxembourg's recent investment funds across the nation's space sector as it applies to the UAE's National Space Investment Promotion Plan. Through channels such as workshops, forums, and MoU's, the UAE and Luxembourg Space Agencies will continue to collaborate and share their experiences with the goal of growing their respective space sectors.

Arab Space Cooperation Group

In terms of regional cooperation, the UAE led the establishment of the Arab Space Cooperation Group in 2019. Currently, 14 nations are members from across the Middle East and North African regions, and that number has continued to grow since the group's inception. Overall, the main goals of the cooperation are to: establish Arab space agencies and sustainable space programs, support research and development efforts for sustainability, inspire and educate talent for the space sector, and generate a significant international presence [87]. The UAE led the establishment of the Arab Space Cooperation Group to enhance general collaboration within the Arab space sector while creating a mechanism to provide cutting-edge science and technology to the region in an effort to advance Arab societies and welfare [88]. Additionally, the UAE sought to use the group as a means of sharing lessons learned with other Arab nations to strengthen the region's space sector. For example, as several member states do not have their own space agencies, the UAESA has shared the benefits of establishing an overarching government entity to advance space activities that could be of equal benefit to these member states.

The Arab Space Cooperation Group's first major project will be the development of the "813" satellite, which will be built in the UAE by scientists from all member states. The goal of the satellite is to address climate change and environmental issues and improve urban planning within the Arab region through monitoring the atmosphere [89]. This collaborative effort will be a significant achievement for the Arab region, demonstrating a clear application of scientific and engineering knowledge sharing amongst Arab nations.

The United Nations

Part of the ultimate goal of the UAE's National Space Policy is to strengthen the UAE's status and role regionally and globally and one of the most prominent efforts to achieve this goal has been the UAE's contributions to international frameworks, which are best highlighted by the UAE's various collaborations with the United Nations. When the UAESA was first established in 2014, the UAE was only an observer of the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS). Without a central agency coordinating space activities, the nation had never thought to become a member of UNCOPUOS. As a relatively new entrant into space, the UAE had felt challenged by the lack of existing international laws regulating the space sector when forming their space agency. The UAESA was inspired by this challenge to become more involved in the development of international laws, starting by joining UNCOPUOS as an official member in 2015 [90]. The UAE has remained an active member of UNCOPUOS, even encouraging other nations in the region to become members of the Committee.

UAESA has focused their contributions to the UN and the global space community on two areas: space as a driver for socioeconomic sustainability and the sustainability of space itself. With the release of the UAE's National Space Policy in 2016, the UAE became the first nation to require that its space sector comply with the voluntary Long-Term Sustainability Guidelines (LTSG), which would not be officially approved by the UNOOSA until 2019. The UAESA and Mohammed Bin Rashid Space Centre have since both signed Memorandums of Understanding with the United Nations Office for Outer Space Affairs (UNOOSA) to increase the collaboration between the UAE and UNOOSA on promoting the peaceful uses of outer space and the long-term sustainability of outer space activities [91] [92].

The UAE has also hosted a variety of events and conferences for the United Nations, including a discussion of how space can drive sustainable socioeconomic development that would later inform the UNISPACE+50 resolution. The UAE was also involved in the creation of the UNOOSA-ICAO Symposium, a series of three conferences that took place in Vienna, Montreal, and Abu Dhabi and focused on examining the overlap between UNOOSA and the International Civil Aviation Organization (ICAO).

"In its only six years of operation, the UAE Space Agency has created and executed its visionary plan for Mars exploration and developed a multi-stage, progressive, and agile policy and regulatory framework."

Key Takeaways

Overall, the UAE has established a clear strategy for its space activities since the establishment of its space agency, laying out concrete plans for future goals and deliberately executing them. In its only six years of operation, the UAE Space Agency has created and executed its visionary plan for Mars

exploration and developed a multi-stage, progressive, and agile policy and regulatory framework. The UAE was the first nation to include the Long-Term Sustainability Guidelines (LTSG) as a mandate within their National Space Policy and has been actively pursuing opportunities to influence the greater space community to follow these guidelines as well.

The main lessons learned for the establishment of a new space agency based on the UAE's experience and unique regulatory framework are:

- Prior to establishing its space agency, the UAE identified a clear need for creating the organization. Economic diversification, geopolitical impact, and coordination/centralization of national space activities were major motivators for creating the UAE Space Agency (UAESA). The UAE also benchmarked other space agencies prior to establishing its agency, and from these consultations, concluded that a "light" approach was the best model for its space agency.
- When formulating regulations, the UAESA ensured that they were agile, scalable, and technology neutral. These regulations allow for adaptability to the fast-paced environment of evolving technologies. They also encourage innovation and invite companies to participate in space activities within the UAE.
- The UAE highly values influencing the global space community and growing its presence as a global space leader. The UAESA has engaged in international cooperation with the global space community including other emerging space nations through UN involvement, MoUs, cooperation groups, workshops, and "benchmarking" knowledge exchanges.

Though these lessons learned can help inform the establishment of new space agencies, the UAE model may not be applicable to all emerging space nations.

- The UAE model requires strong political will of space activities from government leaders in order to ensure the stability of space projects while also allowing for quick and effective decision making.
- This model also requires strong financial backing and a space agency with financial and administrative independence.

CONCLUSION

Concluding Policy Recommendations

The following policy recommendations were drafted based on the conclusions found in the general assessment and both case studies.

FOR EMERGING SPACE NATIONS

1. Determine the core purposes and rationales of your space agency--including what you hope the agency to accomplish in the near- and long-term-- ahead of its establishment, and prior to developing a regulatory framework.
2. When designing both governmental and commercial policy and regulatory frameworks for commercial space activities within your nation, design them to be agile and technologically neutral, so that they are future-proofed to remain applicable in the face of technological innovation. Ensure that high standards for mitigating risk to human life and for preserving the outer space environment for sustainable use are upheld, to the highest extent possible and as early as possible.
3. Taking into consideration your nation's existing capabilities, identify gaps in the global space industry that your nation can excel in and specialize to fill them, rather than generalizing in multiple capabilities or emulating the programs of established space agencies by default. At the same time, ensure that your government's space activities do not compete with any existing commercial activities within your nation.
4. Follow international best practices related to the use of space and take time to thoroughly consider the option to sign and ratify existing international treaties relating to space activities that correspond with your nation's goals. As early and as often as practicable, participate in international fora for space cooperation and multilateral information exchange, such as the UNCOPUOS and others.
5. Work with established space nations to take advice from their areas of expertise, but avoid becoming wholly dependent on them, instead approaching them as prospective colleagues. Take into consideration that their long histories have affected their organizational practices, and may have influenced them negatively, such as reducing their tolerance for taking risks. When engaging with established space agencies, make sure to identify and advocate for your own national priorities and specializations.
6. Collaborate with international partners and across domestic sectors to ensure your nation maximizes its returns from the utilization of space data and applications. Share best practices as they manifest; transparency on the world stage promotes the visibility of your nation's goals and capabilities, while easing the way for other, more established space agencies to identify areas of potential cooperation and knowledge exchange.

FOR ESTABLISHED SPACE NATIONS ENGAGING WITH EMERGING SPACE NATIONS

1. Engage in capacity-building with emerging space nations, especially related to the establishment of regulatory frameworks within emerging space nations. While doing so, consciously foster a spirit of partnership and bilateral knowledge transfer, rather than a teacher-student cooperative dynamic. In short, be receptive to learning from emerging space nations; engage with the intention of evolving your relationship over time to that of coequal

peers. As you evaluate and observe evidence of successful approaches from emerging space agencies, consider opening investigations into how those methods might be incorporated into your own agency's organizational structure.

2. Ensure a level playing field by acting as a good role model for emerging space nations as they begin to develop their influence over the space environment. Abide by international treaties, regulations, and best practices to the greatest extent possible--and be proactive in accelerating the adoption of transparent, responsible behavior in space. In particular, prioritize engagement in sustainable practices that help to preserve the space environment, such as mitigation of the creation of debris, planetary protection, transparency in space domain awareness data-sharing, and sustained engagement in multilateral policy-making and legal fora, such as the UNCOPUOS.

Future Work

Though this report assessed sixteen emerging space nations established between 2014 and 2019 – of which two were analyzed in detail – the broader space community could highly benefit from continued and further research. The remaining fourteen emerging space nations identified in this report could be further explored as unique, in-depth case studies utilizing a similar methodology of collecting firsthand accounts. By diving deeper into these recently established space agencies, additional insights can be gleaned not only for future emerging space nations, but also for established space nations.

We also recognize that nations' participation in the global space community is constantly evolving, with new space agencies being formed at an unprecedented rate. As the list of emerging space nations continues to expand, we encourage similar research to be conducted to continue to fill knowledge gaps and contribute to a greater understanding of how modern space agencies are operating in a rapidly evolving space environment.

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APPENDIX: Detailed General Assessment

African Union (2018)

Formation of the Space Agency

The legislation to establish a space agency was first passed in 2018 at the 13th Ordinary Session of the African Union Commission. At the 32nd Ordinary Session of the African Union Commission in 2019, Egypt was selected to be the headquarters of the new agency. The selection of the host country was highly contested, with Ethiopia and Nigeria also making strong bids. Egypt included a donation of USD 10 million with its bid. With the host nation selected, the implementation of the African Space Policy and Strategy was implemented immediately [93] [94].

The agency plans to start by working closely with South Africa and Nigeria, whose national space programs are some of the most advanced on the continent and, based on the African Union Agenda 2063, the AU plans to establish the African Space Agency in 2023 [93].

Rationale

The primary motivation in the agency's formation was to use technology to solve Africa's greatest challenges, from infrastructure to agriculture and disaster management and to foster regional coordination and cooperation [95].

Organization

The African Space Agency is comprised of the African Space Council, an Advisory Committee, the Secretariat, and Director-General. An annual report from the agency is to be submitted to the STC-EST.

Role and Activities

The African Space Agency has four primary technology focuses: Earth observation, communication, navigation and positioning, and astronomy. The main objectives of the agency are to promote and coordinate the implementation of the African Space Policy and Strategy and support member states in building their own space programs [96].

Australia (2018)

Formation of the Space Agency

Despite the nascent stage of its civil space agency, Australia has a longstanding history of involvement in the space industry, across civil, military, and intelligence sectors. It was a key player in original Space Race-era rocketry research and development, becoming the seventh nation to launch a satellite in 1967. Australia's strategic remote location has also made it an ideal host for various astronomical, ground station, and space domain awareness (SDA) structures, such as the Space Surveillance Telescope (SST), the high frequency Skywave Over-The-Horizon-Radar (OTHR), the Space-Based Infra-Red System (SBIRS), and the Learmonth Solar Observatory (LSO), among others [97].

From 1987 up until its disbandment in 1996, the Australian Space Office (ASO) was in operation to carry out a National Space Program initiative to grow a globally competitive commercial space industry in Australia [98]. But the Program was eventually determined to be unsuccessful and was abolished, leaving the nation as one of the only OECD nations without a formal civil space agency until the creation of the ASA.

In 2017, an expert investigation into the creation of a space agency was led by the former chief executive of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the federal scientific research agency of the

Australian government. Following this inquiry, the intent to form the ASA was announced in September of 2017 at the International Astronautical Congress hosted in Adelaide [99]. Senator Michaelia Cash officially announced the Australian Space Agency's launch date as the 1st of July, 2018.

Rationale

The Australian Space Agency's Charter cites a need to grow a "globally respected" commercial space industry as a major rationale for its formation [100]. It expresses the view that a robust space industry bolsters the overall economy, improves the lives of Australians and fosters international engagement. The Charter further characterizes the ASA as a new "front door" to international space programs and economic activity.

The 2019 Australian Civil Space Strategy outlined four strategic pillars that have developed alongside the formation and first year of operation of the ASA. These pillars are: 1) open the door to international cooperation, 2) develop competitive advantages in national capability, 3) ensure safety and national interests are addressed, and 4) inspire and improve the lives of Australians. The Australian government also has seven overarching National Civil Space Priorities, under which it has allocated funds to programs across various government agencies, categorized by year: Position, navigation, and timing and Earth Observation in 2018-2019; Communication technologies and ground infrastructure in 2019-2021; and R&D, Space Situational Awareness, Robotics and automation, and access to space in the 2021-2028 period.

Overall, between the outlining of a Civil Space Strategy and the formation of the ASA, Australia has affirmed its dedication to space activities, laying a foundation for increased engagement with international space agencies, a bolstering of the domestic commercial space economy, and phased investment in domestic civil space infrastructure.

Organization

According to the ASA's Charter, for its initial years of operation, the ASA has been housed under the Department of Industry, Innovation and Science, though it is a non-statutory agency. It is structured around the primary roles of an Agency Head, a Deputy Head, and a skills-based Advisory Board, which is a non-governing body made up of up to ten members [100]. The Advisory Board's purpose is to "review and advise the strategic direction and performance of the Agency," as well as to support the Agency generally. Members are appointed by the Minister of the Department of Industry, Innovation, and Science, at the recommendation of the Agency Head.

The 2018 federal budget allocated AUS 26 million (USD 17 million) in initial funding for the ASA to be distributed over four years, a relatively small amount that faced some public criticism [101]. However, the ASA also manages investment and grant funds to invest in the commercial space industry in Australia (See *Role and Activitie*s below).

Role and Activities

The ASA's two primary functions within the Australian government are a) the coordination of various existing civil space activities across the government and b) supporting the growth of the commercial space industry. For many years, Australia has had well-established space science and research infrastructure, and incorporates space data and services across several government agencies and offices. For example, it owns a number of geostationary communications satellites that serve the Australian population and Australian Defense Forces, as well as purchasing other space-based capabilities in the commercial market [102]. Government agencies utilizing space data include the Bureaus of Rural Sciences and Meteorology, as well as the Australian Centre for Remote Sensing and the Australian Space Weather Agency. There is also an assortment of robust space research capabilities in Australian academia. The

ASA is designed to operate as a "whole-of-government" coordinator between these civil space activities, rather than centralizing all activities under one agency. In this sense, while there is a foundation of inter-agency coordination, the ASA's role is operationally divorced from the Australian Defense Force (ADF)'s military space efforts.

The ASA also supports the growth of the commercial space economy, and the use of space data, services, technologies, and applications across the Australian economy. It manages several programs to invest in and administer grants to Australian commercial space companies, including the Space Infrastructure Fund (at AUS 19.5 million or USD 12.7 million), the International Space Investment Initiative (at AUS 15 million or USD 9.8 million over three years), and, beginning in mid-2020, the Moon to Mars initiative (at AUS 150 million or USD 98 million).

The ASA is also responsible for providing strategic space policy guidance to the government. Australia's Civil Space Strategy outlines a ten-year plan for the future of Australia's commercial space sector, with an overall goal of tripling the sector's contribution to the GDP to AUS 12 billion (USD 7.8 billion) and creating an additional 20,000 Australian space industry jobs by 2030. Lastly, the ASA is the body within the Australian government responsible for regulating Australian space activities and launch sites, as well as coordinating international agreements affecting space regulation. For the moment, the majority of space regulation overseen by the ASA pertains to launch [103].

Bahrain (2014)

Formation of the Space Agency

The process of creating the space agency itself was relatively uncomplicated; as Bahrain is a constitutional monarchy, the Agency was established at the decision of the King, and officially enacted by Royal Decree No. 11 for the year 2014 [104]. Since its establishment, Bahrain has worked closely with the United Arab Emirates (UAE) to develop its agency's activities, signing several cooperative agreements with the Mohammed Bin Rashid Space Center and the UAE Space Agency (UAESA) for the implementation of joint projects, capacity-building, and data-sharing. In 2016, a joint Bahraini-Emirati capacity-building workshop was held, wherein the UAE Space Agency helped to evaluate the candidates for the Bahrain Space Team that will be responsible for constructing Bahrain's first satellite and ground station segment. The UAE also held a workshop to advise NSSA on the drafting of Bahraini national space law, which is expected to be released in the coming years.

Rationale

The nation of Bahrain has worked since 2008 to build a government-wide strategy for sustainable development, economic growth, social welfare, and scientific and technological development, called the 2030 Vision. The NSSA was established in 2014 to align within this wider Vision, with the aim of harnessing space data, technology, science, and research for broader socioeconomic improvement for Bahraini citizens. Bahrain has taken a practical approach to its space agency, identifying the niche of space science and research as one means of sparking technological innovation towards the Vision. The NSSA has closely tied its activities with the UN Sustainable Development Goals, in tandem with a long-term vision to reach international recognition in space science research by cultivating "national skills" to be competitive regionally and internationally in the space industry.

Organization

The NSSA reports to the Council of Ministers, with primary supervision of the agency entrusted to the Minister of Education. The NSSA has a seven-member Board of Directors, which includes a Chairman and a Vice Chairman in leadership positions. The Minister of Education recommends the appointment of Board members, which are adopted

by Decree into four-year terms. The Board acts as the primary governing body of the NSSA, responsible for drawing up the Agency's general policies, business strategies, and annual programs for approval by the Minister of Education. The Board also controls the budgetary and administrative decisions for the Agency. Last, the Agency has a Chief Executive Officer, who reports directly to the Chairman of the Board and submits regular reports to the Board of Directors detailing the NSSA's business progress on its goals.

Role and Activities

The NSSA's primary functions are twofold: first, geared toward an overall 2030 Vision within the government, to apply space technologies and applications towards sustainable development. In keeping with this function, the NSSA has been active in directly tying its initial activities and National Space Policy to the UN Sustainable Development Goals. Planned activities falling under this primary function include building and launching nanosatellites and remote sensing satellites and establishing a lab for space image and data processing. Second, the NSSA aims to foster the development of a commercial space industry in Bahrain. In service of this function, it has planned activities including capacity-building, education and awareness efforts, the establishment of a simple ground station in Bahrain, and conducting a feasibility study to utilize a Bahraini license for slots in geostationary orbit, with the goal of attracting investment opportunities and initiating joint projects [105].

In its 2019-2023 Strategic Plan [106], the NSSA outlined the following six core strategic objectives:

1. Building national capabilities to create a prominent and excellent national space science foundation.
2. Promoting space science within the Kingdom through awareness, developing advanced research programs and enhancing innovation, to keep abreast of the development currently witnessed by the Kingdom towards a scientific and technological development commensurate with Bahrain's 2030 Vision.
3. Constructing a sound infrastructure for achieving comprehensive and sustainable development and for ensuring a leading position.
4. Establishing relationships of cooperation on regional and international joint projects with space agencies and with technical, industrial and research organizations actively engaged in space science.
5. Responding to national requirements through providing space information and earth observation data that serve the comprehensive development process and contribute to advancing space science and the sustainable development of the Kingdom.
6. Encouraging the Kingdom to become a party in international conventions and agreements of space science and associated technological concepts, and approving the principals regulating the Kingdom's activities in leading outer space activities and utilizing the space for peaceful purposes.

In service of these strategic objectives, it further explained five immediate initiatives and priorities it was launching beginning in the 2019 fiscal year [106]. Currently, each of these activities remain in the early planning stage of development [107].

- Establish a lab for processing space data and images,
- Launch Bahrain's first nano satellite for the purpose of capacity building,
- Launch a remote sensing satellite to fulfill national requirements,
- Establish a ground station for receiving space data and training on its operation management, and
- Feasibility study for launching a satellite for telecommunications and television channels.

Egypt (2019)

History of the Space Sector

The National Authority for Remote Sensing & Space Sciences (NARSS) was established in 1991 as an American-Egyptian venture that promoted the use of space technology to promote domestic development and incorporate advanced space-based technologies into regional planning. NARSS consisted of two main sectors: Remote Sensing and Space Sciences. The vision of the organization seeks to develop a robust geospatial system for sustainable country development through mechanisms such as human capacity building and development of infrastructure, supporting R&D within industry, promoting scientific research and education, and fostering international collaboration [108].

In May 1999, NARSS received approval from the Egyptian Space Council to create an Egyptian space program to develop technical capabilities in the manufacture and use of space technologies. Since its inception, NARSS has evolved from an outreach organization to establishing itself as a leading remote sensing institution with expertise across these fields. It has been responsible for Egypt's national space program and serves as the operator of the nation's Earth observation satellites. NARSS also engages with international partners on behalf of the Egyptian government and has been at the forefront of the nation's space diplomacy efforts [109].

Rationale for the Establishment of the Space Agency

In January 2018, the Egyptian government sought to focus its National Space Program on the development of domestic space capabilities and space commercialization. Established by the Law No. 3 of 2018, the Egyptian Space Agency was created as an "upgrade" of NARSS through a structural transition that concluded in August 2019, which marks when the Agency became fully operational [110]. The creation of the Agency centralized national space activities under one organization and avoided the duplication of these efforts between two government agencies operating under the same mandate [111]. However, there has been a lack of definition as to the role that NARSS plays with the Egyptian Space Agency [112].

Organizational Framework

Shortly after the establishment of the Egyptian Space Agency in August 2019, Egypt's president inaugurated a new board of directors for the Agency, which is headed by the Prime Minister with representation by Ministers of Higher Education and Communications, along with the CEO of the Agency and the head of the scientific research academy [113].

The Agency features several divisions including Space Environment Studies and Testing Center, Ground Control Station - Mission Control Division, Spacecraft On-board Computers and Space Software, Space Imaging Department, Space Design Execution Center, and Systems Engineering [114].

Role

The Egyptian Space Agency is responsible for carrying out the government's mandate of utilizing Egypt's capacity in space science and technology while supporting the country in reaping the economic and social benefits of space [111]. The Agency is executing a 10-year development plan with the specific objectives of addressing societal needs, building space infrastructure, supporting the Egyptian space program financially with an economic and sustainability plan, promoting knowledge sharing amongst national users and partners, fostering regional and international

cooperation, building capacity and human capital, encouraging space awareness, and fostering industry participation [115].

In addition to the 10-year development plan, the Agency also has a national space law in the works. The new space plan was presented and approved by the Egyptian government in March 2020, and the highlights of the plan include short-term, medium-term, and long-term goals for the Agency to execute to. Capacity building, development of space missions, and upgrading Egyptian industry facilities to support commercial sector growth are amongst the focal areas along with establishing a sound legal framework around such pillars. International collaboration is another key focus for the Agency over the next 10 years [113].

The Egyptian Space Agency is also partnering with the UAE, China, France, Italy, Kazakhstan and the United states on space sciences, satellite manufacturing, and space exploration [116]. Within the region, the Agency additionally has plans to train 20 participants from African nations on the use of space technology to mitigate greenhouse gas emissions [117].

Capabilities

Egypt, through NARSS, has experienced continued involvement in satellite activities since the 1990's. It was the first Arab African country to own a satellite, NileSat-101, which launched in 1998. Egypt later launched its first remote sensing satellite, Egypt-Sat 1, in 2007 and continues to lead the region in the number of satellites launched per calendar year in 2019 [113] [118].

The Egyptian Space Agency's latest endeavor is the announcement of a nationwide, six-year long competition to select Egypt's first astronaut by 2025, with the eventual goal of sending the individual to the International Space Station [119]. The Agency is further assessing areas of cooperation with the United Arab Emirates (UAE) in this effort on the heels of its recent Emirati astronaut return from the ISS in October 2019 [120].

Greece (2018)

Historical Context of Space Sector in Greece

Greece's long history with space began in 1840 when Baron George Sinas, Consul of Greece in Vienna, established the National Observatory of Athens. The Observatory still exists today and now includes the Institute of Astronomy, Astrophysics, Space Applications & Remote Sensing (IAADET) as well as three national laboratories [121] [122].

Greece launched its first satellite, a communications spacecraft called Hellas Sat-2, from Cape Canaveral in 2003 [123]. From 2002 to 2003, prior to the launch of Hellas Sat-2, Hellas Sat had briefly leased the German satellite DFS-Kopernikus 3 [124]. Hellas Sat 3 and 4 were launched in 2017 and 2019, respectively. A team of Greek scientists based in the United States built a Greek 1-U Cubesat called Lamdasat that was launched in 2015 [125]. The first satellite designed and built entirely by Greece was a 2-U Cubesat called UPSat and was deployed from the ISS in 2017 [126].

Greece signed its first cooperation agreement with the European Space Agency (ESA) in 1994 and cooperation continued between the two organizations until 2003 when Greece applied to become a member state of ESA. Greece was accepted into ESA as the 16th member state in 2004 [127]. Greece's ESA membership was followed by the establishment of the Hellenic Association of Space Industries (H-ASI) in 2008, a non-profit organization designed to support the commercial space sector [128].

In December of 2017, Greece and ESA signed a memorandum of cooperation with the intention of forming a new ESA Business Incubation Center (BIC) in Athens, Greece [127]. The establishment of a Greek BIC would allow start-ups and entrepreneurs in Greece to take advantage of ESA's technology development and funding opportunities, which can help the space sector develop more rapidly. Both ESA and Greece were hopeful that the BIC would help jumpstart the recovering Greek economy, which is struggling after the European financial crisis. The space sector had been largely ignored by the previous two Greek government administrations and, by signing this cooperation agreement, Greece made it clear that the space sector would be an important part of the nation's recovery process [127, 129]. At this time, the Greek BIC has not yet been established [130].

Formation and Rationale of the Hellenic Space Agency

The possibility of bringing an ESA BIC to Greece prompted the government to begin considering the formation of a space agency to help ensure that entrepreneurs were aware of how useful space technologies could be for their businesses [129]. The legal framework for the agency, Greek Law 4508/2017, was passed in 2017. This law primarily served to regulate the licensing and registration of space objects and in addition to being the founding law for a Greek space agency [131, 132]. On March 3rd of 2018, the Greek Ministry of Digital Policy, Telecommunications and Information announced the establishment of the Hellenic Space Agency (ELDO) with the primary motivation of helping to rebuild the Greek economy after the nation's severe debt crisis and provide space for Greece to prove it was still a strong and relevant on the global stage [133, 129]. ELDO's first board of directors was also announced, consisting of seven members with Stamatious Krimizis as the Board's Chairman.

The aims and motivations of the agency, as described by the official announcement, included a desire to increase the competitiveness of the Greek economy, making use of space technology to boost other sectors, using satellite technology to improve Greece's defense capabilities, and providing an arena to partner with other, more technologically advanced, nations. The Minister of Digital Policy, Telecommunications and Information, Nikos Pappas, stated that "the establishment of ELDO gives a new impetus to the efforts we are making to utilize the space sector. Space investment is about USD 200 billion a year worldwide, according to the latest study from the European Space Agency (ESA). That is, for one of the largest ratios in any industry [129]."

Accomplishments

At the 2018 International Aeronautical Congress, Christodoulos Protopapas, ELDO's second Chairman of the Board, announced that the Agency would soon be implementing its first enhanced national space program. The program would be based around two major pillars: (1) the design and launch of a constellation composed of eleven microsatellites to support citizens, academia, and industry in Greece and (2) Greece's official participation in high profile space projects being led by other nations, like NASA's Lunar Gateway [134].

On April 8th of 2019, NASA and ELDO signed a Declaration of Cooperation to allow Greece to cooperate with NASA on advanced human and robotic missions to the Moon and opened up the possibility of cooperation in other areas of space. ELDO announced that, as part of this agreement, it planned to send the first lunar rover to the Moon by 2022 and become one of only ten nations to have landed a vehicle on the Moon. The vehicle for Greece's lunar mission, dubbed "Hellas to the Moon," was to be designed and built in collaboration with Greek academic institutions and research centers as well as the Greek commercial space industry [135, 136].

Controversy and the Abolishment of the Hellenic Space Agency

After only four weeks of existence and just three meetings of the Board of Directors, ELDO's first Chairman, Stamatious Krimizis, announced his resignation. In a public letter, Mr. Krimizis made allegations that the Secretary General of Telecommunications and Post, Nikos Pappas, undermined ELDO's role in Greece and ESA, taking on the role of "Space Tsar." The letter claimed that two Ministerial Decisions, Resolution 3095/2018 and Government Gazette 915 (15/3/2018), removed almost all powers that ELDO had been granted by its founding law, Law 4508/2017, leaving the agency as "an unreliable bureaucratic structure that could be subordinated to any politician" and without any real ability to lead the nation's space sector. Mr. Krimizis, a former NASA scientist, felt that decisions about ELDO's direction were being made by politicians without any detailed understanding of the technologies involved and that the leadership overseeing the agency were promoting actions that strayed from international standards. Mr. Krimizis implied that issues of corruption may have been involved in these decisions, but claimed that he had not witnessed anything illegal in his time as President of the Board of ELDO [137]. Even though Mr. Kriminzis continued to serve as an advisor to the government, his sudden and contentious resignation tainted the public's image of ELDO and led to its abolishment.

Kenya (2017)

Formation of the Space Agency

Kenya's involvement in space dates back to the early years of the space age. That is because its geographic location on the equator and west of the Indian Ocean attracted international partners who aspired to economically and safely launch heavy payloads into orbit [23]. This led to the establishment of the Italian Space Agency's Broglio Space Center in Kenya, in 1964. While the Center represents Kenya's main space infrastructure still today, it has been mainly used by Italy, with little benefit provided to the Kenyan population. Since 1983, there have been discussions within the Kenyan government about developing a national space center, but that has not yet materialized [23].

However, the past decade has seen a growing interest by the Kenyan government in taking charge of and developing the national space sector. In 2013, the Kenyan Space Secretariat was established, under the Ministry of Defense, as the governmental body responsible for coordinating space related activities [23]. In 2016, an "equal-footed" agreement was signed between Kenya and Italy to promote shared responsibility over the Broglio Space Center [23]. In the same year, University of Nairobi's 1KUNS-PF CubeSat was selected as the first satellite to be launched under the KiboCUBO program, a partnership between UNOOSA and the Japanese Aerospace Exploration Agency (JAXA) to improve space technology of emerging space nations. 1KUNS-PF was launched to the International Space Station in April 2018 and was deployed from the Japanese Kibo module the following month [138], marking the first satellite registered by Kenya to be launched into space.

Amidst this process, in March 2017, President Uhuru Kenyatta signed the Gazette Supplement No. 24, which formally established the Kenyan Space Agency (KSA) as the successor to the Space Secretariat, making Kenya the fourth African nation to have a space agency. Four months after the launch of 1KUNS-PF, in September 2018, Kenya Defense Forces announced the inauguration of the first Kenyan Space Agency Board [139], appointed by Ambassador Omamo and headed by the Kenya Defence Forces' Major General (Rtd). The board is composed of secretaries from key state ministries and departments, the defense forces, academia, and the private sector [93] [17].

Rationale

The formation of KSA was largely motivated by the benefits that space can have across many domestic industries. The Agency aims to use space to solve local problems, such as drought and communication gaps, as well as to grow Kenya's science and technology expertise [16] [17]. The creation of the Space Agency was also connected to the development of the KiboCUBE program [13], which enabled the launch of Kenya's first satellite. In the KiboCUBE Announcement of Opportunity, it was determined that "the country of the Selected Entity will register the CubeSat either in accordance with the Convention on Registration of Objects Launched into Outer Space or, if the country of the Selected Entity is not a party to the Convention, in accordance with General Assembly resolution 1721B (XVI) [14]." UNOOSA's Director, Simonetta Di Pippo, has suggested that the creation of the KSA was an important step in regularizing Kenya's space activities and ensuring compliance with international registration requirements [15].

Role and Activities

The Agency's primary role is to enhance coordination between government, commercial, and academic organizations pursuing space activities as well as to implement Kenya's space policy and programs. KSA will also advise the government in the development of space-related regulations and the implementation of space related-treaties that Kenya is party to as well as engage in mutually beneficial agreements with foreign agencies and other organizations. Finally, the Agency aims to promote awareness of the benefits of space and technology [16].

Cooperation

International cooperation has been a very important aspect of the Kenyan Space Agency development. Its creation and first satellite were largely connected to the triangular cooperation with Japan and UNOOSA enabled by the KiboCUBO program. Since then, the Kenyan Space Agency has been actively seeking partnerships with international partners to help expand its program. The Italian and Kenyan Space Agencies, with the support of UNOOSA, developed a training course entitled "Earth Observation and Remote Sensing, Space Science, Law and Policy" which will be administered to students from across Africa at the Broglio Space Center in Malindi. The Agency is also in talks with China to cooperate on the development of satellite technology [140].

Regulatory Framework

Kenya does not yet have a national space policy, but the KSA is tasked with developing one in the coming years. Kenya is a signatory to two of the five key space treaties: the Outer Space Treaty (1967) and the Liability Convention (1972) [141].

New Zealand (2016)

Formation of the Space Agency

The New Zealand Space Agency had a "non-traditional" beginning, not relying upon large government investments unlike many other established space agencies. The Ministry of Business, Innovation and Employment (MBIE) established the New Zealand Space Agency in 2016, a process that took just 18 months, with a budget of NZD 20 million (USD 14 million) over 4 years in order to develop a legislative framework and establish a presence in the global space community [142].

As a result, the 2017 Outer Space and High-Altitude Activities Act was passed into law, governs the launch of vehicles and satellites and further regulates launch facilities through a licensing system. The law specifically covers the high-altitude activities, such as super-pressure balloons, and treats them in a similar fashion as satellites [143].

Rationale

Firstly, New Zealand recognized the growing small satellite launch vehicle market, particularly with the introduction of Rocket Lab, a U.S. based corporation with a subsidiary in New Zealand, as one of the main commercial players in New Zealand's space industry. Rocket Lab is a smallsat launch service provider offering high frequency, lower cost launches to its customers. The company was originally founded in New Zealand in 2006 and relocated its registration from New Zealand to the U.S. around 2013. However, it possesses a manufacturing facility and launch complex in New Zealand, which is licensed to launch rockets every 72 hours for 30 years, with its latest in New Zealand taking place in November 2018 [144]. Given the potential for high-frequency of launches through Rocket Lab's capabilities and with additional players entering the smallsat launch service provider market, New Zealand acknowledged the need for a regulatory body to oversee the nation's growing commercial space industry and allow for a lighter touch framework to encourage such activities.

In addition, the country established its space agency in an effort to facilitate commercial space-related activities in order to reap their economic benefits. To date, New Zealand's space economy is almost entirely commercially driven. More specifically, a majority of these companies are considered "New Space," representing a mix of both startup and well-established smaller and larger entrepreneur-driven and privately-funded space companies from the federal and private industries. By providing a framework and process for these companies to operate in, the New Zealand Space Agency allows its government to capitalize on space-related activities and grow its economy. From 2018-19, New Zealand's total estimated revenue of the space economy was NZD 1.75 billion (USD 1.06 billion), representing 0.27% of global space economy revenues. The main contributor to this revenue was space manufacturing, representing NZD 247 million (USD 149 million) of total revenue [145]. Moreover, a national focus on space would stimulate the labor market, and it is anticipated that by 2030, the New Zealand space industry could create about 20,000 high-paying jobs [142].

New Zealand also recognized an opportunity to process and analyze space-based observation data within the country rather than outsourcing to other competitors elsewhere. The New Zealand government predicts that with more small satellites come more launches, and with more launches come more data.

Organization

The MBIE's Minister of Economic Development directly oversees the New Zealand Space Agency, attesting to New Zealand's goal of utilizing national space activities to benefit the nation's economy [146].

Role and Activities

The New Zealand Space Agency is responsible for the nation's policy, regulation, and business development of space-related activities. The Agency firstly supports rocket launches from New Zealand while providing policy recommendations to the government on furthering space research and development, developing the national space industry, and engaging the general public on the role and importance of space [18].

Overall, the New Zealand Space Agency is currently working to develop a national space strategy and a general overview of the space industry's capabilities and gaps in order to make the best decisions and investments. The

strategy will particularly address the area of space-based observation data by creating a central point in charge of Earth observations and allow for governmental and non-governmental entities to utilize these data for applications such as agri-technology, hazard management, oceanography, and meteorology [147]. The Agency is also specifically looking to prioritize the areas of sustainability, agility, and collaboration through its space strategy and participate in larger space missions globally [148]. The Agency reported a budget of NZD 3.8 million (USD 2.3 million) for 2018-19 and MBIE spent an additional NZD 6.02 million (USD 3.65 million) in support of space science research that year [145].

Regulatory Framework

Employing the regulatory regime set forth by the 2017 Outer Space and High-Altitude Activities Act, the New Zealand Space Agency administers permits for transfers of payloads and licenses for launches, launch facilities, and high-altitude vehicle launches. The Agency's regulatory framework seeks to minimize unnecessary requirements and reduce compliance costs by also allowing overseas licenses to meet requirements, and overall, the Agency has been acknowledged "for listening and enabling rather than mandating." An additional provision that the Agency requests through the Act is the submission of an orbital debris mitigation plan for all launch applications to ensure the safe and responsible use of space [147]. New Zealand has been a member of UNCOPUOS since 2016 and has ratified the Outer Space Treaty, the Rescue and Return Agreement, the Registration Convention, and the Liability Convention [141].

Cooperation

The Agency has engaged in several international partnerships and agreements with other agencies, NGOs, private companies, and universities. In October 2018, the New Zealand Space Agency signed an agreement with the German Aerospace Centre (DLR) to collaborate on Earth observation, space-systems, and space-related transportation and energy technologies [142]. Most recently, in February 2020, the New Zealand Space Agency announced a partnership with NASA to collect climate data utilizing commercial passenger aircraft [149]. The partnership highlights the New Zealand Space Agency's focus on sustainability and further allows New Zealand engineers and researchers to engage in international collaboration while contributing to major scientific investigations. Other international partnerships include the Australian Space Agency, Japan Aerospace Exploration Agency (JAXA), European Space Agency, and French National Centre for Space Studies (CNES).

The New Zealand Space Agency relies upon academic partnerships as well, particularly with the Centre for Space Science Technologies (CSST), now named Xerra, based in Alexandra, NZ. This was one of the country's first regional institutes for space-based observation data and continues to focus on in-house research capabilities. This center is now developing cloud-based tools and platforms to allow New Zealand researchers and regional industries convert satellite imagery data into useful information - one of the areas of opportunities identified by the New Zealand Space Agency [142].

From a commercial standpoint, the Agency has also partnered with LeoLabs on space situational awareness. The company has helped develop a Space Regulatory and Sustainability Platform for use by the Agency, enabling it to track satellites in low Earth orbit and ensure that satellites launched from New Zealand comply with licensing regulations [150]. Other commercial partnerships include New Zealand-based Dawn Aerospace, Kea Aerospace, and Air New Zealand.

Paraguay (2014)

Formation of the Space Agency

The Agencia Espacial del Paraguay, or AEP for short, was created by a law passed by Congress in 2014. The Agency was placed under the administration of the president. Overall, Paraguay has employed a deliberately phased and investigative approach in establishing its space agency, rather than taking swift action. The nation has prioritized creating a working group in its initial phase that would assess the feasibility and costs of various types of space programs before proceeding to its next step.

Rationale

The Paraguayan government established a national plan of development known as the 2030 Paraguay Vision, which includes long-term strategic objectives such as: capacity building, aerospace development, infrastructure, and sustainability [151]. Establishing the AEP could directly address these strategic goals, and the Agency's overall objectives were created in line with the government's 2030 *Paraguay* Vision.

Specifically, one of the AEP's main goals is to develop the nation's satellite capability in order to lower the financial costs of external satellite services. Through establishing a satellite capability, Paraguay aims to not only enhance its domestic capabilities directly, but also attract potential investors in demonstrating its stability and maturity [152].

Role and Activities

The AEP's primary role is to promote and develop national space activities while supporting innovation through peaceful means. Its current main priority is creating knowledge and technology through training of its personnel and fostering the youth's interest in astronomy in space. Paraguay has also been a member of the UNCOPUOS since 2018. The AEP's first national space policy and Strategic Plan were approved within the first two years of establishing the space agency, and the AEP is actively joining efforts in developing a Latin American Space Agency [19].

Capabilities

The AEP plans to launch its first satellite in 2021, which will represent the first step in developing the nation's larger satellite capability. The Agency aims to utilize satellite imagery for Earth observation, communication, and navigation. It largely emphasizes the use of such imagery data for natural disaster emergency response and management, such as dealing with domestic floods and wildfires. The AEP has also begun to develop cubesats and establish its first Earth observation program [19].

Philippines (2019)

Formation of the Space Agency

The Philippines' first federal activity in the space industry was the construction of a ground station built in 1968 by Philcomsat, a Philippine public telecommunications entity (PTE) which had partial state ownership (35%) and was an original member of Intelsat. Since the 1960s, the nation has seen scattered programs over the decades until the mid-2010s. The Philippines acquired its first national satellite in 1996, when Subic-based commercial aerospace company Mabuhay Satellite Corporation bought an Indonesian commercial telecommunications satellite Palapa B2-P, renaming it Agila-1. Most early activity in the Philippines was conducted by commercial or semi-private firms, with efforts to develop national space policy and regulation somewhat stymied by shifting administrative priorities.

Around the time of the successful deployment of its first Filipino-designed satellite, *Diwata-1* in 2016 (See *Role and Activities* below), legislative efforts were revamped to establish a formal space agency. House and Senate versions of a bill establishing the space agency and a Space Development and Utilization Policy, which functions as a National Space Policy, were introduced and debated over several years to further define the purpose and scope of a space agency's activities. The final bill, the Philippine Space Act (Republic Act 11363), formally established the Philippine Space Agency (PhilSA) when President Duterte signed it into law on August 8th, 2019.

Rationale

Legislation proposing the establishment of the PhilSA illustrates the Philippine government's view of the formation of a space agency and investment in space science and technology as a kind of 'equalizer' for developing nations [153]. Calling space infrastructure "an essential requirement for any modern country," the House bill notes that a strong national space policy and agency will enable the Philippines to become a more significant spacefaring nation, citing benefits to Filipinos "not just in the economic sense, but also in terms of societal benefits and social inclusivity." From this, it is clear that socioeconomic return of investments in space science and technology was a clear rationale in spurring the formation of the PhilSA.

Another key rationale behind the formation of the PhilSA is geopolitical standing and soft power. Many nations in the Asia-Pacific region have seen meaningful developments in space activities in recent years, such as Japan, which have bolstered political momentum within the Philippines to formalize their own capabilities in response [154]. The Philippines has had increased involvement in regional space activities in the past decade; for example, the 23rd Asia Pacific Regional Space Agency Forum (APRSAF) was hosted in Manila in 2016. In a presentation at the Secure World Foundation's Summit for Space Sustainability in early 2019, president of Regulus SpaceTech and former head of the National SPACE Development Program Dr. Rogel Mari Sese presented data from the IMF World Economic Outlook 2018 and the UN Registry of Space Objects, indicating a positive correlation between the number of satellites operated by ASEAN (Association of Southeast Asian Nations) nations and their GDP [155]. He also noted that, in comparison to other ASEAN nations participating in space, the Philippines was the only nation operating only a mixture of nano-, micro-, and small satellites, while others also operated communications satellites. Dr. Sese emphasized in his remarks the need for more proactive and sustained cooperation between established and emerging space nations, while maintaining that relations should eventually evolve from a "teacher-student" model to that of colleagues.

Organization

Until the establishment of PhilSA, various decentralized agencies conducted Filipino space technology and science programs and cooperative activities over the years, separated by mission types and funded largely through the Department of Science and Technology (DOST)'s National SPACE Development initiative. These include agencies such as the National Mapping and Resource Information Authority (NAMRIA) and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), among others. At the time of PhilSA's creation, DOST had already invested nearly PHP 7.48 billion (USD ~150,000) [156].

Upon its establishment, PhilSA received initial funding of PHP ~1 billion (USD ~19 million) from the 2019 fiscal year's appropriation of the Office of the President. Going forward, the PhilSA will receive annual funding under the General Appropriations Act, coupled with PHP ~10 billion (USD ~200 million) from the newly established Space Development Fund over five years [157], at a rate of PHP 2 billion (USD 40 million) per year [158].

Role and Activities

The PhilSA's primary role is to act as a centralizing agency to unify the nation's existing space efforts under one organization. The Philippine Space Policy, which is the nation's "primary strategic roadmap for space development," cites six Key Development Areas (KDA) for Philippine space science and technology development [153]. They include:

1. applications to preserve and enhance national security;
2. applications to enhance hazard management, disaster mitigation strategy, and ensure resiliency to climate change;
3. space research and development to "spur rapid scientific growth,"
4. space industry capacity-building to support the nation's space program through private sector involvement;
5. space education and awareness to establish a "sustainable pool of trained space scientists, engineers, and communicators," and
6. international cooperation to become a "key player in the ASEAN and global space community."

The Secretary of Science and Technology at the DOST, Fortunato dela Peña, confirmed in a press conference that future missions for the PhilSA will include Earth observation spacecraft designed to produce data that will facilitate improved hazard management and climate studies, modernization of farming and environmental monitoring, investment to bolster domestic space research, and programs for added national security [156].

In recent years, the Philippines has worked to build cooperation with neighboring countries, most notably Japan. In fact, the first Filipino-designed satellite, Diwata-1, was an Earth observation microsatellite designed by the Department of Science and Technology (DOST) and the University of the Philippines in partnership with Japanese universities Hokkaido University and Tohoku University. The microsatellite, which was released from the Japanese Kibo module of the International Space Station in 2016, was produced to monitor natural disasters, vegetation, and water level changes, among other phenomena. Diwata-1 was followed by two subsequent missions, Diwata-2 in 2018, and Maya-1 a university-level technical demonstration facilitated in part by the Japanese Kyushu Institute of Technology, also in 2018. A third Diwata satellite is also planned, with a target launch date of 2022. It is expected that the PhilSA will continue to develop close relationships with ASEAN regional nations, particularly with Japan.

Poland (2014)

Formation of the Space Agency

Poland has been conducting scientific research in space-related fields since 1976 under the Polish Academy of Sciences' Space Research Center, which has contributed to a number of major international space projects, including Rosetta, Cassini-Huygens, Mars-Express, and others [159]. Poland's participation in the European space sector dates back to a cooperation agreement signed with the European Space Agency (ESA) in 1994, followed by the signature of the European Cooperating State Agreement in 2007, which paved the way for Polish participation in several ESA research projects [160]. Poland officially became a member of ESA in November of 2012.

In December 2013, the Polish Parliament received a draft bill on the Establishment of the Polish Space Agency, which included a statement of reasons for establishing such an agency. After passing through committees and the Senate,

the bill was adopted by the Act of 26 September 2014, and was signed by the President on October 20, 2012 [161]. The Polish Space Agency (POLSA) was officially established as an executive agency in the second half of 2014 and became fully operational in late 2015 [162]. For its first year of operation, POLSA received a budget of PLN 10 million (USD 2.4 million), which was estimated to be the cost of establishing the new Space Agency [163].

Rationale

The rationale for the establishment of the Polish Space Agency is outlined in the Statement of Reasons within the draft bill on the Establishment of the Polish Space Agency [164], which argued that the main barriers to the development of the space sector in Poland were of an organizational and financial nature, and suggested that these challenges could be overcome with the creation of a centralized government institution that would manage funds for research and development of space technologies, and apply these technologies to sectors of significant importance to the national interest [165]. The draft also submitted that the lack of appropriate state structure made it harder for Polish companies and research institutions to access the opportunities associated with the ESA membership. Again, it reasoned that a central State institution could tackle this problem by coordinating national cooperation with ESA [165].

Therefore, the Agency was created to support the Polish space industry and coordinate the space sector by combining the world of business and science, ensuring the coherence of the Polish space policy and programs, representing the Polish economic and scientific interests before ESA, obtaining ESA funds for Polish entrepreneurs, and promoting the development of satellite technology that can be applied for the benefit of Poland, including communications, navigation, environmental monitoring, weather forecasting, and national defense [166]. Poland's motivation was largely a pragmatic one, aiming to take advantage of space applications, rather than "aimlessly pursuing ambitions and independent space exploration [167]."

Organization

The Polish Space Agency is headquartered in Gdańsk, with offices in Warsaw and Rzeszow. It consists of an executive body and a supervisory body. The executive body is guided by the Agency President and two Vice Presidents, one for science and one for defense affairs. The supervisory body consists of an Agency Council, which includes the Chairman of the Council, representatives of the Government Administration, as well as representatives from the scientific community and industry. The Agency's revenues include the State budget, resources from the European Union, revenues from operations, voluntary payments, interest of free funds, and revenues from other titles [166]. Although the rationale for the creation of the agency was in part to coordinate the national space sector, the Polish Space Agency still shares this responsibility with other governmental bodies, such as the Polish Ministry of Economic Development, which was given the tasked with developing and implement the National Space Strategy, while the Space Agency was tasked with developing and implementing the National Space Program.

Role and Activities

According to the president of the Polish Space Agency, POLSA's main role is to coordinate the functioning of the Polish space sector, which was previously scattered among various departments, and to identify important space applications of interest to Poland [168].

The Act of 26 September 2014 outlines the following roles for the Agency [166]:

1. To guide major research directions and the development of space programs in support of the national interest;
2. To analyze national space projects and ensure coherence between the Polish space policy and programs;
3. To represent Poland on the international arena and defend Polish economic and scientific interests in research and the use of space internationally;
4. To promote international cooperation in the use and exploration of space;
5. To cooperate with the Polish Committee for Standardization in the development of definitions, norms, and technical specifications for space technology;
6. To prepare assessment reports and provide consultancy in regard to research and the use of space;
7. To keep a register of space objects as required by the Registration Convention;
8. To promote favorable conditions for research and development of space activities;
9. To conduct educational activities and support education in the space field; and
10. To increase national defense capabilities through the promotion and use of technologies in Earth observation, space observation, navigation, and satellite communications.

In sum, the roles of the Agency are more associated with the provision of services rather than the development of hardware and other operations. That is confirmed by POLSA's high expenditures in salaries and salary derivatives for the years of 2016-18, which represented over 50 percent of the total amount spent of the Agency's budget in each of these years [165].

A draft on a new Act on Space Activities and the National Register of Space Object was submitted to Parliament in 2017 and is still under consideration, under the leadership of the Ministry of Investment and Economic Development. In its current shape, the bill would officially assign POLSA responsibility over the authorization of space activities and the registration of space objects [162].

Cooperation

Polish cooperation efforts are focused on, but not limited to, the frameworks of ESA and the European Union. In addition to pursuing participation in European programs and setting up an ESA Business Incubator Centre, POLSA also signed cooperation agreements with the Chinese National Space Administration (CNSA) in June 2016 [169], the Mexican Space Agency in April 2017 [170], the Israeli Space Agency in June 2018 [171], the Romanian Space Agency in November 2018 [172], and NASA in October 2019 [173]. In addition, Poland became a member of the Space Surveillance and Tracking (SST) Consortium in 2018and signed a space situational awareness (SSA) sharing agreement in 2019 with the United States Strategic Command (USSTRATCOM) [174, 175].

Capabilities

The first Polish satellite was PW-Sat, a CubeSat developed by the Warsaw University of Technology and launched in 2012. The Polish Space Research Center is also part of the BRITE consortium, which launched Poland's BRITE-PL-1 and BRITE-PL-2 nanosatellite in 2013 and 2014, respectively. In 2019, a Polish startup deployed two nanosats, the Swiatowid and the KRAKsat, which are expected to be the first of a 1,024 nanosats Earth observation constellation by 2026 [176]. Polish industries have also had experience building instruments and components for international space missions and satellites, including ESA's ESEO/S-50 satellite, ICEYE-X2, and the penetrating device for NASA's InSight rover [177].

As previously stated, most of POLSA's budget has been used to cover personnel expenses, with not many resources appearing to have been invested in the development of technologies. Some critics have suggested that the sector has been slow to take off due to limitations in funding. For the first three years of operation, POLSA has received a budget of approximately PLN 10 million (USD 2.4 million), a mere nominal revenue when compared to the budgets of other Polish executive agencies, which average around PLN 900,000 (USD 214,000) [165]. In fact, until 2016, Poland allocated 0.01 percent share of its annual gross domestic product (GDP) to the space sector, compared with Germany's 0.05 percent or France's 0.1 percent [178]. But that is expected to change with the passing of Poland's first Space Strategy in 2017 and the National Space Program in 2019.

The strategy sets a number of ambitious goals to be completed by 2030, including the launch of a security data gathering satellite system for optoelectronic Earth observations, followed by the launch of a synthetic aperture radar (SAR) reconnaissance satellite; the establishment of a satellite data receiving station for the Copernicus system; and the development of rocket technology to serve both the purposes of launching objects into Earth's orbit and to modernize the Polish Armed Forces' air defense systems [179]. A prototype of Poland's suborbital rocket BIGOS 4 was successfully tested on November 25, 2018 [180].

In order to accomplish these goals, the Polish Space Agency has proposed the first National Space Program (NSP), which has been in consultation since December 2018. The NSP aims to allocate close to PLN 1.43 billion (USD 420 million) over an eight-year period and PLN 248.5 million (USD 73 million) for the period between 2019-2021, of which PLN 111.4 million (USD 32.8 million) will be allocated to POLSA. An overarching goal is to have the Polish space sector obtain 3 percent of European space market by 2030 [181].

Portugal (2019)

Formation of the Space Agency

Portugal has been a member state of the European Space Agency (ESA) since 2000. The Portuguese space agency, officially named Portugal Space, was created in 2019. Before that, national space activities had been largely managed by the Foundation for Science and Technology (FCT), with participation of the National Communications Authority (ANACOM) and the Public Agency for Small and Medium-Sized Enterprises and Innovation (IAPMEI) [182], although none of these government agencies were specifically focused on space.

Portugal Space was created as part of a wider strategy initiated in 2016, and formally adopted by the Portuguese Government in February 2018, to achieve "European convergence [183]" by 2030 and to boost research and innovation, together with skilled job creation and wellbeing [184]. One of the specialized R&D agendas set forth within this effort was a new strategy called "Portugal Space 2030 [185]," which included, among other goals, the creation of a Portuguese space agency. For this purpose, the Council of Ministers established a working group responsible for developing a financial and institutional proposal for the creation of a Portuguese Space Agency, to be presented at the end of 2018 [186].

On March 13, 2019, the Council of Ministers adopted resolution No 55/2019, which formally approved the creation of Portugal Space. The resolution authorized the FCT to partner with the National Agency for Innovation (ANI), as well as two other entities, one appointed by the Ministry of National Defense and another by the Azores Autonomous Region, to work as founding members of Portugal Space. FCT and ANACOM are expected to invest EUR 8 million (USD 8.8 million) (between 2019 and 2021 to build up the new agency [187]. The Portuguese Space Agency Business and

Installation Plan presented a more general stepwise approach, anticipating funds to be made available from both public and private sources, at national and international levels [188].

In regards to the Portuguese-European budget, ESA's most recent Ministerial Council, "Space19+", approved the most ambitious plan to date for the future of ESA and the whole European space sector, including 14.4 billion for ESA's 2020-24 budget and EUR 16 billion (USD 17.5 billion) for the 2021-27 European Space Program budget. As European countries boost their financial commitments to space, Portugal's contribution to ESA has increased from EUR 73 million (USD 80 million) for the previous budget in 2016 to EUR 102 million (USD 112 million). The 2019 strategy for Portugal's participation in "Space19+" sets the target of attracting EUR 2.5 billion [189].

Rationale

The motivation to create a national space agency in Portugal was based on three main perceptions outlined in the Portugal Space 2030 strategy: (1) that the importance of space for life on Earth will continue to grow as we approach an increasingly interconnected society and digital economy; (2) that investments in the space sector have potential for significant economic returns, and that a strong space industry ecosystem is important for the growth and competitiveness of the national economy; and (3) that the emergence of the "New Space" sector provides small and medium sized countries like Portugal with new opportunities to harness the benefits of space [185]. Ultimately, Portugal recognizes that space is "no longer seen as a way for countries to show off their technological prowess and sovereignty, but rather as an added value to society and a competitive advantage for industries and economy [189]."

From this perspective, Portugal Space was created with the aim to facilitate the growth of the national space sector by stimulating entrepreneurial capacity. This includes encouraging and managing the development of national space initiatives, programs, and infrastructure, fostering investments, and supporting the creation of new services, firms, and qualified jobs in the field [187]. The new agency was designed primarily as an instrument of the Portuguese Government to turn the country into a center of space-related innovation, particularly in regards to Space-Earth-Climate interactions, drawing on Earth observation technologies and emerging possibilities within "New Space [190]." With the support of the new space agency, the Portuguese Government aims to create one thousand new jobs and increase investments in the national space sector by a factor of ten within one decade, reaching EUR 40 million (USD 44 million) [191].

Finally, it is important to note that Portugal Space was the first space agency to be created as a "hub of the European Space Agency [192]," with the purpose to improve coordination and strengthen national-European cooperation, facilitating greater engagement of Portuguese stakeholders in European programs [193]. This European focus is reflected in the founding members' decision to nominate as the first President of Portugal Space Dr. Chiara Manfletti [194], a senior official at ESA, of Italian-German nationality.

Organization

Portugal Space was created as a "private non-profit entity [187]," affiliated with ESA, with participation of other national government agencies involved with science, technology, and defense, and with funds from both public and private sources [187]. It is headquartered on the island of Santa Maria in Azores and has additional offices in Lisbon. The Santa Maria island was already home to ESA's Hill of Flowers ground station and is also the planned location for a new spaceport, from where Portugal intends to launch micro and small satellites by 2021 [195]. The site was chosen because of its geographic position in the Atlantic Ocean, close to the European, American, and African continents.

Portugal Space was created to be a small, non-traditional space agency [196]. According to the Portugal Space Agency Business and Installation Plan, the agency shall be designed as "a network of public entities and stakeholders, space and non-space, connected according to the needs of each successive initiative and project [188]." The first staff was to be recruited internationally, including non-domestic staff, and will be followed by a mainly domestic next generation of staff [188]. Currently, Portugal Space has an Executive Board, which includes a foreign president and a Portuguese vice president; a General Assembly, consisting of one secretary and two founding members from FCT and the ministry of Defense; and a Fiscal Board, with two founding members from ANI and the Azores Region, and a statutory auditor [190]. Finally, the agency also relies on an Advisory Committee that provides advice on strategy, targets, performance, and resources [188].

Role and Activities

Unlike legacy space agencies like NASA or ESA, Portugal Space is not tasked with building hardware, conducting experiments, or developing space missions of its own [197]. Instead, it is a customer-oriented agency that was given the primary role of fostering new markets, businesses, and activities in the national space sector [196]. Portugal Space has a double function: (1) it is responsible for national operations beyond the scope of ESA and, (2) as an ESA hub, it is also responsible for Portuguese-ESA budgets, relationship, and for fostering a new context for national-European interactions in the area of "new Space" [188].

In sum, its roles can be summarized as follows:

1. To facilitate growth of the national space sector, with emphasis on "New Space";
2. To promote, implement, and propose updates to the Portuguese space policy and strategy (Portugal Space 2030);
3. To promote an adequate spectrum management, technology transfer and regulatory frameworks for the responsible use of space;
4. To foster interaction with ESA;
5. To promote an active engagement of Portuguese stakeholders in European programs;
6. To represent Portugal on the international scene, promote cooperation, and serve as Portugal's gateway to space in Portugal and around the world.
7. To manage and promote the Azores International Satellite Launch Program (ISLP);
8. To promote the creation of a Space Fund to foster investments in new space technologies and proof-of-concepts [188].

Cooperation

Part of the mission assigned to Portugal Space is to strengthen and extend international strategic partnerships. In particular, the agency's Business Plan highlights Portugal's cooperation with ESA as well as with "natural partners," including Africa, Brazil, New Zealand and the United Kingdom [188]. It further prioritizes transatlantic initiatives in space related areas, including (1) defense issues among NASA, ESA, the Brazilian Space Agency, and (2) research on climate, land, space, and ocean through the Atlantic International Research (AIR) Centre [188], which includes the governments of Portugal, Brazil, Spain, Angola, Cape Verde, Nigeria, Uruguay, São Tomé and Príncipe, and the region of the Azores [198]. Portugal wishes to take advantage of Earth observation satellites in the ambit of an international collaboration to better understand, protect, and harness the potential of the ocean for economic and security purposes [199].

In June 2019, Portugal Space signed its first cooperation agreement with the French Space Agency (CNES), encouraging the exchange of personnel, information, and best practices for the development of activities related to Earth observation, New Space, nanosatellites, and launch [200]. At the same time, Portugal Space joined the Space Climate Observatory (SCO), an international cooperation of over 20 space agencies using satellite data to model and track climate change [201]. The following month, Portugal Space and the UK Space Agency signed a memorandum of understanding (MoU) for collaboration in space projects and activities and to facilitate the exchange of information, technology, and personnel in the areas of space policy and law, human capital development, space applications, science, and technology, including existing collaboration on propulsion technology [202].

Capabilities

In the last decades, the Portuguese space industry has developed expertise in the software domain, with the existence of a Space-Aeronautics-Defense Cluster since 2017 [188]. The Portugal Space 2030 strategy focuses on fostering the fields of Earth observation, space safety, telecommunications, and space transportation. Given Santa Maria's strategic location in the Atlantic Ocean, Portugal aims to provide launch capabilities to small satellites and potentially human suborbital spaceflight from its territory through the Azores International Satellite Launch Program (ISLP). Plans include the development of a spaceport by 2021, based on the existing infrastructure of the Santa Maria airport, as well as a new environmentally sustainable rocket that would launch from the new facility [195].

Additionally, Portugal has been strengthening the strategic advantage of its geographical positioning in the Azores to develop, in partnership with ESA, the installation of an advanced ground station infrastructure, including ESA's Estrack station used to track European launches and a Galileo Sensor Station. Tracking capabilities are actively being expanded through the development of a new antenna of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and the repurposing of ESA's Perth station [196].

The first and only Portuguese satellite, PoSat-1, was an experimental microsatellite launched in 1993 and is no longer operational [203]. Efforts are currently underway to develop a new Portuguese satellite called Infante, which is planned to be a precursor to a constellation of 12 satellites in low-Earth orbit for remote sensing and telecommunications services [204]. The satellites are being developed by a consortium of Portuguese companies and R&D centers, working together with partners from Europe, Brazil, and China.

Saudi Arabia (2018)

Formation of the Space Agency

In 1985, Prince Sultan Salman Al-Saud from Saudi Arabia was the first Arab and Muslim astronaut in space, as he flew aboard the American Space Shuttle Discovery (STS-51-G) as a payload specialist, deploying the Arabsat-1B satellite [205]. This event marked the start of space science exploration efforts by the nation, as it first established the King Abdulaziz City for Science and Technology (KACST) and later The National Center for Remote Sensing Technology.

The Saudi government subsequently invested SAR 1 billion (USD 266.2 million) into the space services sector, leading to the establishment of the Saudi space agency, named the Saudi Space Commission, on December 27, 2018 [206]. Prince Sultan Salman Al-Saud, the former astronaut, was appointed Chairman of the agency by his father, the King of Saudi Arabia.

Organization

The Saudi Space Commission is an independent government entity that was established through a royal decree directly from the Saudi king. As the Saudi Space Commission is mainly responsible for the nation's space policy and strategy, the King Abdulaziz City for Science and Technology (KACST) maintains its role as a separate governmental institution for satellite manufacturing and scientific research and development [207].

Rationale

The Saudi Space Commission's main mission, and one of the main motivators for its establishment, is to achieve the space-related goals laid out in the Saudi Vision 2030, a roadmap focused on three themes: diversifying the Saudi economy, enhancing the nation's society and quality of life, and developing a transparent and accountable governing strategy [20]. Specific Saudi Vision 2030 goals that are related to space are:

1. Localizing the space industry
2. Meeting different local demands
3. Manufacturing and developing the latest Earth surveillance technologies
4. Strengthening geographic information services
5. Engaging the local commercial sector
6. Promoting international cooperation in space exploration
7. Security and peace within space, establishing an international law of space through space exploration programs, Moon exploration programs, space telecommunications programs and space technology programs

In line with the Saudi Vision 2030 goals, the Saudi Space Commission is also focused on the development of higher education in aerospace and STEM training programs. In February 2020, the agency announced the launch of the Human Capital Program to establish a national base for human capital in the space sector [208]. The program will promote STEM interest in the country to develop future leaders in space science. The Saudi Vision 2030 goals also recognize the need for an increased female workforce, which the Saudi Space Commission and KACST note as a major goal for the future development and success of the national space sector.

Role and Activities

The role of the Saudi Space Commission is to coordinate and produce national space policy and strategy across the civil, commercial, and military sectors in cooperation with other Saudi government ministries and agencies [21]. Saudi Arabia has been a member of the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) since 2001 and has ratified 4 of the 5 of the major UN space treaties, with the exception of the Rescue and Return Agreement [141].

Capabilities

The satellite communication industry was Saudi Arabia's first introduction into the space sector with its first satellite launch of Arabsat-1 in 1985, prior to Prince Sultan Salman Al-Saud's mission. Arabsat, or the Arab Satellite Communications Organization, is a major satellite operator that is headquartered in Riyadh, Saudi Arabia with over 20 member countries in the Middle East and North Africa regions. Arabsat currently owns and operates 7 satellites and offers a full spectrum of broadband and telecommunications services to its member states [102].

KACST has also launched 16 satellites into both low Earth and geostationary orbits for the main applications of telecommunication, reconnaissance, and remote sensing, with its latest satellite launch in February 2019. Of note,

SAT 5A and SAT 5B, launched in 2018, were fully manufactured in Saudi Arabia by Saudi technicians and engineers in KACST [206].

Cooperation

The Kingdom has signed several conventions on outer space technologies agreements with large space nations, such as the United States, Russia, China, France and Germany [206].

Most recently, Russia's Roscosmos State Space Corporation for Space Activities and Saudi Arabia announced that they had agreed to a cooperation program with the potential goal of launching a Russian astronaut from Saudi soil for a short-duration flight. Additionally, the Russian Direct Investment Fund expressed interest in launching a satellite from Saudi Arabia utilizing Russian technologies [209]. The overall Russian-Saudi partnership has been in place for two decades now, as Russian vehicles have been launching Saudi satellites since 2000 for KACST.

Saudi Arabia has also been an active partner of the United States for space research initiatives. In 2009, KACST established a cooperation agreement with NASA to jointly collaborate on lunar and asteroid science research. NASA has continued to partner with KACST's Saudi Lunar and Near-Earth Object Science Center as part of the Agency's research activities related to human space exploration [210].

In terms of regional cooperation, Saudi Arabia participated in the first pan-Arab agreement in 2019 on the coordination of national space exploration programs through the Arab Space Cooperation Group, led by the United Arab Emirates. The Arab Space Cooperation Group will be further discussed in the Case Study section of the report in the context of the United Arab Emirates Space Agency.

Turkey (2019)

History of the Space Sector

Prior to the formation of its space agency, Turkey had already established a large and well-rounded space sector that involved the government, commercial, and academic sectors.

The nation made its first significant space investment in 1990, when the state-owned satellite communications company, Türksat Satellite Communications and Cable TV Operations Company, was formed. Turkey placed its first satellite, Türksat 1B, on-orbit in 1994 [211].

Turkey's TÜBİTAK Space Technologies Research Institute, shortened to TÜBİTAK UZAY, began specializing in the development of space and satellite technologies in 2001. TÜBİTAK UZAY, based in the city of Ankara, is a government-funded research institute and a collaboration between the Middle East Technical University and The Scientific and Technological Research Council of Turkey [212].

In 2013, the Turkish army released a "space roadmap" that laid out a plan to establish a Space Group Command under the Turkish Air Force by 2023 [213]. That same year, Turkey issued a contract for ROKETSAN A.Ş., a major Turkish defense company, to begin the development of a Turkish satellite launch vehicle and launching station, called the Space Launch System. The Turkish Space Launch System never made it past the pre-conceptual design phase [214] but showed the government's increasing interest in developing an independent space capability.

By 2017, when Turkey started drafting legislation to establish a space agency, the nation had a well-established commercial sector composed of large defense contractors, several federally-funded space-research centers, and a

growing military space program. A commercial defense contractor, Turkish Aerospace Industries, had established a USD 112 million Space Systems Integration and Test Center with the capacity to deliver a satellite of up to 5 tons. The Turkish Ministry of National Defense launched its second reconnaissance satellite, Gokturk-1, and claimed that the Turkish space industry had been responsible for about twenty percent of the satellite's development. Turkey was positioning itself to be able to independently build a satellite with no support from international contractors by 2019 [213] [215].

Formation of the Space Agency

Turkish President Recep Tayyip Erdoğan and members of his Justice and Development Party began vaguely promising the formation of a Turkish space agency during the presidential campaign in 2002, but it was not officially added to the government's action plan until 2016 [216]. On December 13, 2018, President Recep Tayyip Erdoğan signed an executive order to establish Turkey's first space agency, Türkiye Uzay Ajansı (TUA). The decree also included the TUA's first assignment: the development of Turkey's first Space Program [217].

The executive order included funding cuts from existing space researchers and rerouted to the new space agency. The twenty percent of the budget for the Space Technologies Research Institute of Turkey (TÜBİTAK–UZAY) and Directorate General of Civil Aviation was redirected to the new space agency. Based on these budget cuts, at least TRY 30 million (USD 5.7 million) was dedicated to the space agency during its first year of operation in 2019.

The formation of the TUA also involved the abolishment of the Department of Aviation and Space Technologies under the Ministry of Transportation and Infrastructure.

Motivation and Mission

The establishment of Turkey's first space agency coincided with the government's desire to build its first indigenous satellite. Tukey's first two military satellites, Gokturk-1 and Goturk-2, were both primarily developed by the Italian space company Telespazio with some contributions from the Turkish space sector. In 2017, Turkey made a claim that it would build its first indigenous satellite by 2019. The nation missed the 2019 milestone, but Gokturk-3 is expected to become the nation's first entirely indigenous satellite in 2021 [218]. Turkey's desire to develop a more independent space sector heavily influenced the formation of the TUA.

Part of the purpose of the TUA is to "reduce external dependence in space and aviation science and technologies, to increase the competitiveness in the international arena, to create scientific and technological infrastructure and to develop new technology." The nation's focus on reducing dependence on other countries seems especially focused on the defense industry [219]. The TUA will encourage an independent space sector by strengthening Turkey's aerospace industry and improving its scientific infrastructure [11], which will, in turn, generate more space jobs to help keep scientists and engineers in Turkey. Many skilled Turkish engineers and scientists are forced to leave the country to find work in their field. By creating more job opportunities in the space industry, the nation hopes to bring scientists back to Turkey [220].

The TUA also aims to establish Turkey as a regional and global space power [11]. Mustafa Varank, the Minister of Industry and Technology, speaking at the Turkish parliament's planning and budget committee, stated that, "Countries that do not make it to space, will not have a say on earth in the future [221]."

Organization

The TUA is headquartered in Turkey's capital city of Ankara, a hub for the Turkish space industry. The space agency reports to the Ministry of Science and Technology [11], which is responsible for the industrial and commercial affairs in Turkey [222]. The TUA also has an executive board made up of seven members with each member, except for the chairperson, serving three-year tenures [223] [224]. The TUA has its own budget and financial and administrative autonomy to carry out its mission [217]. The agency's 2020 budget is TRY 24.5 million (USD 3.5 million) [225].

The TUA has been tasked with managing all Turkish national space activities, including R&D, STEM education, international cooperation, and international representation [11]. The TUA is also to coordinate all space-related work being done by Turkish commercial companies and academic institutions, but the agency cannot control tasks carried out by the International Telecommunication Union (ITU) [219]. The agency is also tasked with pursuing multilateral and bilateral cooperation opportunities with international partners [217].

The TUA's most prominent task is to prepare and administer a national space program based on the president's policies [11]. The first Space Program was released in 2020.

Regulatory Framework

Turkey does not yet have a national space policy, but the TUA is expected to release the first national program in 2020. In a speech from January, President Erdoğan promised that the national space program will be unveiled very soon. President Erdoğan also announced several new satellites. Türksat 5A will be launched in 2020 and Türksat 5B will follow in 2021. Türksat 6A is planned for 2021 and will be the first geostationary communications satellite to be indigenously designed and built. President Erdoğan stated that "With the [Türksat 6A] project, Turkey will become one of 10 countries in the world that produces its own telecommunication satellites [226]."

Turkey has ratified all key space treaties, including the Outer Space Treaty (1967), the Rescue and Return Agreement (1968), the Liability Convention (1972), the Registration Convention (1975), and the Moon Agreement (1979) [141].

Zimbabwe (2018)

Formation of the Space Agency

The intention to harness space as a means to support Zimbabwe's development dates back to 2015, when the country became a member of the Group on Earth Observation (GEO) [22] at the request of the Research Council of Zimbabwe (RCZ) [227]. These efforts gained momentum after Emmerson Mnangagwa assumed the Presidency of Zimbabwe in November 2017, marking the first transition of power since Zimbabwe's independence in 1980. The new government embarked on a mission to re-engage with the international community and to restore confidence in the national political and economic systems [228]. To that end, the government introduced the Transitional Stabilization Program (TSP) towards the implementation of Vision 2030, which seeks to turn Zimbabwe into an upper-middle-income economy by 2030 [229].

Recognizing space technology and data as important components of this political and socioeconomic 'rebirth,' the Ministry of Higher and Tertiary Education Science and Technology Development (MHTESTD) launched the Zimbabwe National Geospatial and Space Agency (ZINGSA) on July 10, 2018, in terms of section 24, Chapter 10:22, of the Research Act of Zimbabwe [23]. The Agency is to be constructed in stages, through the adoption of a phased approach to mobilize the necessary financial and human resources [230] [23], including private investment in

Zimbabwe's new space industry [231]. The government has already allocated approximately USD 3 million as core funding for the establishment of ZINGSA and expects that the new agency "will make much more business than it will cost [230]."

Rationale

The rationale for the formation of ZINGSA was national development, in support of the new government's Vision 2030 to drive the country towards an upper-middle-income economy status within the next decade. The Agency's architects were not focused on "grandeur and glory," exploration missions, or sending astronauts into space [231]. Instead, ZINGSA was created to harness the usefulness of research, development and innovation in solving real life problems faced by the Zimbabwean population [232]. President Mnangagwa expects the new space agency to tap into global technological development and help advance national interests in geospatial science, earth observations, and satellite communications [233] - capabilities which, in his view, are necessary for a productive economy [231], and which he considers strategic for enhancing the Zimbabwe's agriculture, disease surveillance, wildlife monitoring, climate prediction, infrastructure and resource management [234].

Role and Activities

ZINGSA's mandate is to design and promote research and innovation in geospatial science, regulate related activities [230], and increase public awareness and knowledge [23]. More specifically, its functions include the coordination of scientific research and educational programs; preparation and implementation of Earth Observation missions; satellite command and control; management of communications between space and ground segments; strategic planning of space operations; facilitating access to launch services; and the development of budgets, timelines, and business plans [235]. ZINGSA was also tasked with enhancing Zimbabwe's capabilities in global policy discourses and taking the lead in Zimbabwe's space-related international cooperation [23].

Organization

ZINGSA operates under the Ministry of Higher and Tertiary Education, Science and Technology Development [236]. It is organized into one Finance and Administration Department and the following four founding technical departments, which are in line with the priorities set forth by the Government [23]:

1. The Space Operations and Launch Services Department, responsible for the strategic planning and implementation of space missions;
2. The Space Science Department, responsible for championing research;
3. The Space Engineering Department, responsible for providing technical advice and assistance to ZINGSA programs; and
4. The Geospatial and Earth Observation Department, responsible for the research and development of activities related to geospatial applications and earth observation, with a focus on mineral exploration, disaster management, meteorology, smart agriculture, water, energy, health, and other strategic applications [237].

Cooperation

In late 2018, ZINGSA signed a non-financial capacity building agreement with South Africa's Space Advisory Group, which is expected to share expertise on satellite manufacturing and the management of a space agency [238]. The

Minister of Higher and Tertiary Education, Science and Technology Development also indicated that private South African investors were interested in manufacturing satellites in Zimbabwe, which would help create jobs within the national industry [231]. Additional countries that have demonstrated interest in collaborating with and investing in Zimbabwe's space program include Kazakhstan, Belgium, and China [23]. In September 2019, Zimbabwe launched a database built as a collaboration between the Chinese Academy of Sciences and the University of Zimbabwe, which uses satellite data to address challenges of agriculture productivity and climate change [239] [240].

Capabilities

Zimbabwe is upgrading its satellite communications infrastructure by expanding the Mazowe Satellite Station, which was opened in 1985 and is ran by TelOne. The decision to not set up its own new, separate infrastructure elsewhere was a result of an effort to operationalize ZINGSA at the lowest cost possible. A budget of USD 25 million was allocated for the refurbishment of the Mazowe Station [241]. While Zimbabwe's capabilities do not yet include satellites, the government has indicated that this is one of the future ambitions of ZINGSA [23] and announced the allocation of resources for the launch of a satellite in its 2020 budget [242].

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