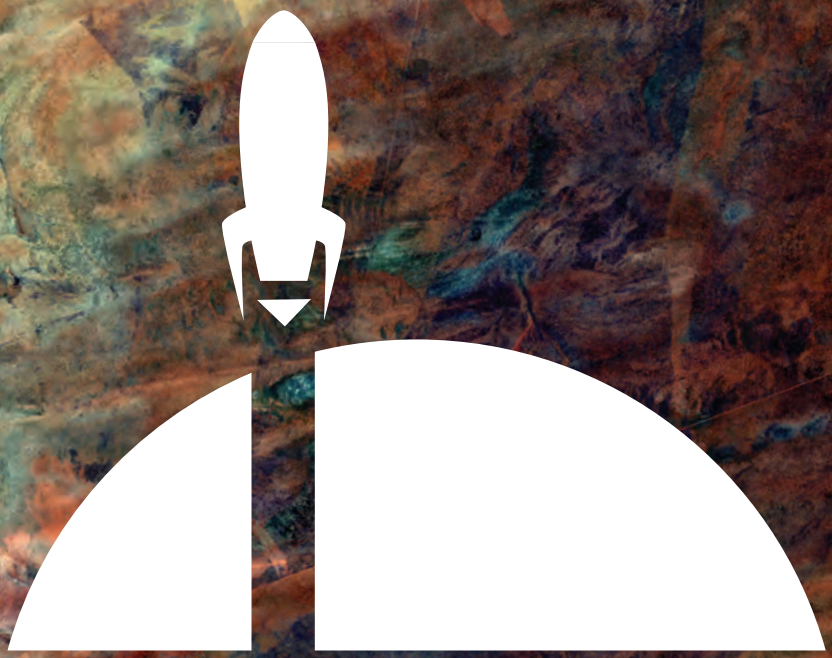
Final Report Southern Hemisphere Space Studies Program 2018

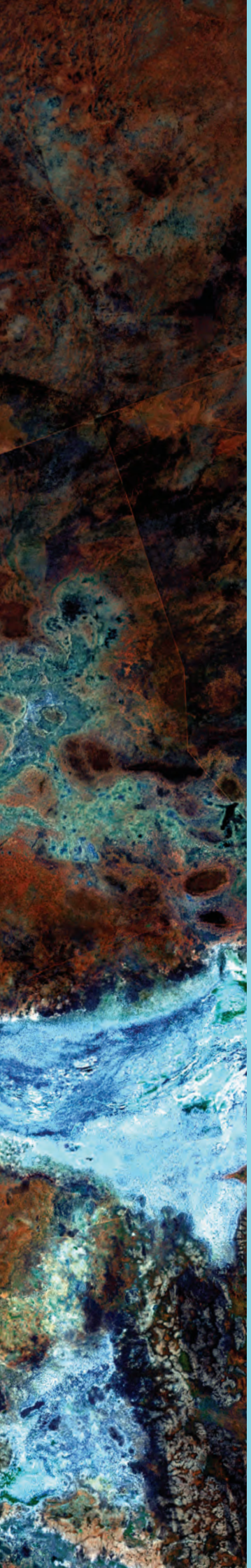


SPACE READY

THE LAUNCHPAD FOR EMERGING AGENCIES

University of South Australia

INTERNATIONAL® SPACE UNIVERSITY



Welcome

SPACE READY
THE LAUNCHPAD FOR EMERGING AGENCIES

Our mission

"An international comparison and analysis of space agencies to provide recommendations for the benefit of emerging space states."

SPACE READY
THE LAUNCHPAD FOR EMERGING AGENCIES

Abstract

With the rapid evolution of space technologies, there is an advantage for nations to benefit from space derived data and space enabled applications to develop domestic space capabilities. Since the 1950s, many states have begun to engage in the development of space agencies with a range of different structural designs, aims, policies and capabilities. Deciding on the best model of agency for emerging space states is accordingly a major challenge.

The purpose of **Space Ready** is to make a comparison of different types of space agencies from all over the globe. It considers the funding, structure, program aims, and activities of 14 agencies to provide emerging states with an analysis of the different models used internationally.

Preface

Space Ready: The Launchpad for Emerging Agencies, was written by an interdisiplinary group of participants at the Southern Hemisphere Space Studies Program 2018 (SH-SSP18) conducted by the International Space University and the University of South Australia. The program was held from 15 January to 16 February 2018. The participants who are part of this project acknowledge the support and guidance they received from the Chair and Associate-Chair, Michael Davis and Andrew Butler, the Teaching Associates, Scott Schneider and Lydia Drabsch, as well the faculty members from the International Space University and the University of South Australia.

This report compares and analyzes existing space agencies under different themes and provides recommendations for the benefit of emerging space states. While 14 agencies will be compared throughout the report, other agencies will be discussed on a case-by-case basis.

With the announcement of an Australian Space Agency it is hoped that this document will provide guidance to support this development in Australia and any other country considering a space agency. The findings of this report will be presented by participants to government organizations, officials and stakeholders, including at the 2018 International Astronautical Congress (IAC).

With the evolution of space technology there has been an increasing international interest in gaining capacity to access space resources and commit to scientific exploration. The team is also aware of an increasing recognition of the need to develop national legislation to integrate with international frameworks relating to space. This project has influenced all the participants on a personal level, to inspire and educate the population about space and the opportunities it provides.

Faculty Preface

The genesis of this project is the decision announced in September 2017 by the Australian Government to establish a national space agency. The charter of this agency is the subject of recommendations by an Expert Reference Group. Their report is still to be delivered to the Government.

The 24 Southern Hemisphere Space Studies Program participants comprising the Space Ready team have undertaken the challenging task of comparing the key features of national space agencies throughout the world with a view to providing a report that will be of value to the Australian Government and to policy makers throughout the world.

With remarkable industry and research expertise the team has collected and analyzed information from multiple sources. The synthesis of information is impressive and persuasive. The team is to be congratulated.

The team was greatly assisted by subject matter experts Dr. Michael Simpson and Mr. Chris Johnson of Secure World Foundation, Dr. Kai-Uwe Schrogl of ESA, Dr. Danielle Wood of MIT, Mr. Duncan Blake of International Aerospace Law & Policy Group, as well as our distinguished visitor, Dr. Christyl Johnson, Deputy Director at NASA Goddard. Our thanks are also extended to our hard-working teaching associates, Scott Schneider and Lydia Drabsch.

Michael Davis, Space Industry Association of Australia
Project Chair

Andrew Butler, Melbourne Social Equity Institute, University of Melbourne
Project Associate Chair

February 2018

How to use this document

The purpose of **Space Ready** is to provide a thorough comparison and analysis of existing space agencies to inform emerging space states about developing their own agency. It is intended to be used as a guide to explore the themes of aims, structure, funding, and program activities in consideration of the individual nature of each state.

Space Ready is a guide for emerging nations to demonstrate considerations necessary to establish the most effective agency based on the individual requirements of each state. **Space Ready** does not provide nation-specific advice for any state, but evaluates the influencing factors of successes and failures for 14 agencies. Such that, emerging space states have the opportunity to identify models of agency that suit their individual needs.

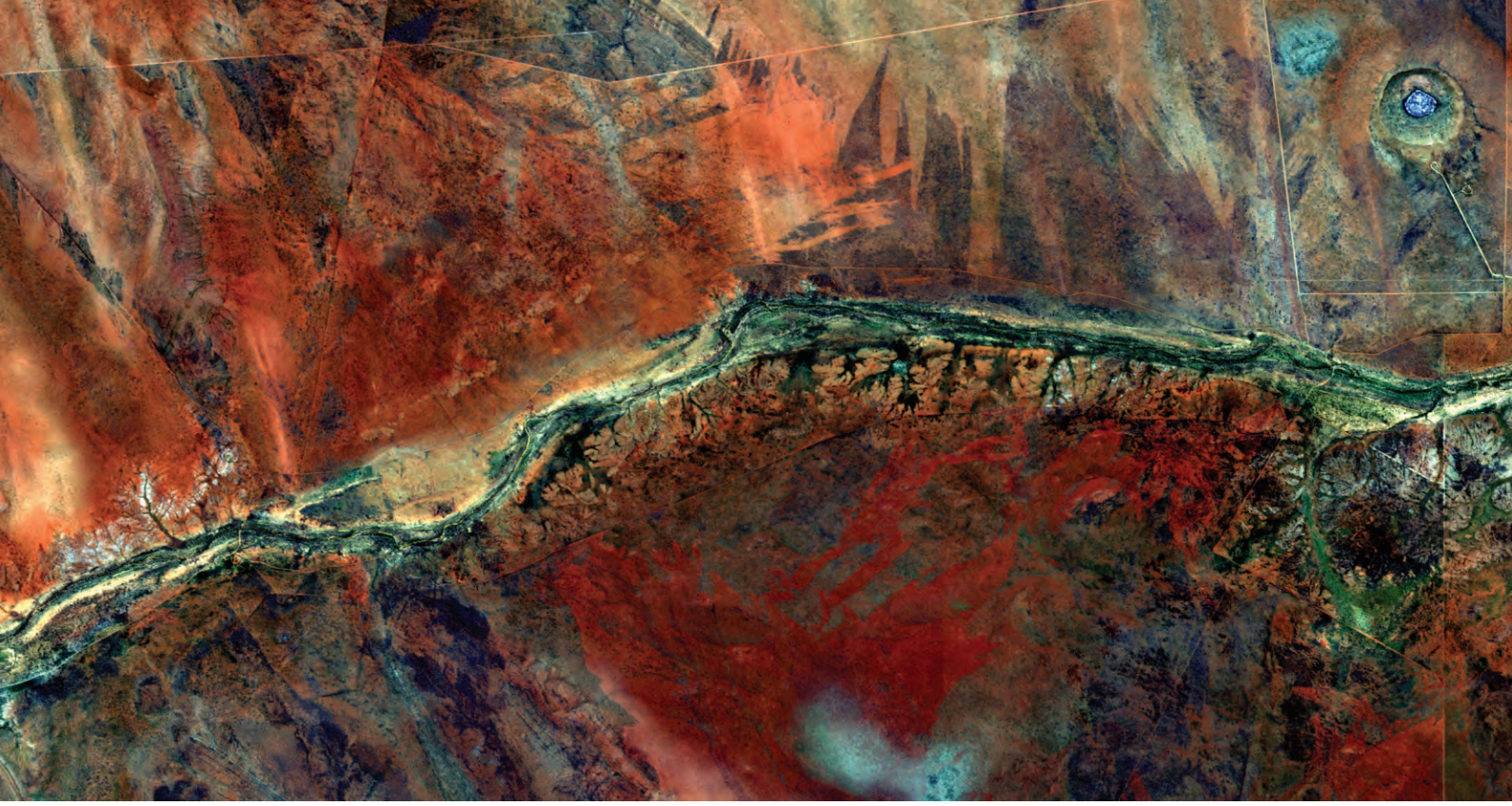
Chapter 1 provides a concise summary of all the agencies that have been included in **Space Ready** and an overview of the emerging space nations. It includes information relating to Australia's recent announcement to develop its own space agency in September 2017. It provides a brief summary of the chosen states: Brazil, Canada, Chile, China, India, Luxembourg, Malaysia, New Zealand, Spain, South Africa, United Arab Emirates, United Kingdom, the United States of America, as well as considering the European Space Agency as a model of international cooperation.

Chapters 2, 3, 4, and 5 deal with the aims, structure, funding, and program activities respectively. Each chapter uses case studies and discussion to analyze the influencing factors that affect each theme. **Space Ready** provides subject-specific recommendations for emerging space states to consider when developing a space agency.

Chapter 6 provides a summary of the discussions contained in **Space Ready** as well as a thorough set of recommendations for any emerging space state to consider when establishing a space agency. The report encourages states to consider the best course of action based on their own policies, aims, and objectives. It also provides an evaluation of establishing an independent national agency, joining or initiating a collaboration with other states.

Acronyms and Abbreviations

ACE	Aerosol Cloud Ecosystems
ACS	Chilean Space Agency
AFC	Administration and Finance Committee
ALC	Alcantara Launch Center
ANGKASA	Malaysian Space Agency
APRSAF	Asia-Pacific Regional Space Agency Forum
APSCO	Asia-Pacific Space Cooperation Organization
ARMC	African Resource Management Satellite Constellation plan
ATB	Agency technology and product Transfer Board
ATSB	Astronautics Technology
CNSA	China National Space Administration
CSG	Guiana Space Centre
DG	Director General
DSN	Deep Space Network
EAC	European Astronaut Centre
EADS	European Aeronautic Defence and Space Company
ECS	European Cooperating States
ECSAT	European Centre for Space Applications and Telecommunications
EO	Earth Observation
ESA	European Space Agency
ESAC	European Space Astronomy Centre
ESEC	European space Security and Education Centre
ESOC	European Space Operations Centre
ESRIN	ESA centre for Earth observation
ESTEC	European Space Research and Technology Centre
EU	European Union
FAA	Federeal Aviation Administration
GDP	Gross Domestic Product
GLAE	Groupement luxembourgeois de l'aeronautique et de l'espace
GNSS	Global Navigation Satellite System
IND	Interplanetary Network Directorate
INTA	National Institute of Aerospace Technology
IPC	Industrial Policy Committee
IPP	International Partnership Program
IRC	International Relations Committee
ISRO	Indian Space Research Organisation
ISS	International Space Station
JAXA	Japan Aeropsace Exploration Agency
JCB	Joint Board on Communication Satellite Programs
JPL	Jet Propulsion Laboratory
LIST	Luxembourg Institute of Science and Technology
MoU	Memorandum of Understanding
MRSA	Malaysian Remote Sensing Agency
MSP	Mission Support Plan
NASA	National Aeronautics and Space Administration
NZSA	New Zealand Space Agency
PB-EO	Earth Observation Program Board
PB-LAU	Launchers Program Board
PB-NAV	Program Board on Satellite Navigation
PB-SSA	Space Situationnel Awareness Program Board
PPP	Purchasing Power Parity
RDI	Research Develop Innovate
SANSA	South African National Space Agency
SDG	Sustainable Development Goals
SPC	Science Program Committee
SSA	Space Situational Awareness
UAE	United Arab Emirates
UK	The United Kingdom of Great Britain and Northern Ireland
USA	United States of America
USD	United States Dollars
USSR	Union of Soviet Socialist Republics



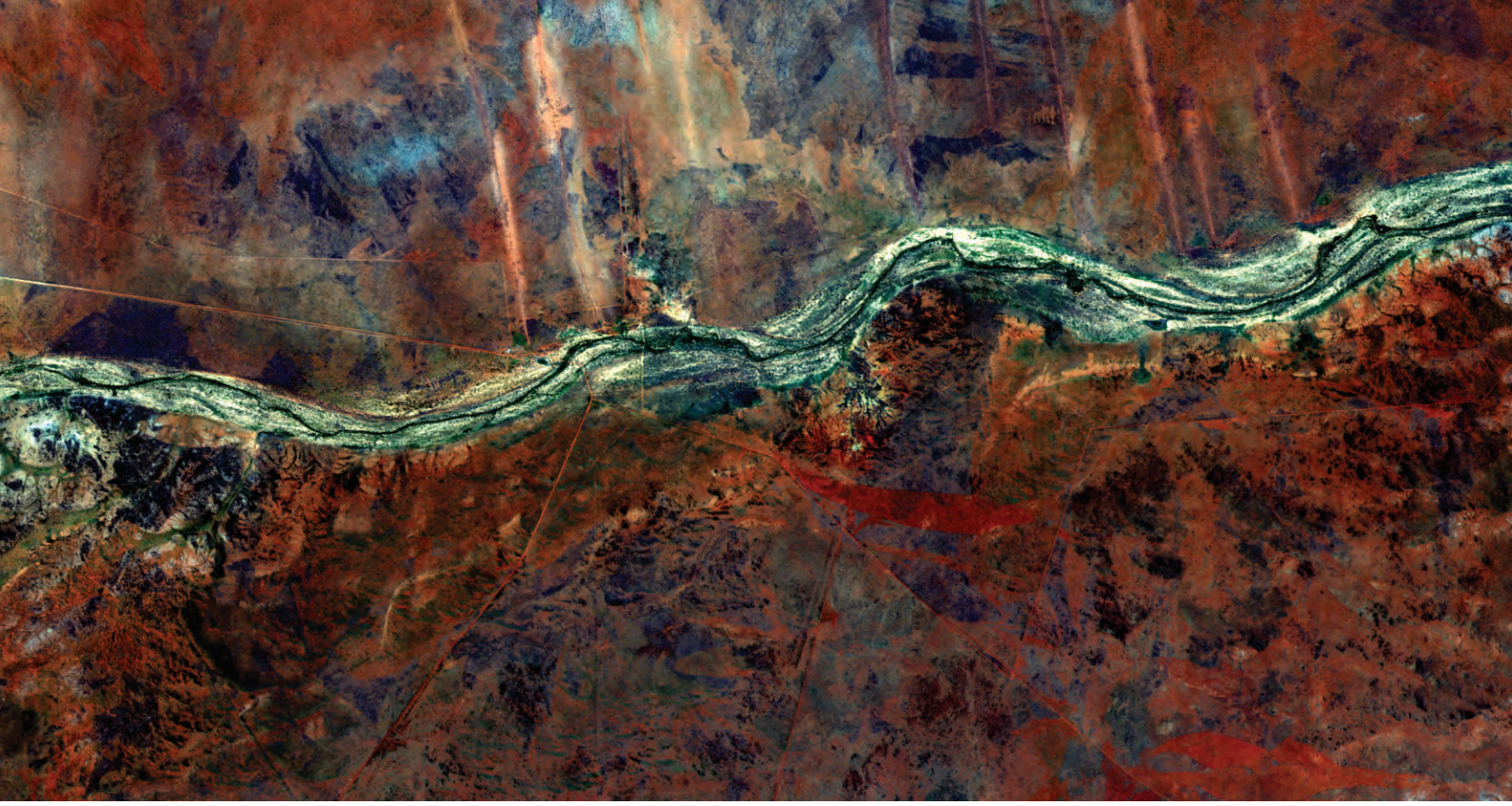
Mission Statement

An international comparison and analysis of space agencies to provide recommendations for the benefit of emerging space states.

Project Justification

With the advances in technology, space is no longer the exclusive domain of powerful states with significant national budgets for their space programs. Smaller states, as well as a vast number of commercial enterprises, have become increasingly involved in the space arena and have demonstrated the immense socio-economic benefits that ensue. This recent growth in commercial space activities has not only increased state responsibility to adequately regulate the commercial sector, but has also fueled aspiring states to capitalize on this new potential. These changes mean the role of a space agency has expanded and is more complex than in previous decades.

The authors of this report have identified the need for insight into how existing national space agencies were formed, how they have evolved over the years, and how they carry out their mandates. There is currently a lack of interdisplinary research on the multifaceted roles of a space agency, and the recent advent of new actors has presented an opportunity to consider the factors that drive the success of a space agency. The aim of this report is to assist emerging space states that are seeking to establish or develop a national space agency.



Scope

This report compares 14 space agencies. It includes the European Space Agency (ESA) as an example of a regional agency. The states were chosen to provide diversity in several areas such as the agency's age, aims, activities, and geographic location. Furthermore, some agencies were chosen to make use of the information and expertise available to the team at the time of writing. Additional agencies or countries were included on a case-by-case basis.

This report intends to build upon the report titled *A Roadmap for Emerging Space States (ARESS),* generated during the International Space University's 2017 Space Studies Program in Cork, Ireland. The ARESS report aimed to provide recommendations to emerging space states that will "enhance and inspire social and economic growth" (Al Habsi, et al., 2017). **Space Ready** is more specifically focused on recommendations for such states that actively developing a new agency. The question of whether it is appropriate for a particular state to form a space agency is considered outside of the scope of this document.

Project Objectives

Main Objective

The main objective of this report is to provide a series of recommendations that may be considered by an emerging space states when establishing a national space agency.

Specific Objectives

In order to accomplish the goal, the **Space Ready** team pursued the following objectives:

- to investigate the forces and circumstances that determine the aims of a space program,
- to analyze how the structure of a new agency may be shaped by the program aims and in turn how the structure may influence the pursuit of the aims,
- to discuss how the funding model can determine the success of the agency in fulfilling its aims, and
- to investigate how the proposed space activities integrate into the agency structure and funding to fulfill its aims.

Overview

Brazil

Brazil's space agency was founded in 1994 as a civilian agency under the President's executive office. It is the largest space agency in the southern hemisphere and works alongside the Ministry of Science, Technology and Innovation, the Department of Aerospace Science and Technology and the Ministry of Defense. Prior to the agency's formation, Brazil had cooperated with countries such as Russia and China for satellite development and launch. Brazil's agency continues to embark on national and international partnerships for sharing the high costs and risks of space ventures. Their 10-year plan from 2012 to 2021 sees an overall investment in space of approximately USD9b. The Brazilian space agency has long been committed to the development of autonomous and sustainable space technology, and encourages civil research institutions and private capital to participate in the national space program. (Ministerio da Ciencia, Tecnologia e Inovacao, 2018)

Canada

The Canadian Space Agency (CSA) was formed in 1990 and is responsible for promoting the peaceful use and exploration of space, using science to advance the knowledge of space, and ensuring that space science and technology provide social and economic benefits for Canadians. The CSA is led by a President who reports to the Minister of Innovation, Science and Economic Development. Its main divisions contain Space Utilization, Space Exploration, Space Science and Technology. The CSA has approximately 670 employees, and 4 active astronauts. The CSA's budget has decreased in recent years from USD432m in 2016/17 to USD353m in 2017/18. Canada is an official Associate State of the European Space Agency and collaborates on certain projects of national interest. This partnership has led to increased business opportunities for Canadian companies, and brought huge benefits to the Canadian economy. (Government of Canada, 2018)

Chile

The Chilean Space Agency was formed in 2001, with a mandate to advise the Presidency on all space related matters. The agency falls under the jurisdiction of the Telecommunication Ministry. It is responsible for formulating policies and plans regarding the use and development of Chilean space technologies. Additional expectations include the promotion of Chilean space activities and coordination with government organizations and private companies to maximize the state's science and space capabilities. The Agency strives for economic and social development through the integration and utilization of fundamental space technologies, particularly geospatial imagery, satellite communication, navigation systems, agricultural and military applications. The Chilean Space Agency has had an eventful evolution, whereby three major administrative changes culminated in its disbandment in 2012 and reconstitution in 2015. (Gobierno de Chile, 2011; Biblioteca del Congreso Nacional de Chile, 2015)

China

The China National Space Agency (CNSA) was founded in 1993 under the Ministry of Industry and Information Technology. CNSA has six departments which cover general administration, coordination, development and planning, foreign affairs, systems engineering, and science, technology and quality control. There are also three centers– the Remote Sensing Demonstration Centre, the Earth Observation Program Centre, and the Lunar Exploration and Space Program center. CNSA outlines its responsibility to manage space activities not only for China's benefit, but also for the benefit of mankind. Their five year plan includes completing the development and launch of a core module for their national space station, Tiangong-2, which is a key component facilitating China's human spaceflight activities. CNSA also plan to continue work on the Beidou-2 satellite navigation service, and both lunar and mars exploration missions (China National Space Administration, 2018).

Europe

The European Space Agency (ESA) is a collaborative organization with headquarters in Paris. Its Member States consist of: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, and the United Kingdom. Through international cooperation, ESA engages in Earth observation, human spaceflight, space transportation, navigation, operations, and science, engineering and technology. The aim is to ensure that investment in space continues to deliver benefits to the citizens of Europe and the world. ESA's budget for 2017 was approximately USD7b – this is derived from the member states through return or investment agreements. Collaboration has enabled ESA to conduct space activities which are beyond the capacity of any individual member state (ESA, 2018).

India

The Indian Space Research Organization (ISRO) was set up in 1969 and its mandate is to harness space technology for the socio-economic benefit of the country, while pursuing space science research and planetary exploration. ISRO is closely linked with the Department of Space, which works directly under the Prime Minister of India. ISRO's Chairman also holds the position of Secretary for the Department of Space. ISRO is currently engaged in launch vehicle development, launch port operation, satellite design and integration, interplanetary missions, payload development for satellite based telecommunication, optical and microwave remote sensing, navigation, meteorology, and remote sensing data analysis. ISRO executes these functions through its several field centers spread across India. ISRO's total budget for the year 2017-18 was roughly USD1.4b. Indian partners with many international space agencies like NASA, ESA and CNES for executing joint/multilateral space missions (Government of India, 2017).

Luxembourg

Luxembourg has no centralized space agency, but conducts space affairs through a number of interconnected initiatives. The Ministry of the Economy oversees the space sector – approximately 30 companies and two public research organizations – whose activities are guided by its national space policy. The policy outlines key aims such as contributing to the diversification and sustainability of economic activities and extending skills in space. The Luxembourg space program is primarily a support structure that fosters commercial enterprises. In 2017, Luxembourg passed legislation enabling the exploitation of space resources, which has promoted new industry focusing on space mining. Synergy and cooperation at a national and international level is fundamental to Luxembourg's research, development and innovation projects. Luxembourg became a Member State of ESA in 2005 (Luxinnovation, 2018).

Malaysia

The Malaysian Space Agency, ANGKASA, was established in 2003 and is administered the Malaysian Ministry of Science, Technology and Innovation. ANGKASA seeks to "spearhead the development of the space sector in Malaysia and contribute to sovereignty and competitiveness of the nation" (Agensi Angkasa Negara, 2018). Their mission statement is to encourage "economic growth and knowledge advancement for societal well-being through the development of space capability." Significant space-related achievements for Malaysia include their telecommunications satellite constellation MEASAT, and the equatorial imaging provided by RazakSAT. Space assets are an important contribution to Malaysia's economic growth. Malaysia's aerospace industry consists of over 120 companies and contributes to approximately 2% of the Malaysian gross domestic product (GDP). Most of Malaysia's space ventures have been in collaboration with various international existing space states.

New Zealand

The New Zealand Space Agency (NZSA) was formed in 2016 under the Ministry of Business, Innovation and Employment. Key activities include regulation of space activities, supporting rocket launches, enabling space-related business, science and innovation, and engaging internationally. NZSA seeks to benefit the economy, society and environment through their space ventures. In particular, through collaboration with Rocket Lab, NZSA have established the world's first private orbital launch ranges on the east cost of the North Island. The range specifically aims to provide customers with more frequent low-earth orbit launches. New Zealand have ratified the Outer Space, Rescue and Return, and Liability treaties, and have bilateral agreements with NASA and ESA (Ministry of Business, Innovation & Employment, 2017).

South Africa

The South African National Space Agency (SANSA) was founded in 2010 mandated by the South African National Space Agency Act of 2008. (SANSA, 2012). With the vision to position South Africa as an international hub for space solutions and the mission to lead and inspire the South African space community to create a better future, SANSA has set seven strategic goals, which are implemented into five programs: Administration, Earth Observation, Space Operations, Space Science, and Space Engineering. The annual funding has fluctuated in recent years, but returns to approximately USD19m in 2017-18. SANSA cooperates widely with international space agencies including in the UK, Germany, Russia and Japan.

Spain

Spain's National Institute of Aerospace Technology (INTA) was established in 1942 under the Ministry of Defense. Their scope of activities extend beyond military applications, and involve all aerospace fields. One of the four sub-directorates of INTA relates to Space Systems. Specific programs controlled by the Space Systems directorate include the Madrid Deep Space Communication Complex and the El Arenosillo rocket launch site in southern Spain. Within INTA, space technologies currently attract 46% of the total budget. Space capabilities are also strengthened by research in other INTA directorates, including aeronautics, hydrodynamics, security and defense. INTA has a history of strong international collaboration, particularly with NASA and ESA (INTA, 2018).

United Arab Emirates

The UAE Space Agency was established in 2014 and has quickly earned credence as a leading space power in its region. By focusing on development of national capabilities in space technology, the UAE agency aims to contribute towards economic diversification and the consolidation of a knowledge-based economy. Agency values include national integrity, excellence, commitment, cooperation and innovation. The UAE Space Agency plans to send an unmanned probe to Mars by 2021, making them one of only nine countries worldwide who are planning Mars based missions. The UAE Space Agency is an affiliate of the Council of Ministers and has branches in both Abu Dhabi and Dubai (UAE Space Agency, 2018).

United Kingdom

The UK Space Agency was created in 2011, and is part of the Department for Business, Energy & Industrial Strategy. The agency is responsible for all strategic decisions relating to the UK civil space program, in order to provide a clear, single voice for their space ambitions. Particular aims include coordination of space activity, supporting industry, encouraging academic research, increasing understanding of space science, and inspiring the next generation of UK scientists and engineers. The Agency's work with government, industry, business and academia has created major successes for the UK industry and economy - experiencing a decade-long growth trend in the space sector. The agency plans to capture 10% of the global market for space by 2030. Continued focus is given towards cooperation and participation in the European Space program (UK Government, 2018).

United States of America

The United States space agency, the National Aeronautics and Space Administration (NASA), was formed in 1958 and is an independent body of the executive branch of the US federal government. The Administrator of NASA is nominated by the President and confirmed by the Senate vote. Research is a fundamental component of NASA's activities, including human spaceflight, and technological development for earth observation and solar system exploration. NASA conducts extensive domestic and international collaboration with universities, industry and other space agencies. In recent years, with the support of NASA and other government agencies, a number of private enterprises have made great progress such as Elon Musk's SpaceX. NASA receives its funding from the annual federal budget passed by the United States Congress - the 2018 Budget request of NASA is USD19.1b. In the past 60 years, NASA has made outstanding achievements, such as landing astronauts on the Moon, leading an international collaboration for the International Space Station and exploring planets and bodies within our solar system (NASA, 2017).

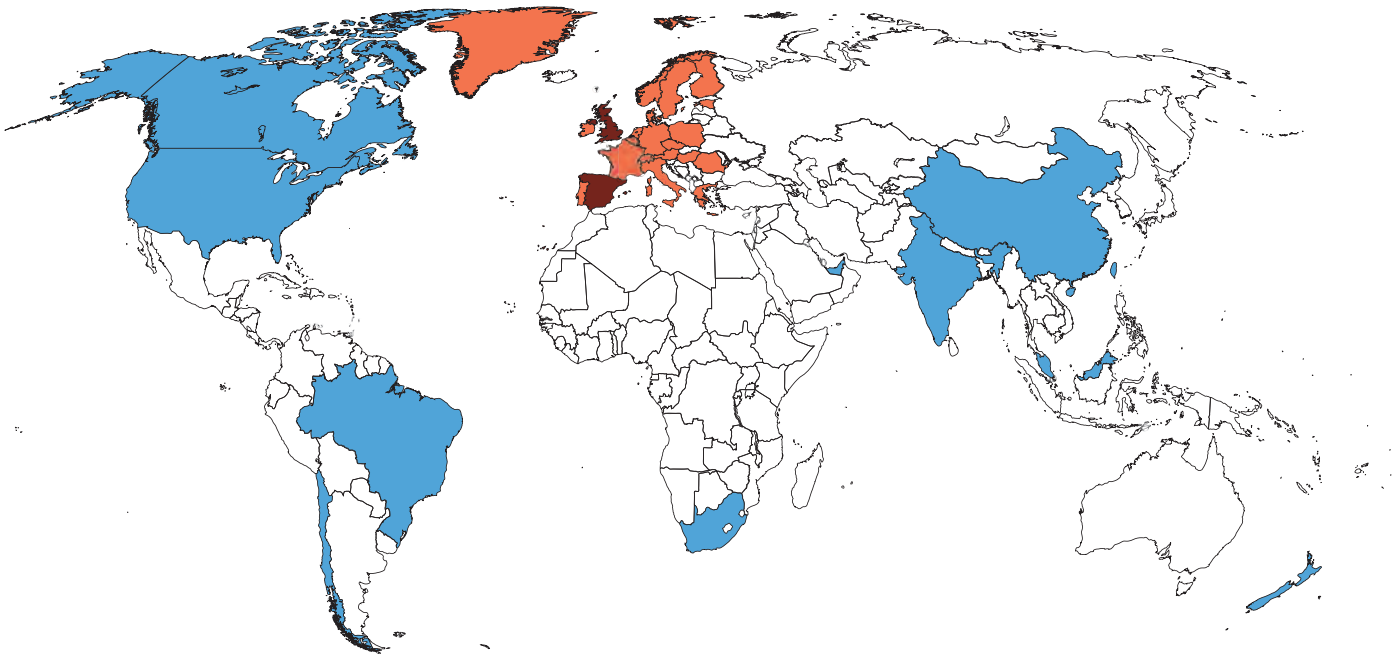


Figure 1: States investigated (blue) ESA member states (orange) States within ESA investigated (red)

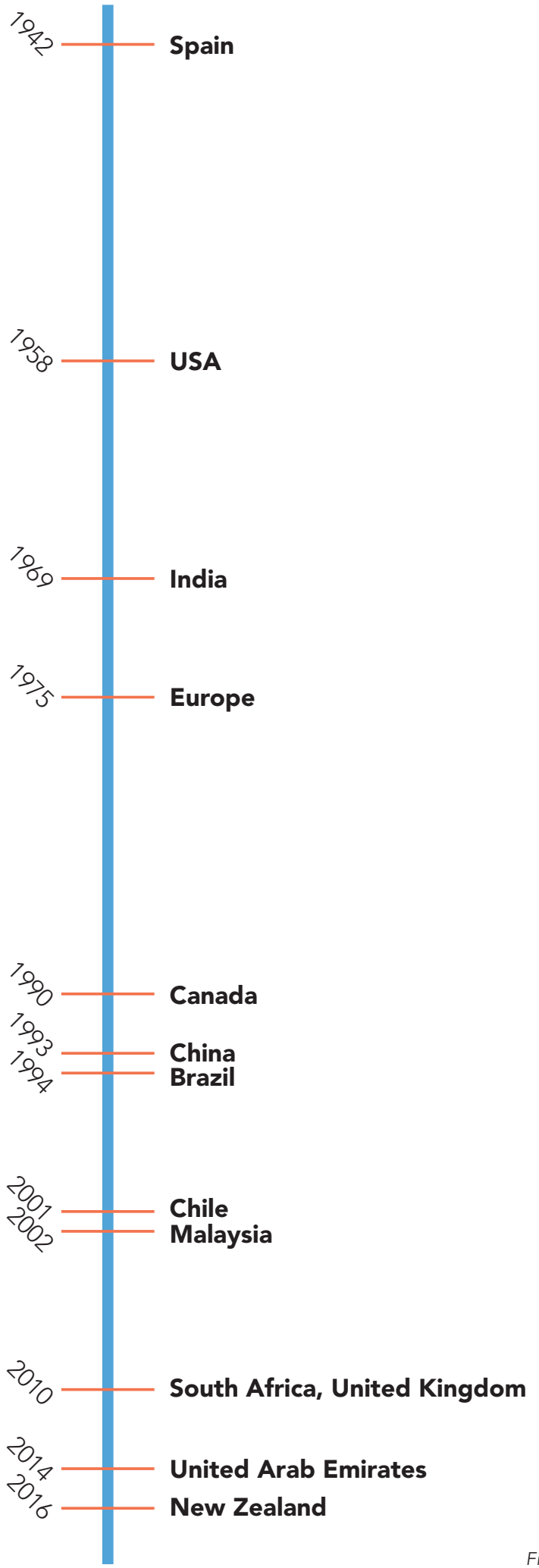


Figure 2: Founding dates of space agencies

Aims

"In the long run men hit only what they aim at."

Henry David Thoreau

The socio-political landscape that drove the space-race differs drastically from the current globalized scene. While their motivations for entering space signify an important historical chapter, it is more relevant for emerging space states to understand how new actors in space have established and implemented agency aims. Whereas space was once an arena for the superpowers, in more recent times we have seen smaller and developing countries enter and succeed in space (Andsell, et al., 2011). Underlying this trend is a new understanding of how a presence in space can help nations to expand their domestic programs and boost their international status. Among many things, a space program can enable more reliable communication services, foster innovation, and enable economies to reap the benefits of spin-off technologies. Countries embarking on the journey into space usually do so with some guiding principles. These aims are the embodiment of their motivations for establishing a presence in space (Harding, 2013). This chapter seeks to compare, contrast, and then analyze the aims of existing space agencies with the intention of providing recommendations for emerging space states.

What are Aims?

For analysis, it is important to begin by considering the definition of 'aims' concerning the space sector. The term aim is interchangeable with mission and refers to the general ambitions of an organization. Objectives, or strategic goals, have a narrower scope and refer to the measurable stages en route towards achieving an aim (University of South Australia, 2015). Both aims and objectives fall under an agency's policy - this denotes the guiding principles as to how an organization conducts space activities (Secure World Foundation, 2017). This philosophy is apparent in the way NASA manages its space programs, whereby a Mission Support Plan (MSP) is used to ensure the integration of policy, aims, and objectives (NASA, 2010).

Aims are a fundamental component that helps to steer a national space agency. They seek to encapsulate an agency's ambition by striking a balance between specificity and flexibility. When evaluating an agency's aims, it is also important to consider the underlying social, political and economic conditions in which those aims were developed. Additionally, the legal framework of existing international space treaties can implicitly impact how a state develops its space-related aims, as can a commitment to international undertakings such as the United Nations Sustainable Development Goals (SDGs) (ESA, 2017). The ensuing discussion explores the factors which shape how space agencies decide upon aims, and provides an analysis of the link between agency aims, structure, and activities.

Different Aims for Different Countries

Between states, there are significant differences in social structure, political systems, economic conditions, and geographical location. It is this range of factors that can shape a state's realization and consolidation of their aims in the space sector. Some countries, including the South Africa, pursue pragmatic policy based on utilizing existing space capabilities to enhance their socio-economic growth (Andsell, et al., 2011; Mosteshar, 2013). Other countries, including the USA and the UAE, have incorporated more ambitious visions into their agenda, such as interplanetary exploration (Dunbar, 2017; Extance, 2014). Included in the short-term aims of the UAE Space Agency is the plan to send an unmanned probe to Mars by 2021. NASA on the other hand continues to be a world leader in space

research and innovation (Mohammed bin Rashid Space Centre, n.d.). Entering into its sixtieth year, NASA has some inspiring achievements such as the first human on the Moon, exploration missions to most planets in our solar system, along with the Voyager spacecraft which lead the way in deep space exploration (NASA, 2017). An agency's aims strongly impact the way it will conduct future space activities. Accordingly, emerging space states need to consider how they envision their role in space.
Firstly, it is important for emerging space states to consider their relevant social and political climates and how these may either promote or limit the scope of their aims. The Indian Space Agency (ISRO) provides a pertinent example of how social factors can guide space-related aims. India is one of the most densely populated nations on Earth, and while its economy has proliferated, there is a lag in the provision of social services and infrastructure (Sen, 2013). ISRO has received great acclaim from within and outside of India for its efforts in developing applications of space technology for societal benefits (Christensen, et al., 2009).
Over fifty Indian government departments have shown interest in using ISRO technology to hasten their domestic projects (Dasgupta, 2016).
Similarly, political forces have been a significant factor in shaping China's approach to defining its motivations in space. Concerns regarding China's economy, foreign policies, ideology, and military aims contributed to its isolation from the International Space Station (ISS) (O'Brien, 2013). In response to the condition of international politics, the Chinese Space Agency has a clear aim "to protect China's national rights and interests," and have subsequently created an independent space station (Information Office of the State Council, 2016). Social and political forces, both nationally and internationally, warrant consideration by emerging space states when shaping their agency aims.
The state of the economy also affects the aims of a national space policy. In South Africa, there is a broad perception by public and some policymakers that space activities are luxurious and unnecessary (Ntlhe & Magagula, 2016). The less developed economy also presents a challenge, resulting in more frugal budgets and shifting political priorities (World Politics Review, 2016). For this reason, the South African National Space Agency (SANSA) has emphasized more populistic and practical activities for socio-economic development, and so promotes Earth observation as a critical aim of the agency (Andsell, et al., 2011).
In contrast, the UAE is an affluent nation in the Middle East, looking to diversify its economy to avoid an over-reliance on oil. To this end, the UAE Space Agency explicitly states "contributing to the diversification of the national economy through an advanced national space sector" as a principal aim. The shift in focusing on high tech industry has resulted in space projects with the goal of demonstrating the UAE is a world leader when it comes to solving ambitious engineering challenges. This is evident in plans to send an unmanned probe to Mars by 2021 (Extance, 2014).
In some cases, specific commercial activity has shaped the aims of agencies. For example, one of five major aims of the New Zealand space agency is specifically to support the rocket launches of the New Zealand subsidiary Rocket Lab (Ministry of Business, 2017). A similar example is Luxembourg, where the growth of the space industry has led to the Luxembourg Space Cluster. This Space Cluster is not a space agency but a government initiative with the aim to "contribute to the diversification and sustainability of economic activities in Luxembourg" (Cluster, 2017). In order to meet market expectations, emerging space states need to consider their national economic priorities when proposing agency aims.
Additionally, a state's existing space-related organizations may shape the creation of an agency. There are instances where these organizations have been used as a platform for developing agency aims. In Malaysia, there are three sectors dealing with space activities: The National Space Agency (ANGKASA), The Remote Sensing Agency (MRSA), and a government-owned company named Astronautics Technology (ATSB) (Geospatial World, 2014). MRSA was established in 1989 to continue pursuing the application of remote sensing for societal benefit, including the monitoring and protection of Malaysia's endangered forests (Malaysian Remote Sensing Agency, 2015). ATSB was set-up in 1998 and coordinates ongoing satellite technology projects (Harding, 2013). ANGKASA, Malaysia's national space agency, was the last of these structures to be formed – with its establishment in 2003 (ANGKASA, 2017).
Taking into account the existing agencies, ANGKASA's scope of aims and activities were able to be directed towards filling roles that were not already a part of MRSA or ATSB's agendas. In particular, this included a strong focus on management, policies, and planning of space-related ventures (Geospatial World, 2014).
Moving forward into the climate of Space 2.0, where private companies are taking a greater share of responsibility for space technology development and space exploration, it is important for emerging space states to consider their existing industries and skill-set to help shape their national space agency aims.

Geography and Geopolitics Matter

Another factor demonstrating relevance in the formation of space agency aims is the geographical location of a nation, and the broader regional dynamics within which they exist. For example, Malaysia's space industry thrived under the guidance of Prime Minister Mahathir and Dr. Mazlan Othman in the early 2000s, by setting aims and undertaking programs relevant to their nation's location and interests (Moltz, 2012). Their RazakSAT satellite program pioneered remote sensing space applications for capturing images of the equatorial region - an area which previously had a paucity of Earth imaging due to issues with cloud cover (Kramer, 2018).

Geographical location in the Asia region presents agencies with the opportunity to harness the benefits of an equatorial launch site (National Geographic, 2011). Australia is in the midst of preparations for re-commissioning a national space agency and plans to develop an equatorial launch capability in the Northern Territory have been announced (Zillman, 2017). The Asia-Pacific region is characterized by a unique political and cultural dynamic, manifest in the development of two separate regional space organizations – the Asia-Pacific Regional Space Agency Forum (APRSAF) led by Japan, and the Asia-Pacific Space Cooperation Organization (APSCO) led by China (Venet & Baranes, 2012).

While regional dynamics have contributed to division in Asia, in Europe, however, they promote collaboration in the form of the European Space Agency (ESA). Through intellectual and financial resource management, "ESA aims for programs and activities far beyond the realm of any single member state's capabilities" (Moslinger, 2017). Emerging space agencies may also consider their location and regional dynamics when constructing their agency aims in order to achieve the same possibilities.

Figure 3: Sustainable Development Goals

Be Unique

The formulation of aims for emerging space states is a key process when setting up an agency. This requires an evaluation of national interests and international obligations. Emerging space states can consider aligning their aims in the interest of international cooperation. Through doing so, emerging space states are still encouraged to pursue programs relevant to their national interests.

As an example, in 2006 the Malaysian Space Agency sponsored and coordinated the *Seminar on Islam and Living in Space* (Fischer, 2008). This conference included space industry experts and religious authorities and subsequently led to the development of *Guidelines for Performing Islamic Rites at the International Space Station* (Lewis, 2013). This is an 18-page guidebook which has been translated across numerous languages and provides support to Muslims in space regarding balancing mission objectives and performing religious obligations (Harding, 2013; Lewis, 2013). Malaysia's ability to carve out a niche area in the space sector illustrates to smaller and developing emerging space states that significant achievements can be made without entering into direct competition with existing agencies such as NASA or Roscosmos.

Be a Team Player

Emerging space states should aim to support the United Nations Sustainable Development Goals through their space ventures. In 2015 the United Nations set forth a collection of seventeen global goals targeting critical issues for humanity and the planet (United Nations, 2015). With regards to ending poverty and hunger, satellite technology can benefit agriculture and help countries to meet their food demands (Lazzari, 2017).

Through collaboration with public health services, space infrastructure can be used to improve population health. The European Space Agency collaborates with the World Health Organization, International Telecommunications Union, and European Commission, to form the Telemedicine Alliance (Agency, 2004). Telemedicine refers to the use of telecommunication services to provide healthcare services across geographic, temporal, social and cultural barriers (Reid, 1996). Remote sensing space applications are utilized by many space agencies to foster sustainable cities and communities, "ensure sustainable production and consumption patterns, and take action against the variety of consequences from climate change" (United Nations, 2015).

The International Partnership Program (IPP) run by the UK Space Agency is a 5-year effort, including 21 chosen projects, to deliver space expertise to developing economies in Africa, Asia, Central and South America with the overall aim for sustainable societal benefits (UK Space Agency, 2017). Integration of Sustainable Development Goals with the aims of emerging space states is essential for encouraging global partnerships to help improve quality of life and the welfare of our planet.

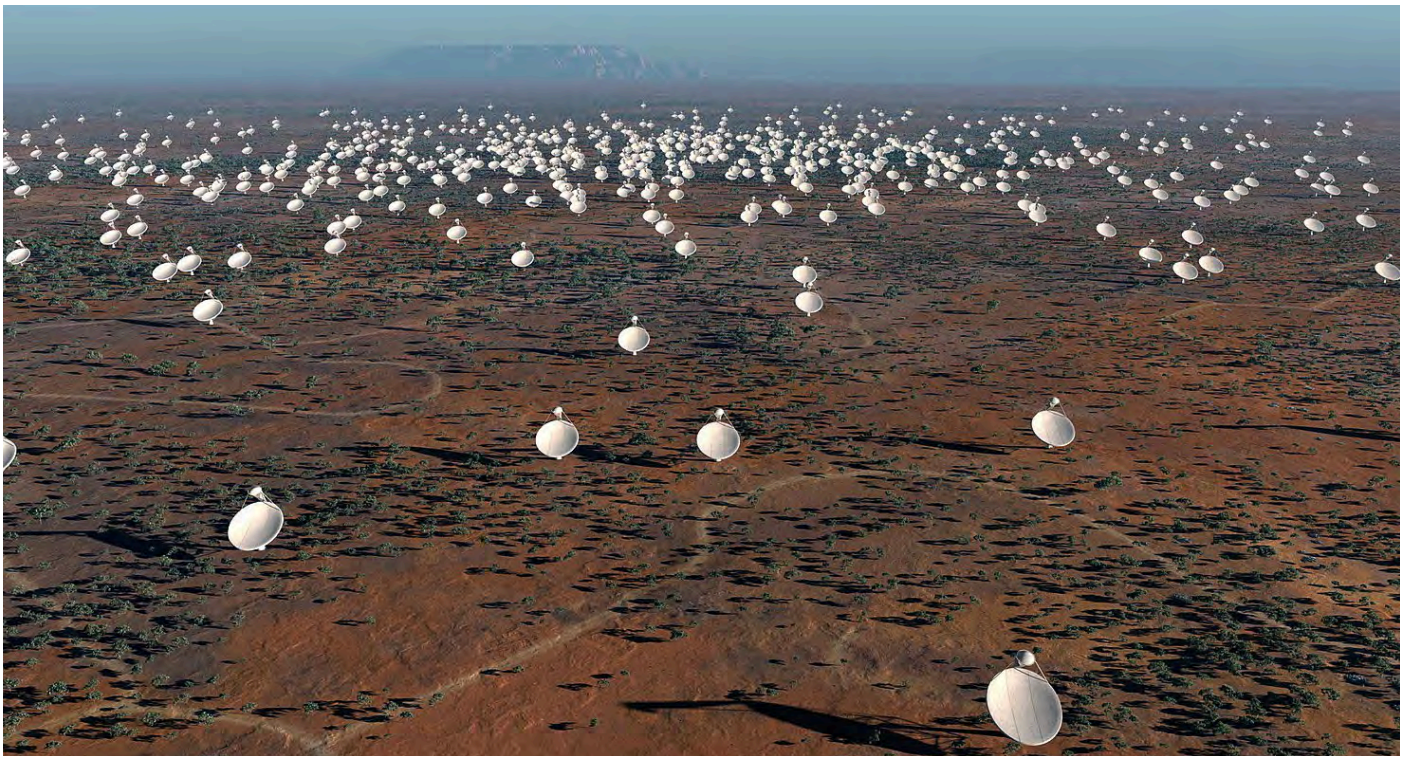


Figure 4: Square Kilometer Array *SKA Project Development Office and Swinburne Astronomy Productions 2010*

Case Study:

SANSA and the Pursuit of Pragmatic Aims

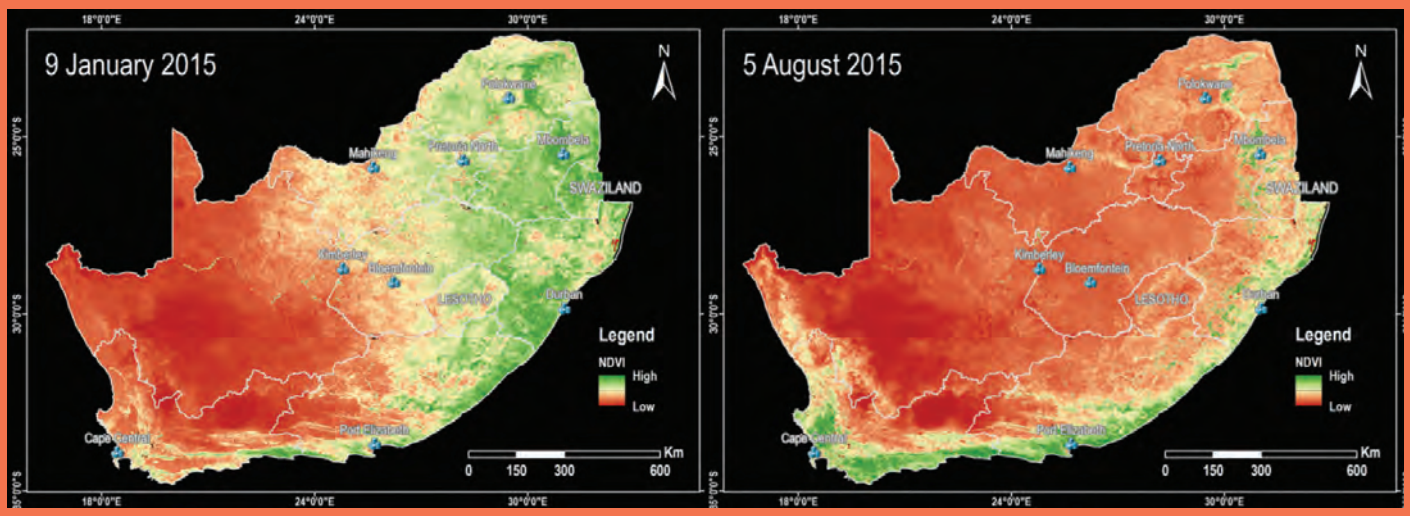


Figure 5: SANSA develops drought monitoring system

The emerging space state South Africa has a clear and transparent national space policy. The aims of the SANSA as outlined by the South African National Space Agency Act (2008) are as follows:

- Promote the peaceful use of space.
- Support the creation of an environment conducive to industrial development in space technology.
- Foster research in space science, communications, navigation, and space physics
- Advance scientific, engineering and technological competencies and capabilities, through human capital development, outreach programs, and infrastructure development.
- Foster international cooperation in space-related activities.

Due to political and socioeconomic factors in South Africa, such as some official skepticism of the value of space activities and a lack of funding, SANSA has prioritized focusing on activities generating socioeconomic development and popular support (Ntlhe & Magagula, 2016). To achieve this goal, Earth Observation (EO) was explicitly put forward as one of the major departments of SANSA, alongside Space Operations, Space Science and Space Engineering, as Earth observation data can be used to improve the use of land, mitigate the consequences of natural disasters, and support agricultural activities to ensure food security. The Earth Observation department has obtained more than 150TB of remote sensing data, dating back as far as 1972. Through developing drought monitoring systems and by preparing exact locality and listing maps for use in surveys and field work, this data has been used to meet the aim of socio-economic development (Ntlhe & Magagula, 2016). The coordination of data acquisition in a centralized agency also prevents a 'silo effect' where separate entities are now aware of publicly available satellite imagery licensed by the South African government, instead of buying redundant licenses (World Politics Review, 2016).

To further its domestic Earth Observation capability, South Africa is part of the African Resource Management Satellite Constellation plan (ARMC). This project includes Algeria, Kenya, Nigeria, and South Africa. Each provides a satellite to integrate into a constellation enabling the stakeholders to benefit from enhanced capabilities, such as improved temporal resolution. The Space Project Division of SANSA Space Engineering leads the technical coordination of space system and subsystem development of the South African satellite EO-Sat 1. However decreased funding in 2016-17 due to shifting political priorities has impacted the development of this satellite (Ntlhe & Magagula, 2016). South Africa's heritage with astronomy is also being leveraged by SANSA to pursue the aim of fostering research in space science. In 2011, sixty astronomers (comprising over half of all astronomers in Africa) were working in South African facilities such as the Hartebeesthoek Radio Astronomy Observatory and the Southern African Large Telescope (Butterworth-Hayes, 2011). To enhance this capability, South Africa won a bid to host 70% of the Square Kilometer Array, a radio telescope fifty times more sensitive than any other radio telescope today. As of 2012, South Africa has already invested USD110m in this project, but a funding cap of USD785m imposed by the project founders has resulted in a scaling back of capability of the array (Wild, 2017). The project is also attracting criticism from the local community which does not see it as a priority (Wild, 2016).
Although South Africa and Nigeria have similarities in the sociopolitical challenges faced by their space agencies, the two countries have a different approach to developing national space capabilities. This is because SANSA explicitly perceives advancing technological capability and developing human capital among its fundamental aims. South African space activities tend to be smaller satellite projects, from the development of two CubeSats for the QB50 project to the development of the larger EO-Sat 1. This allows contractors and universities involved with these projects, such as Denel Spaceteq, SCS Space, and Stellenbosch University, to gain firsthand experience with satellite design and manufacturing (Ntlhe & Magagula, 2016). Conversely, Nigeria tends to use partnerships with foreign companies to acquire hardware and build domestic capability. The consequence is Nigeria has a more diverse and advanced portfolio of space systems, whereas South Africa has more rapidly established an independent domestic capability (Andsell et al., 2011). South Africa also actively encourages training in space through universities, offering scholarships for undergraduates and graduates, and having supported over 30 students at the University of KwaZulu-Natal in research projects (Ntlhe & Magagula, 2016).
It is recommended in the report Space Applications for International Development that "...space programs in developing nations should begin by focusing on programs with a direct benefit to society. They should keep costs as low as possible and ensure that the benefits are communicated to the public..." (Hauser & John, 2009). South Africa is a clear example of a nation following this principle by reducing the extent of public opposition. It also demonstrates reduced funding by delineating aims and pursuing projects which present a clear socio-economic benefit for the public.

Conclusion

There are many unique factors to guide the conception of aims for a space agency, ultimately ensuring those aims can be achieved most effectively. For example, if the aims of a space agency do not compliment the sociopolitical expectations of the population, a culture of disillusionment towards the agency and space in general could follow.
Aims must also be selected on the basis of how achievable they are after considering the economic context of a nation. In nations of a burgeoning middle class, or a desire to spend money on economic diversification, the pursuit of ambitious space activities to appeal to national pride may be more beneficial. In developing nations with less opportunity for funding, an agency should instead consider more pragmatic aims with clear socioeconomic benefits for the public. Where a nation's circumstances favor the pursuit of a niche area of the space industry, this can lead to opportunities for significant national achievements without the complication of having to compete against more established agencies. Moreover, agencies establishing and pursuing its aims in line with other international organizations, such as the UN Sustainable Development Goals, will foster healthier relationships with such organizations.

Structure

During the establishment phase of a space agency, considering the standing, autonomy, and architecture is critical for its long-term success. These considerations will affect a space agency's capacity to achieve short-term aims and enact its long-term vision. In this section, we show how a new agency can be set up most effectively to achieve its aims. This report compares examples of agencies which have archetypal or unique governances and architectures. Consideration is also given to the cost associated with different structures.

National Space Governance

"The heart of good governance lies in a fiduciary obligation to make decisions in the pursuit of the right interests."

(Jakhu & Pelton, 2017)

Degree of autonomy and standing within government

The legislative standing of a space agency within a state may be dictated by the intended purpose. The intended aims and activities of an agency may specifically require military oversight, bureaucratic management from within a ministry, or necessitate direct accountability to the head of government. Each of these situations presents a unique set of qualities to be considered in context with the state's space policy or mandate.

In the US, NASA is an autonomous agency as it answers directly to the US President and enjoys a degree of discretionary powers (Wild, 2017). The Space Act (NASA, 2017) allows for Other Transaction Authority, permitting NASA a degree of autonomy as to how it applies part of its budget, such that it may freely pursue activities to advance its mission and program objectives (NASA, 2017). The US Congress' deliberate choice has enabled NASA to pursue long-term goals that might otherwise have failed from lost project funding due to a lack of political will or support. However, this may result in a sentiment that the NASA structure and activities sometimes lack clear direction and focus. There have been political calls to streamline the agency and divest it from roles that are no longer relevant to its *pioneering* prerogative (Foust, 2012). As observed in NASA's case, it seems having a largely discretional structure within legislative parameters may require some degree of caution to retain such privileges .

National security interests are an inherent feature of the space industry (Jakhu & Pelton, 2017). Secure communication, reconnaissance data, and rocket propulsion technology are dual-purpose technologies that apply to commercial enterprises, government services, and military interests. While the additional funding available from defense budgets can be of benefit to a new space agency, the consequent constraints placed on agency aims, international cooperation, research, and funding transparency might limit commercial engagement and growth.

States may approach national security from directly opposite sides. Spain has positioned its space agency, INTA (National Institute of Aerospace Technology), as a public research organization to act as a technological center within the Ministry of Defense (INTA, n.d.). In contrast, India has positioned its space agency to treat the military as a stakeholder and client, with no direct influence over the policies, governance, or operations of ISRO (Bagla, 2016).

Governance and Long-term Vision

Autonomy and legislative standing within government can give assurance for the future ambitions of the agency. As an agency matures, there may be changes to the national space policy, mandate, aims or activities that were not considered at the time of agency formation. The initial structure of an agency may influence its ability to implement proposed changes in aims or activities.

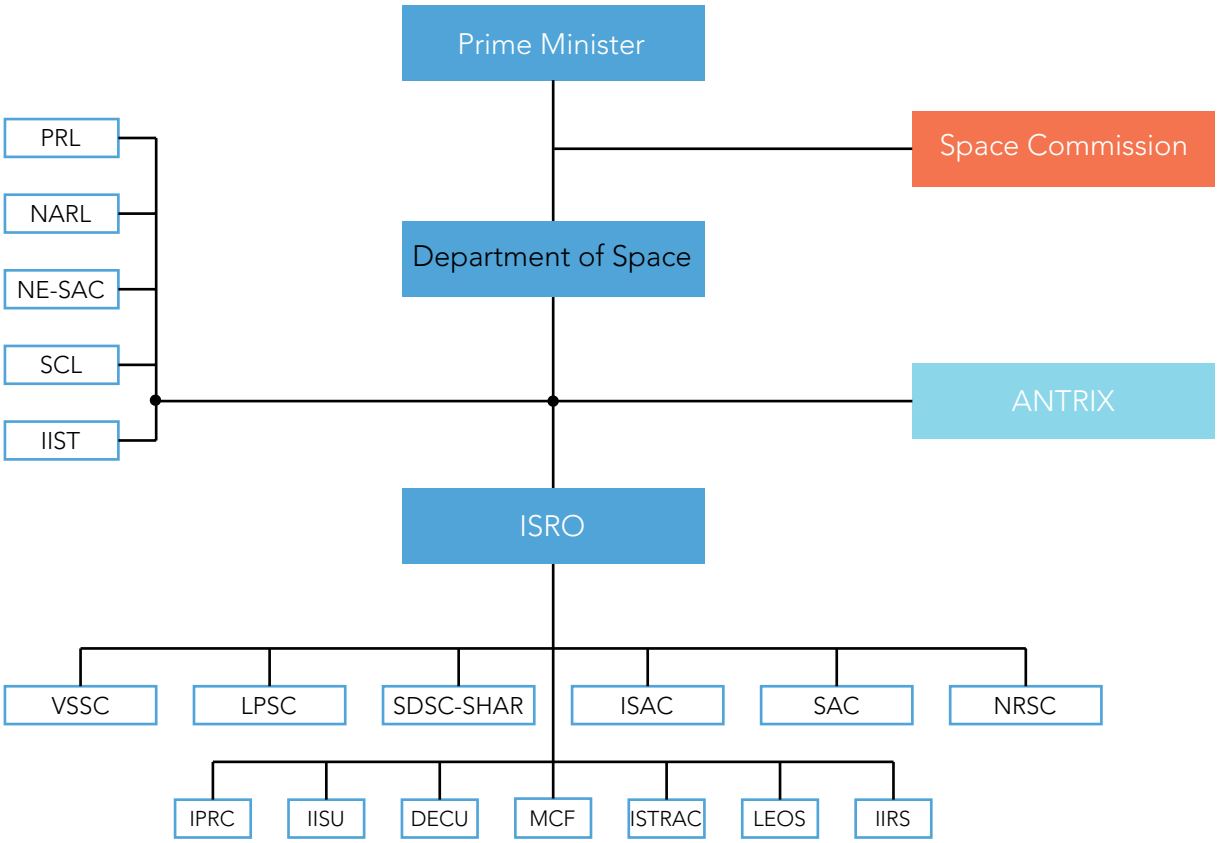


Figure 6: ISRO Organisational Structure

PRL: Physical Research Labratory *NARL*: National Atmospheric Research Laboratory *NE-SAC:* Northern Eastern Applications Centre *SCL:* Semi Conductor Laboratory *IIST:* Indian Institute of Space Science and Technology *Antrix:* Antrix Corporation Limitied *VSSC:* Vikram Sarabhai Space Centre *LPSC:* Liquid Propulsions Systems Centre *SAC:* Space Applications Centre *NRSC:* National Remote Sensing Centre *IPRC:* ISRO Propulsion Centre *IISU:* ISRO Intertial Systems Unit *MCF: ISTRAC: I*SRO Telemetry, Tracking and command Network *LEOS:* Laboratory for Electro-optic Systems *IIRS:* Indian Institute of Remote Sensing

It is a longstanding tradition in India that the Chairman of ISRO has a career background within the agency and concurrently chairs the Space Commission. The same person also sits as Secretary of the Space Department and Chairman-cum-Managing Director of the Antrix Corporation (Aliberti, 2018). Dr K Sivan currently fills these positions. This point of common leadership, directly reporting to the Prime Minister, permits bureaucratic input while promoting a clear sense of purpose for achieving the aims of the agency. ISRO initially had no intention to undertake any form of space exploration, wanting instead to focus on benefitting the common person (Indian Space Research Organization, 2017). They have since been able to change their vision to include “planetary exploration” (Indian Space Research Organisation, 2017). Consequently, without this degree of autonomy, the otherwise bureaucratic deliberation and inherent delays would adversely affect the efficacy of the agency and they would have been unable to change their vision.

In contrast, the New Zealand Space Agency (NZSA) was created in response to the advent of a specific commercial project, Rocket Lab, who launch small payloads from New Zealand soil. The NZSA was established to regulate Rocket Lab's commercial space launches and also to facilitate other commercial space activities that may eventuate in New Zealand (New Zealand Space Agency, 2017). Given the commercial nature of these activities, it made sense to position the agency within the Ministry of Business, Innovation, and Employment. As an organization with a primary purpose of

regulation, there is little need for the levels of agency autonomy that NASA or ISRO possess. Should New Zealand later decide to expand into space activities as an operator or funder, it will likely require additional departmental involvement, funding, and restructuring. The current arrangement is appropriate for New Zealand's circumstances, but it may not be appropriate in countries that do not match New Zealand's unique situation in relation to size and commercial focus. Overall, a state should seriously consider the extent of their ambitions when forming a space agency because — without serious restructuring — the agency's standing in government will significantly impact their ability to achieve their long-term vision. In light of these examples, emerging space states that wish to expand their aims in the future should give their agency a high degree of autonomy. They may do this by either: having the agency report to the head of government, as in NASA's case; or positioning the agency under an independent department or ministry that administers a specific portfolio, as in ISRO's case.

National inter-agency relationship

When forming an agency, consideration needs to be given to how it is positioned relative to other related agencies. While some states choose to group all their space activities under one organizational umbrella, others have chosen to diversify activities in several distinct organizations, a choice which is now a more common option (Weeden, 2017).

A distinction cited in the *A Roadmap for Emerging Space States* is that states may organize their space sectors in two main ways: centralized, decentralized, or as some combination of the two (ISU, 2017).

A centralized structure is typically associated with a single entity, whereas a decentralized structure refers to a series of separate but potentially interconnected initiatives or departments without a unified organization structure. Most agencies display a centralized structure with a single executive making decisions for the rest of the organization.

Interestingly, Luxembourg engages in space activities with a remarkably decentralized structure. According to Marc Seres, Director of Space Affairs in Luxembourg, its government focus is geared towards "encouraging innovation and technological advancement and contributing to the diversification and sustainability of the economy" (Luxinnovation, 2014). As such, Luxembourg does not have a single national space agency but implements its space policy through many interconnected initiatives which foster a flourishing commercial sector. These initiatives are indicated in Figure 7.

Although a centralized structure in which most, or all, space activities are embedded inside one organization – a space agency – has the apparent benefit of effective communication, a decentralized structure may work as well. Despite Luxembourg's decentralized style, its government is confident that different organizations can "operate in total synergy and complementarity" (Luxembourg Space Cluster, 2017). Such a structure can be successful given effective planning and management.

Either style is likely to be successful so long as there is an organization authorized with the ability to manage national space activities. This ensures that "incoherence, fragmentation, and duplication of efforts" is avoided (European Space Agency, 2017).

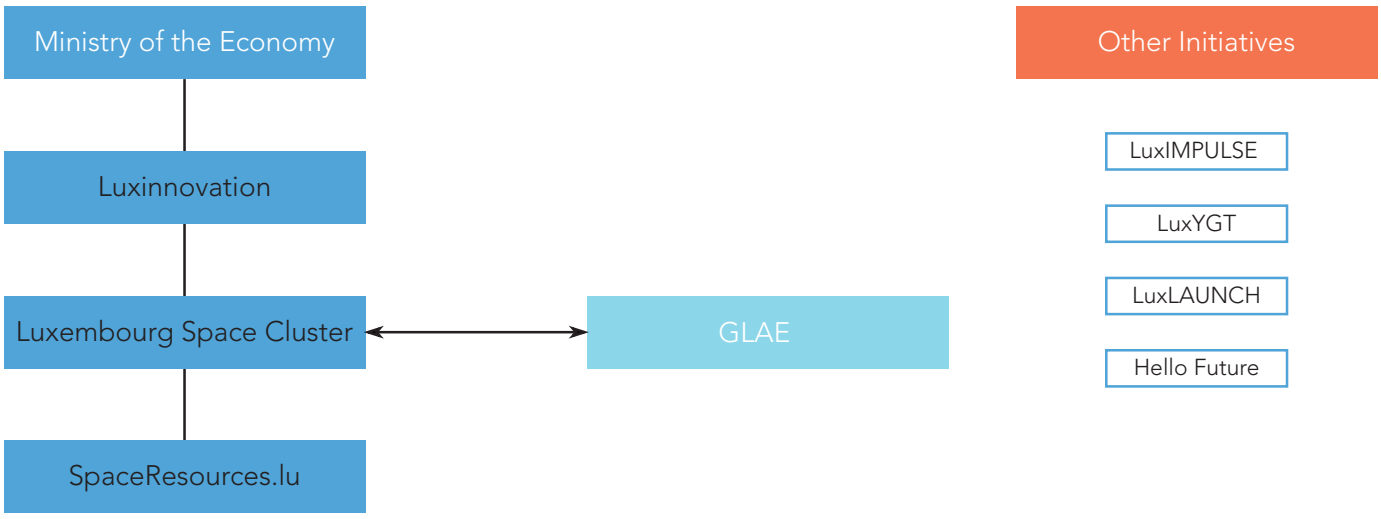


Figure 7: Luxembourg Space Program Luxinnovation, the national agency for promoting innovation and research (Government of Grand Duchy of Luxembourg, 2017); Space Cluster, a network providing support to the aerospace sector by fostering national and international partnerships; and GLAE, the government partner for addressing all questions in relation to initiatives taken by the authorities and national space policy (Luxembourg Space Cluster, 2017).

"Decisions that are made by individual government agencies or entities without coordination and input from other stakeholders, including the private sector, are likely to be suboptimal. This is because barriers between commercial, civil, and national security space activities are increasingly becoming blurred."

(Weeden, 2017)

Internal Space Agency Structure

The structure of departments within or subordinate to a national space agency can contribute to communication and coordination between relevant working groups as compared to those located outside of the agency. It is important that an agency maintains the ability to coordinate with its stakeholders when making decisions (Weeden, 2017). Examples of functions within an emerging agency might include commercial engagement, policy development, research, education outreach, and regulatory or licensing services. Coordination and communication between these internal working groups and external departments can in turn influence the effort required for the agency to achieve its aims and activities. Not only must the macro structure of the space agency be considered, but all levels and projects need to be carefully coordinated in order to successfully fulfill aims.

Commercial and Industrial Engagement

A dedicated internal department is an effective way an agency might choose to engage with the commercial sector. For example, NASA Spinoff is a "Technology Transfer Program" (NASA, n.d.) which liaises with industry to encourage the commercialization of NASA technology. ISRO's Antrix performs a similar function by promoting and marketing its products and services (Antrix, n.d.). The Canadian Space Agency has the Space Technology Development Program which allocates research and development funding to academia, industry or internally for breakthrough ideas (Canadian Space Agency, 2017).

Coordinator of External Entities versus Internal Operation

If an agency has a charter to participate in certain activities, such as science, research, or launch, it will likely adopt the role of either a coordinator or an operator or a mixture of both. A coordinating agency regulates or organizes these activities and will often need to contract specific projects to private external organizations. Conversely, an operator agency will conduct most of the activities themselves.

While Spain's INTA behaves like an operator, containing active units for performing research (INTA, n.d.), Luxembourg exemplifies a coordinator, as it has established the Luxembourg Space Cluster to drive space research through commercial entities and public universities (Luxembourg Space Cluster,

2017). Interestingly, NASA has gone from a typical operator to starting to coordinate, as it began contracting out launch services to commercial entities when the Space Shuttle Program ended (Pearlman, 2011).

Location of Research Centers

For agencies considering setting up research centers, the geographical positioning of these centers may be essential to garner stakeholder involvement. As suggested by the quote from Weeden earlier, input from stakeholders ensures the pursuits of a venture will be more optimal. This could be achieved by spreading research centers around the country, so there is a diverse level of investment. For example, NASA has ten field centers in a range of states focusing on topics ranging from flight and robotics research to global climate change and space science technology (Wilson, 2017). Additionally, New Zealand's recently created research institute, the Centre for Space Science Technology, plans to have offices in four varied, relatively remote regions (Mckenzie-Mclean, 2016). If a new agency is considering research, distinct research centers in varied locations may help amass stakeholder support.

Costs of a Space Agency

Cost and efficiency is a primary determinant of the reasonableness of the aims and ambitions of an emerging space state. Expense, or the perception of expense, is a significant political consideration for states facing conflicting demands on a limited national budget. The careful selection and management of projects can ensure efficient use of potentially limited resources. The structure of the agency will also have a significant influence on its ability to attract an appropriate level of funding from government or commercial sources and on its ability to make efficient use of the funding it receives.

Standing and Governance

It may be appropriate to position an agency with limited aims within an existing ministerial framework rather than being established as an executive agency with autonomy. This implies a reduced need for discretionary spending and would typically require less staffing than an autonomous agency. By acknowledging modest aims and expectations, a government can keep greater control over the agency's operating budget. Conversely, an executive space agency with a degree of budget autonomy is in a better position to perform a broader range of meaningful research and space activities.

National Interagency Relationship

A centralized agency may have higher overhead costs due to staffing and internal bureaucracy but has the immediate benefit of increased internal communication and coordination of activities. A de-centralized agency allows for the development of discrete functional units that are directly accountable for budget and management at the cost of organizational fragmentation. By addressing the budget and expenditure of working groups on an individual basis, a finer degree of control over resources may be achieved. Due to the individualist nature of decentralized departments, significant effort must be taken to ensure robust lines of communication and that they "operate in total synergy and complementarity" (Luxembourg Space Cluster, 2017). If there is not significant collaboration and knowledge-sharing in a decentralized structure, then there may be a duplication of work. The result of this duplication may be costly to a government trying to achieve a set of aims.

Internal Structure

The number and nature of departments and working groups that are subordinate to the space agency has a direct impact on workforce size, activities, logistical, and administrative overheads. While a comprehensive collection of activities within a government hierarchy can lead to an increase in interdepartmental communication and efficiency, it does come with an increase in overhead costs.

Conclusion

Standing within a federal government, national interagency relationship and internal structure are important considerations when establishing a new space agency. The above analysis demonstrates the strengths and weaknesses of different structural concepts, relative to the economic and political situation of the parent states. Designing a space agency is highly specific to the aims, needs, and expectations of a parent state and there are no one-size-fits-all. The centralized monolithic executive agencies that were established during the space race of the 1960s have been replaced by a variety of models that range from small ministry managed agencies and decentralized groupings of different agencies. The emergence of commercial actors on the space scene has seen a variety of agencies, including small ministry-managed regulators, and decentralized non-agencies.
In determining an appropriate model, an emerging space state should strive for synergy between aims, structure, and funding that will maximize its chances of success.

Funding

Funding arrangements and structures are critical to the success of a space program and the aims of a space agency. The type of agency that a government sets up and the range of activities it wishes to pursue need to be within a manageable scope and be given sufficient funding. While this may seem intuitive, there are many ways in which various states have structured the funding arrangements for their space agencies. This chapter aims at discussing some different funding arrangements and their degrees of success in facilitating national space programs.

Frequency of budget allocation

One aspect of funding is the frequency of budget renewal or review. How often an agency's budget is revised, and how this impacts on the planning of space programs is an important consideration for states. The nature of space programs, being technically complex, expensive and requiring long-term development and delivery means that they require a certain level of funding stability to be a success. The annual revision of a space budget, for example, in states such as Canada and the USA, can in certain circumstances expose funding to the political climate or prevailing public sentiment, thus putting at risk the success of agency projects, or of the agency itself. The funding arrangements for ESA, where the ESA Council sets multi-year budgets, are an example of an attempt to balance the need for both short-term and long-term planning.

Case Study:

ESA

The European Space Agency budget is established through a multi-period system that implements planned financial decisions every two to three years for a long-term funding cycle of 10 years (ESA, 2015). The long-term planning, established by delegates to the ESA Council of Ministers nominated by the Member States, guarantees the necessary stability for the missions that need decades to develop: scientists, technologists, space industry and agencies involved in the mission rely on the long-term plan (Giovanni Bignami, 2005). The system proved effective during the financial crisis of 2008; as the 2007-2016 long-term plan protected funds allocated to space agency projects, and despite larger economic woes, this formula allowed an increase in the agency budget.
The delegates of the Member States meet in the Ministerial Council to approve the proposed plan. The Council defines the policy of the agency and the level of resources for the upcoming years. Thanks to work done at ESA Ministerial Council meetings in 2012, 2014, and 2016, the Council has managed to increase ESA operating budget substantially. (ESA, 2014).

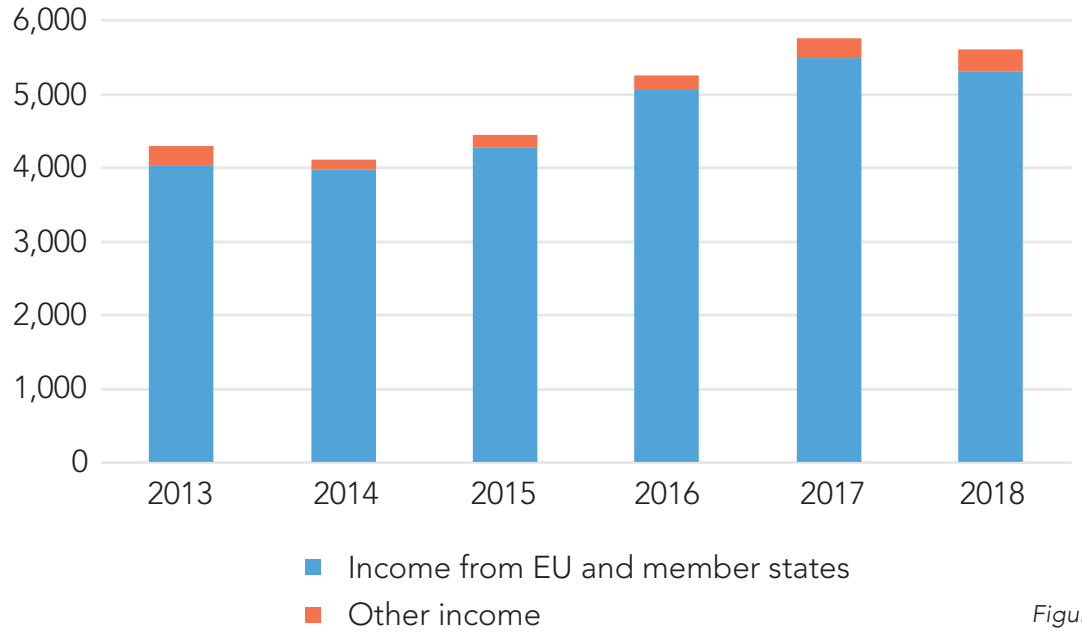


Figure 8: ESA budget (ESA, 2018)

Types of Funding

Within the functions of a space agency, there are different funding options to consider for various programs that the agency pursues. Direct funding of a space program by the government is the most traditional way to develop a space capability, particularly if the state has a clear direction about what capabilities it needs to develop (Bryce Space and Technology, 2017). The prestige and technical know-how that government funding a new capability can bring to a nation could be worth the initial investment if the project is managed well. An example of a well-managed project in this manner is the Canadian government's funding of an industrial consortium in the 1970s to develop the Canadarm, a robotic arm used to move cargo in and out of the cargo bay of NASA's Space Shuttle. The success of this program established Canada's role as a supplier of robotic Mobile Servicing System to the International Space Station (ISS). Canada is now a world leader in space robotics (Bryce Space and Technology, 2017).

Case Study:

Mars Orbiter Mission

As India's Mars Orbiter Mission, Mangalyaan, entered Martian orbit on 24 September 2014, stunning the world and capturing the nation's imagination. In reaching Mars on the very first attempt, India became the first nation to do so (Park, 2014). What was equally impressive was that the mission was achieved at the cost of USD74m, ten times less expensive than a similar contemporary NASA Mars orbiter mission, Maven. India's Prime Minister, Narendra Modi, hailed the mission as one that cost less than the Hollywood movie, *Gravity* (Dean Nelson, 2014).

The low cost of the mission is largely attributed to the lower human resources costs in this populous developing nation (Amos, 2014). The fact that many of the technologies were developed in India was also a contributing factor. With the Mangalyaan mission, India demonstrated its capacity to independently undertake complex interplanetary missions. The mission objectives were limited to a few crucial ones such as finding methane in the Martian atmosphere, related to the possibility of life on Mars (Das, 2014). By adopting modest targets requiring limited funding and executing them efficiently, ISRO project managers achieved India's first interplanetary endeavor within the constraints of a tight project budget. There were some who questioned the benefit of such an ambitious project in a country in need of better sanitation and healthcare. However, such arguments ignore the fact that "investment in science and technology builds capability and capacity, and develops the sort of people who benefit the economy and society more widely" (Amos, 2014). It also helped to boost science interest in a country that can only benefit from a greater number of qualified engineers and scientists (Das, 2014).

The open-ended approach recommended by Bryce Space and Technology in its report to the Australian government is targeted investment in "capabilities with demonstrated or anticipated economic potential" (Bryce Space and Technology, 2017).

A good example of this is the United Kingdom's increasing its annual investment in ESA by 20% commencing in 2013, with the purpose of driving economic growth at home (Bryce Space and Technology, 2017). ESA's geographic returns *juste retour* policy ensures that states get back the ratio of their contribution to the agency in the value of contracts awarded by ESA to domestic industry of that state. As such, ESA is a safe investment for new agencies, which are seeking to grow domestic space activity. For non-ESA states, this would entail entering into a cooperation agreement with ESA, however, as demonstrated by Canada, such cooperation with ESA is not limited to geographical location.

Some states' space agencies, or space programs, are directed solely at assisting private space industry players to grow the domestic economy. Attracting private investment can be done through creating favorable taxation policies and through incubators, or clusters that "draw on non-cash public resources to nurture budding industries" (Bryce Space and Technology, 2017). Luxembourg has done precisely this in the pursuit of expanding their domestic space industry for commercial returns. The government aims to "contribute to the peaceful exploration and sustainable utilization of space resources for the benefit of humankind" (Government of the Grand Duchy of Luxembourg, 2018).

Luxembourg's promotion of space for commercial returns is achieved through government support of corporate enterprises (networking, funding, tax incentives). These are in addition to its membership of ESA and annual contributions of 0.03% GDP.

Case Study:
Luxembourg

Luxembourg has recently implemented several initiatives aimed at capitalizing on and growing the domestic commercial space sector (Government of Grand Duchy of Luxembourg, 2017):

Luxinnovation A national agency for promoting innovation and research. The national point of contact for all collaboration with ESA and the European Commission provides advice to companies considering set-up in Luxembourg.
Luxembourg Space Cluster Managed by Luxinnovation (Luxembourg Space Cluster, 2017). A government sponsored network providing support to the commercial aerospace sector by fostering national and international partnerships through research, development, and innovation (RDI) projects. Synergistic with GLAE.
GLAE (Groupement luxembourgeois de l'aéronautique et de l'espace) A not-for-profit entity established after joining ESA, GLAE operates under FEDIL to facilitate contacts and networking between business and research centers in aerospace. It was formed as a direct result of ESA membership and serves as the government contact for all official initiatives in addition to formulating the Grand Duchy's space policy. It also serves as government partner for addressing all questions about initiatives taken by the authorities and national space policy (Luxembourg Space Cluster, 2017).
LuxLaunch A government sponsored initiative to detect and implement aerospace innovation. It assists companies and researchers to assert themselves and improve visibility within international stakeholders.
National Research Institutes Companies collaborating with national research institutes such as the University of Luxembourg and the Luxembourg Institute of Science and Technology (LIST), for satellite communications and earth observation.
HelloFuture A 2017 project with aims to encourage young people (14-30yo) to take up jobs in the industry within Luxembourg through a range of tools (internet, placements, tours).

Partnerships

There are numerous barriers to states funding and establishing valuable space capability programs, including high capital requirements, technology risk, and longer developments timelines. Public-private partnerships are one tool for overcoming such barriers (Bryce Space and Technology, 2017). They typically require some co-investment between government and industry. NASA has identified three examples from its history where such partnerships worked to develop new space capability and assist economic growth: the history of NASA's assistance in the growth of the American semiconductor industry, NASA's investments that helped establish the U.S. commercial communications satellite industry, and NASA's partnerships for the development of U.S. commercial cargo space transportation systems (NASA, 2014).

Each of these examples of public-private partnerships contributed in some way to economic growth, for example, through "providing substantial early demand as an anchor customer for an important component technology, through the direct development of commercially valuable space technology, and through investing in the development of new private-sector space transportation capabilities" (NASA, 2014). NASA's co-investment and guaranteed market for commercial cargo and crew transportation services helped one of its partners, SpaceX, build a highly competitive satellite launch business, develop capability, enhance its infrastructure, build its workforce, and increase competitiveness in satellite launch (NASA, 2014).
Public-private partnerships, however, come with the risk of exposing national space program to broader market forces such as market fluctuations. They work best when the government understands the market for the capability it wants to develop and is prepared to reduce risk by investing appropriately or becoming an anchor customer. As a warning, the Bryce Space and Technology report provides that public-private partnerships are more likely to fail when "the government places bets on markets it does not fully understand, and over which it has no control, in an effort to defray its own costs" (Bryce Space and Technology, 2017).

Freedom to make financial decisions and flexibility

Investment in space comes with its share of risks and agencies need to be able to take into account unknown and unexpected costs. In this regard, agencies need flexibility within the available funding structure. Discretionary spending, such as is available to NASA, is a potent tool in encouraging exploratory endeavors. This is corroborated by the recent Consolidated Appropriations Act of 2017, which was recently passed by the United States Congress and defies all calls for slashing non-defense discretionary spending (Showstack, 2017).

For emerging space agencies funding needs to be assured and stable for the first few years of its conception. This provides the agency with the due gestation period that any emerging space entity deserves, to begin delivering on its program aims.

Budget size

A review of the space budgets and national budgets of the countries listed in the table below demonstrates a correlation between the size of the economy and contributions to their respective space agencies. The list is topped by the USA whose space budget is approximately more than twice the space budgets of the other listed countries. The following table shows the government spending on space programs (est. 2016).

Table 1: Summary of space agency financial information

Country	**Government Space Budget Millions USD** (Foundation, 2017)	**National budget Billions USD** (CIA, 2017)	**% of budget**	**Population** (ONU, 2017)	**National Space budget per capita USD**	**Government space budget Purchasing Power Parity (PPP) Millions USD**
USA	19,300	3,336	0.58%	322,179,605	59.90	19,300
ESA	6,425	8,316*	0.07%**	511,800,000	12.55	7,830
China	4,300	2,672	0.16%	1,403,500,365	3.06	8,328
India	1,110	248	0.45%	1,324,171,354	0.84	4,299
Canada	488	623	0.08%	36,289,822	13.45	525
UK	414	984	0.04%	65,788,574	6.29	465
Brazil	260	726	0.04%	207,652,865	1.25	402
Luxembourg	223	28	0.80%	575,747	387.32	227
Spain	170	492	0.03%	46,347,576	3.67	230
UAE	150	83	0.18%	9,269,612	16.18	275
South Africa	19	92	0.02%	56,015,473	0.34	42
Malaysia	8	51	0.02%	31,187,265	0.26	24

**Sum of the national budget of Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, and the United Kingdom. (Slovenia and Canada, as Associate Members of ESA are not included.)*

*** The percentage does not reflect the amounts allocated to national budgets of the member states of ESA*

As a percentage of national budgets, space programs make up a relatively small proportion, with only the USA and Luxembourg above 0.5%. On a per capita basis, these two countries rank the highest with Luxembourg spending about USD387 per person and the USA spending about USD60 per person. This falls in line with the leading role the two countries are taking in the modern space economy. India with 0.45% of its national budget going to their space program has effectively and efficiently utilized this budget to come to the forefront of space-faring states. Although with a per capita budget at just USD0.84, there is room for a marked increase especially as India's economy continues to grow.

Elsewhere, as the UAE has taken a leadership position within its region, its space budget now stands at 0.18% of the national budget and per capita spending at USD16.18. With the UAE's stated ambition of transforming into a knowledge-based economy and its stated goal for Mars exploration, the budget is expected to grow further. Canada spends USD 13.45 per person on its space budget and is another country that has a flourishing space program even though its space budget comes in at only 0.08% of the national budget. ESA is an example of strong cooperation amongst states who have banded together and combined their budgets to make meaningful progress and have a definitive impact on the global space economy. The size of a space budget and the kind of funding arrangement best suited for an agency depends on the mandate it has been given. A lean regulatory agency can manage with a small budget, but one with an operational and exploratory role needs a larger budget. It is up to a state to decide what proportion of its national budget it can and should assign to space programs.

Transparency

Transparency regarding the spending of allocated funds is essential to the credentials of the agency. Transparency is vital to engaging with the commercial sector; it enables private entities to stay committed to their contracts and optimize their participation and investment in government space projects (Brennan & Vecchi, 2011). Transparency encourages cooperation with foreign public and private organizations and boosts a state's image as a potential investment destination.

Transparency of financial data is a core policy of NASA. NASA publishes details of program budgets, annual expenditures for programs, how it is being spent over the life cycle of the program, and how funds were spent in the various procurements that support the programs (NASA, 2018). The Indian Space Research Organisation has a similar policy and publishes reports of its annual spending (ISRO, 2018). Open policies help to maintain public support, making it easier to seek enhanced funding for more ambitious projects, which might otherwise be untenable. Transparency also entails accountability as every success or failure can be publicly scrutinized. This leads to responsible spending behavior and helps to keep program goals realistic. There is a paucity of financial data relating to the space agencies that are administered within a state's ministry of defense. The unspoken implication is that military space spending is considered a topic of national security.

Conclusion

A conclusion from this discussion is that a state must be able to decide on the funding structure of its space agency based on the mandate of the agency, and the program it seeks to implement should be funded realistically in accordance with what long-term funds a state can allocate. A space agency budget should be stable enough to allow programs to deliver results, and as budget planning should consider short-term and long-term plans. A state should prioritize the essential space capabilities it wishes to pursue and provide direct funding or indirect funding for these activities. Public-private partnerships should be pursued when a state wants to develop new high-tech capabilities that require significant funding and expertise and where the private sector can perceive a benefit. Such partnerships, when managed properly, can reap significant benefits for the commercial space sector. A flexible funding structure within a space agency that allows some level of autonomy and discretion is beneficial for agencies to be able to pursue relationships with industry and research institutes. Moreover, transparency is essential for new, as well as established, agencies to cooperate with external partners and maintain public support for the programs of the agency.

Activities

There are a broad range of activities that can be undertaken by a space agency. Activities that range from constructing regulation to fostering collaboration and conducting research and development. The success or failures of these activities can often impact the ability to pursue new opportunities. Activities can mean the acquisition of, or the loss of public support. A major development in agency activities over the past decade can be attributed to improved collaboration between agencies and the private sector (David, 2016). Additionally, technology miniaturization, spin-in technologies from the information technology sector, and advanced manufacturing methods have unveiled new possibilities for emerging agencies (Nardini, 2018). This chapter provides an overview of space agency activities, including functions, regulatory measures, and partnerships.

Research

Research and development are the most common activities pursued by both larger, established agencies as well as those smaller and more recent agencies. However, there are significant differences in how agencies facilitate research. Space programs in countries with more resources, capability, and vision have the opportunity to undertake more diverse and more novel research. For example, the development, construction, and operation of the Chinese space station Tiangong-1 allowed the Chinese to explore biological experiments in microgravity, which is important to China's growing biopharmaceutical industry (Xinhua News Agency, 2011).

In contrast, the Chilean space sector has seized opportunities available to it to conduct smaller-scale research missions in space. It has partnered with the University of Chile for research which lead to a student CubeSat being launched into orbit. One of the objectives of this mission was to "study the ionosphere in synchronization with incoherent scatter radar (ISR)" (Space and Planetary Exploration Laboratory, 2017). The engineering development in support of this research enables a domestic capability in the design of satellites. In spite of, some Chilean policymakers having uncertainty in the value of pursuing space activity (Siddiqui, 2017). The success of the SUCHAI satellite has led to Conicyt, the main research agency of Chile, approving the development of two more scientific satellites (Menaa et al. 2016).

Regulatory

States have an international legal obligation to regulate their domestic activities in outer space. States party to the Outer Space Treaty "bear international responsibility for national activities in outer space…whether such activities are carried on by government agencies or by non-governmental entities"
which includes the commercial sector (Outer Space Treaty, art VI). Articles II to IV of the Convention on the International Liability for Damage Caused by Space Objects (Liability Convention) places varying degrees of responsibility on the launching state for damages caused to a third party internationally. An effective way for States to discharge these responsibilities is by establishing a government agency with the mandate to oversee the states's activities in outer space, including those of its private sector. States have an interest in regulating these activities for a variety of reasons including the desire to obtain indemnities from
private launch providers and satellite operators. Agencies differ in their regulatory policies concerning space activity. An important consideration for emerging space agencies is whether to engage in regulatory activities, or leave this task to another government entity, or focus on technology development or to pursue both activities. For most emerging space states, this largely depends on the goals and activities of their space sector. For example, the New Zealand Space Agency was established as a regulatory agency due to the existence of Rocket Lab. The New Zealand Government came to an agreement with Rocket Lab that authorized their current launch activities. After 21 December, 2017 they were required to apply for a license within six months (Ministry of Business, Innovation, and Employment, 2016). For a country like the USA, with an established and globally prominent space agency (NASA), the regulatory body is the Federal Aviation Administration (FAA). The FAA is a national authority that exists to regulate civil aviation in the USA (SKYbrary, 2016). This format may be preferable for large space agencies, but smaller countries may choose to adopt a regulatory approach like that of New Zealand. Emerging space states may adopt a method of regulation somewhere in between these two cases.

An emerging space state with significant space activity in the commercial sector should consider avoiding the same functions and instead adopt more regulatory activities.

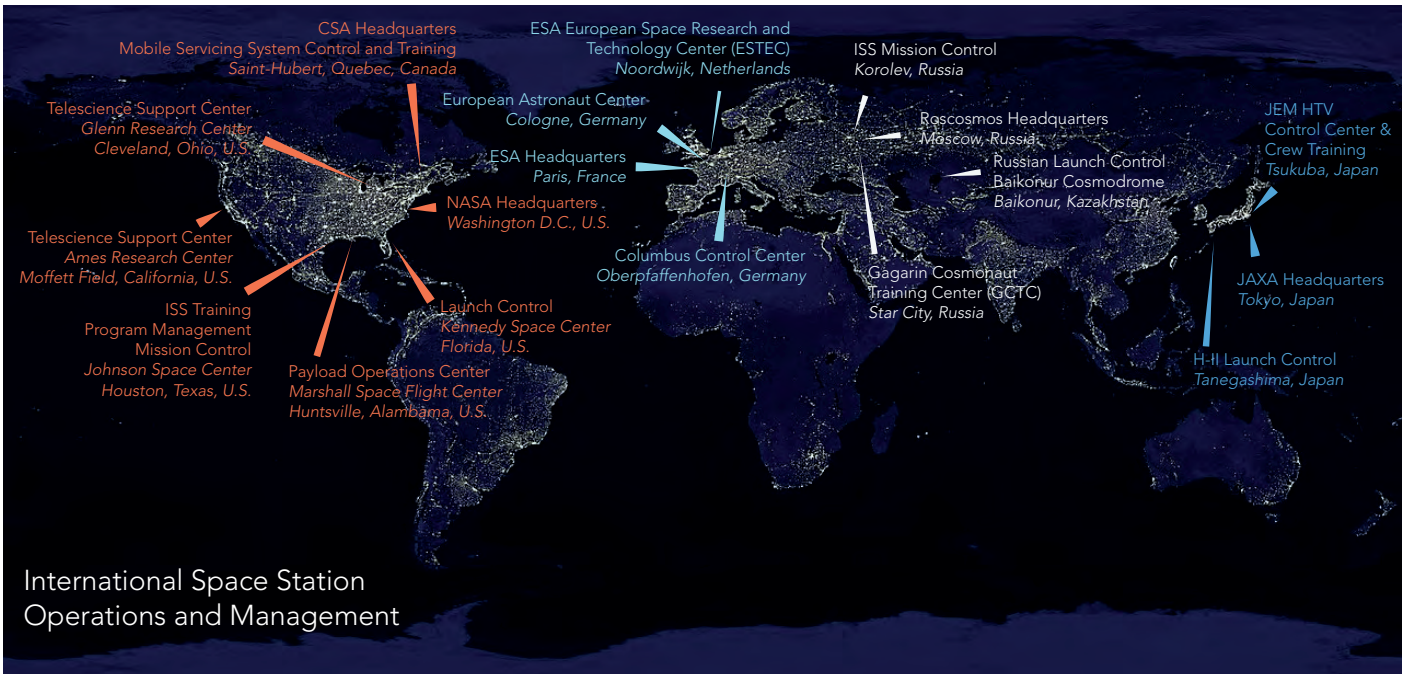


Figure 9: ISS Operations and management

In some cases, agencies may participate in the creation of new legislation designed to meet contemporary challenges to the regulation of the space sector. A stated aim of SANSA is to "support the creation of an environment conducive to industrial development in space technology" (South African National Space Agency Act, 2008). However, the existing Space Affairs Act of 1993 has been identified as not being conducive to commercial space activity, especially involving launches or the operation of spacecraft in space (Makapela, L., 2011). SANSA has identified this as an area for improvement, and the Legal Unit has been working on the construction of a more up to date and comprehensive bill, the South African Outer Space Draft Bill, to regulate space affairs and activities in the country (SANSA, 2017).

Partnerships

International Projects

Agencies at all stages of development place considerable importance on the establishment and preservation of working relationships. Inter-agency cooperation facilitates international collaboration and involvement in large-scale, multi-national projects.

The Deep Space Network (DSN) is the largest scientific telecommunications system in the world. It is managed by the Interplanetary Network Directorate (IND) and operated by NASA's Jet Propulsion Laboratory. The DSN is a prime example of agency success through global engagement of governments, industry and research institutes (Haynes, 1987). Ground stations in Madrid, Canberra and California operate in tandem to achieve constant satellite uplink and downlink. Further analysis provides an understanding of how this project supports agency activities. NASA's New Horizons mission relied heavily on the collaborative use of the DSN (Haynes, 1987). The mission's Principal Investigator, Dr. Alan Stern, confirmed data transfer held top priority across all DSN facilities during the spacecraft's Pluto flyby (Stern, 2017). Without international partnerships, these demands could not have been met. One of the most successful international collaborative projects is the International Space Station (ISS) program. It is considered the "most politically complex space exploration program ever undertaken" (NASA, 1999), involving five principal agencies, namely NASA, Roscosmos, ESA, JAXA, and CSA. Its success may be attributed to several reasons, such as consistent effort has been made by the principal contributors to maintain relationships, but importantly each paticipant's agency has made diligent and substantial individual contributions.

To achieve better international cohesion an agency can assemble an international advisory committee that maintains open dialog and collaboration between partners. Luxembourg has established this as a core business activity through the Luxinnovation initiative and the Luxembourg Space Cluster. Both act as points of international contact for space matters and encourage international collaboration (Luxembourg Space Cluster, 2017).

In summary, emerging space states should consider international partnerships. Doing so will allow agencies to contribute and support new and ongoing projects, based on their specific mandate or capabilities.

Commercial Engagement

A challenge for existing space agencies is integrating themselves with the emerging space commercial sector. It has become increasingly necessary for agencies to work collaboratively with

Figure 10: The Canadarm 2 in operation on the ISS

Case Study:

The Canadian Space Agency's Canadarm Project

The Canadian Space Agency (CSA) has a strong presence in the global space sector. CSA undertakes numerous national space activities as well as making significant contributions to international space projects. In addition to dedicating a large percentage of the budget to space science and human spaceflight, the agency exhibits a niche strategy with a specific focus in the industries of radar technology for Earth Observation and space robotics (Space Foundation, 2017). Canada signed its first *Cooperation Agreement* with ESA in 1979, 11 years before it formally created an agency and has an ongoing partnership with ESA (Canadian Space Agency, 2017). Their advanced capabilities have allowed them to create a unique relationship with ESA, collaborate on numerous projects with NASA and become a valuable contributor to the ISS (Space Foundation, 2017). Canada's active participation in robotics allowed them to contribute the *Canadarm*, a robotic arm used for moving supplies, equipment, and astronauts, to the ISS Program (Canadian Space Agency, 2017). The success of Canadarm cannot be understated and the significance it holds amongst the Canadian space community is immense. Canada's *Cooperation Agreement* with ESA allows Canadian companies to submit bids on ESA Projects and form working relationships with European companies, despite being geographically distant (Canadian Space Agency, 2017). Their partnership has increased the number of domestic business opportunities, and there have been large benefits to the Canadian economy (Canadian Space Agency, 2017). Overall, the partnership that Canada established with ESA paved the way for the first Canadian astronaut to walk in space, and helped to engage and inspire the country's space community. CSA provides a strong example of an agency optimizing its capabilities through partnerships.

commercial actors to develop and grow the space industry. So, emerging space states could take advantage of their nation's existing infrastructure and resources to facilitate commercial relationships. States like Australia, which have a thriving space start-up company landscape, could base its primary activities from its existing infrastructure, technology and research. For example, the new Australian Space Agency could re-establish the Woomera launch site in South Australia and lease out to commercial launching entities.

Emerging space states should exploit any niche interests and capabilities they possess. Even smaller states that have limited resources, whether technical or economic, can identify viable alternatives. For example, Luxembourg's space industry relies solely on interconnected commercial initiatives. To encourage these, the government provides financial incentives to new and existing, domestic and international companies operating in Luxembourg (Luxembourg Space Cluster, 2017).

An activity national space agencies have traditionally undertaken but are now passing over to the commercial sector is the provision of launch services. There are only a small number of national space agencies that developed launch capabilities. Of the agencies with prior launch service capability, some have turned to the services of commercial launch providers. Several companies, such as Arianespace, have capitalized on this change, and been able to provide launch services to agencies, such as NASA, ESA, and ISRO (Spaceflight101, 2017). NASA's program for Mars exploration is in conjunction with various private enterprises such as SpaceX (NASA, 2016) and other private entities. This helps to grow and create healthy competition in the private sector.

Military

Certain space agencies provide support to the needs of the state's military through research and development; handing over the end-user operation. In the UK, the Ministerial Committee on Space Security and Prosperity involves the military in its formulation of government ambitions for space (Network, 2017). Likewise, in Brazil, its military identified space technology as central to the nation's future independence and security. This has since driven the development of rocket launch technology, a program that has been discontinued due to a series of failures in the early 2000's (Pagliuco, 2014).

Activities concerning military applications also provide significant and often valuable contract opportunities. The development of Chile's FASat was contracted via the Chilean Space Agency (ACE) to the European Aeronautic Defence and Space Company's Astrium+. Although the military observation satellite is operated by the Chilean Air Force, it provides useful data to domestic agriculture, mining and public service industries (Reyes, 2014). Emerging space states should consider the extent of military involvement in their national space programs and endeavor to maintain transparency regarding civil space activities. Countries, such as the USA, have created clear distinctions between the civilian space sector and the military despite the evident resource and data sharing that occurs. For other states, the military's influence on the civil program may be more pronounced, and transparency of the civil sector's resources like remote sensing data and space technology research may not be made available to the public. This is an important aspect to consider for emerging space states as the military could have a high level of influence over the civil space program, which could, in turn, have an impact on public support for the work of a civilian space agency.

Public Outreach

Outreach and public engagement is an key activity to be undertaken by space agencies. NASA has an internal Office of Education whose mission is to "communicate education resources and information about NASA's missions and technological and scientific advances to numerous stakeholders" (NASA, 2012). NASA has budget specifically designated for outreach and education, and the combined effect is that NASA has become a very positive national brand in the USA and globally.

Conclusion

It is necessary for an emerging space state to identify which space activities would be beneficial to both the state as well as the international community more broadly. The activities an agency initially undertakes are critical for its successful development due to several important factors. The activities an agency chooses to focus on will impact the support garnered from the private and commercial industry, as well as public support. This has a substantial impact on an agency's capacity to bring about economic growth for the space industry. It is also apparent that the activities an emerging agency chooses to pursue should take advantage of already existing factors such as geographical location, existing infrastructure, and established industries.

Projects with international partners are an essential activity to consider for any space agency. Emerging agencies can partner with more experienced actors to achieve early successes.

A space agency's relationship with the military is another important consideration. Both the agency and military can mutually benefit from shared resources and data, however public expectations about the transparency and work of a civilian space agency need to be managed.

Recommendations

The space agencies of 13 different nations and a regional space agency were studied to understand their broad aims, structure, nature of funding and specific activities. An assessment of the findings was carried out to conclude how these parameters were responsible for either the success or failure of a particular agency. The social, economic and political landscapes of particular nations being studied were also considered as important factors affecting the outcomes of the assessment. An across agency comparison was then conducted vis-a-vis the aims, structure, funding and activities to determine the most suitable models for an emerging space state. Case studies were conducted wherever appropriate, in order to enunciate a finding or for exemplifying a particular model.

It is concluded that the models that best fit the aims, structure, funding and objectives of an emerging space state are a function of factors that are unique to its circumstances. However, there are general lessons to be learnt from existing models and in light of which the following recommendations are made.

Aims

An emerging space state should construct its agency aims to be:

- transparent,
- specifically defined with a clear intent,
- measurable in nature and publicly reported,
- consistent with national interests, and
- consistent with the United Nations Sustainable Development Goals

An emerging space state should consider how the agency aims may be shaped by:

- social, religious and political climate of the nation;
- state of the national economy and the perception on space spending;
- regional influences such as geography and the geopolitical environment;
- existing regional space entities and alliances;
- existing space-related organizations such as government departments, commercial industrial entities, and public institutions; and
- existing commercial, industrial entities and national technical capability.

Structure

An emerging space state may consider structuring its new agency:

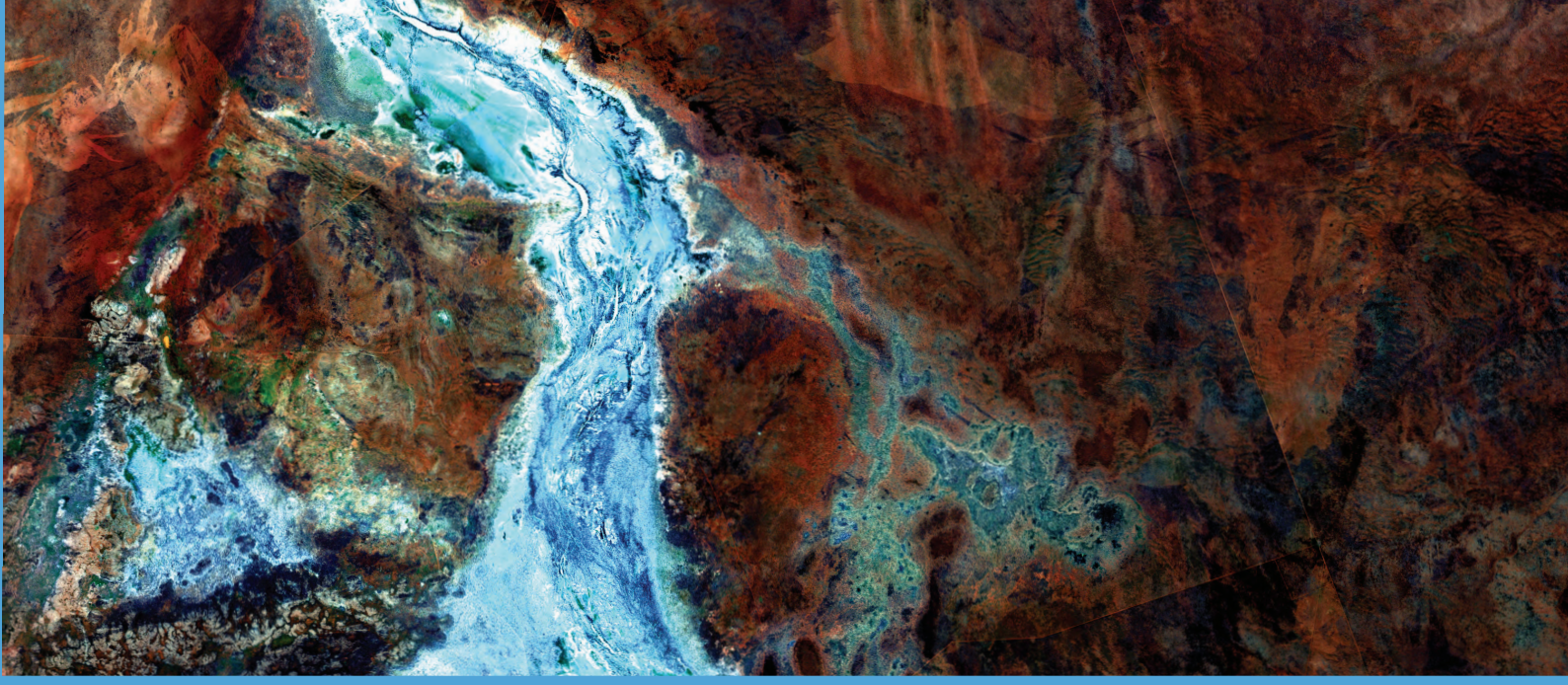
- as an independent ministry to administer a specific portfolio and the flexibility to expand its aims; and
- as a unit within an existing department to perform strictly regulatory and bureaucratic function.

An emerging space state may consider having simplified bureaucratic oversight of its new agency as this will:

- simplify future expansion or revision of scope of aims and activities;
- expedite authority approval to achieve its objectives in a meaningful timeframe; and
- reduce agency vulnerability to a loss of political-will towards the space industry.

An emerging space state may confer a degree of autonomy and discretionary behavior to a new agency such that it may:

- pursue meaningful activities that might not fit a single budgetary cycle or would be delayed while waiting for government funding approval; and
- adapt to future changes in aims or activities and remain relevant as a space operator.



Funding

An emerging space state should consider the funding model of a new agency such that the:

- frequency of budget revision is commensurate with the short-term and long-term plans;
- state provides direct funding for the essential space capabilities that it wishes to develop;
- public-private partnerships are considered for the development of both new high-tech capabilities and the growth of the private sector;
- portion of the domestic budget is committed to the essential programs they expect to deliver;
- autonomy and discretionary spending will promote beneficial partnerships and collaboration; and
- financial transparency will build credentials and encourage industry partnership.

Activities

An emerging space state should undertake space activities:

- under a regulatory, space-faring or hybrid model;
- consistent with the activities of other nations with similar economic, geographic or political landscapes;
- intended to establish and maintain direct commercial, governmental and inter-agency partnerships;
- engaging in commercial partnerships to maximize their technical and economic capacity;
- engaging in global partnerships to understand the intricacies of inter-agency coordination and support agency development;
- supporting new and ongoing projects, based on their specific interests or capabilities; and
- maximizing national support through the promotion of its activities via public outreach and education as a core activity.

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Available at: <http://www.spacedaily.com/reports/What_does_the_Tiangong_1_space_station_mean_for_China_999.html> [Accessed 11 February 2018].

Thank you

The Space Ready team gratefully acknowledge the generous guidance, support, and direction provided by the following individuals throughout the course:

International Space University TP Chair: **Michael Davis**
TP Associate Chair: **Andrew Butler**
TP Teaching Associates: **Scott Schneider, Lydia Drabsch**

The team also gratefully acknowledge the generous guidance, support, and direction provided by the following faculty, teaching associates, staff, advisors, and visiting experts.

Assoc Prof David Bruce, *UniSA*
Dr Graziella Caprarelli, *UniSA*
Mr John Connolly, *ISU/NASA*
Prof Bill Cowley, *UniSA*
Mr Michael Davis, *Space Industry Association of Australia*
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Ms Ruth McAvinia, *ESA*
Ms Alexandra Ryan, *Australian Centre for Field Robotics*
Mr Scott Schneider, *ISU*
Dr Noel Siemon, *ISU*
Mr Wayne Agutter, *SAAB*
Dr Jacques Arnould, *CNES*
Dr Bidushi Bhattacharya, *BSE Space*
Mr Duncan Blake, *International Aerospace Law & Policy Group*
Dr Gordon Cable, *Australasian Society of Aerospace Medicine*
Prof Iver Cairns, *University of Sydney*
Mr Lih Wei, Chia, *BSE Space*
Mr Matthew Cook, *Amateur Radio Experimenters Group*
Prof Andrew Dempster, *University of New South Wales*
Ms Kerrie Dougherty, *ISU*
Mr George Dyke, *Symbios Communications*
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Mr Colin Hall, *ISU*
Mr Chris Johnson, *Secure World Foundation*
Ms Eriita Jones, *UniSA*
Dr Marc Jurblum, *Monash University*
Mr Mike Kenneally, *Speedcast*
Mr Andy Kieatiwong, *Additive Rocket Corporation*
Ms Stacey Lee, *Sky News*
Dr Charley Lineweaver, *Australian National University*
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Mr Paddy Neumann, *Neumann Space*
Mr Brett Newell, *Boeing*
Mr Terry Plane
Mr Scott Pollock, *Southern Cross Pyrotechnics*
Mr Richard Price, *South Australia Space Industry Centre*
Councillor Graham Reynolds, *Salisbury Council*
Dr Laura Rollison, *UniSA*
Mr Nicola Sasanelli, *Defence SA*
Mr Allan Scott
Ms Alexandra Seneta, *Australian Department of Industry, Innovation and Science*
Dr Michael Simpson, *Secure World Foundation*
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Dr Naomi Tsafnat, *Univeristy of New South Wales*
Mr James Waldie, *BAE Systems*
Ms Danielle Wood, *MIT Space Enabled Research Group*
Dr Soyeon Yi, *Korea Aerospace Research Institute*
Dr Christyl Johnson, *NASA*

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The International Space University and the University of South Australia acknowledge the generous support of the following organizations:

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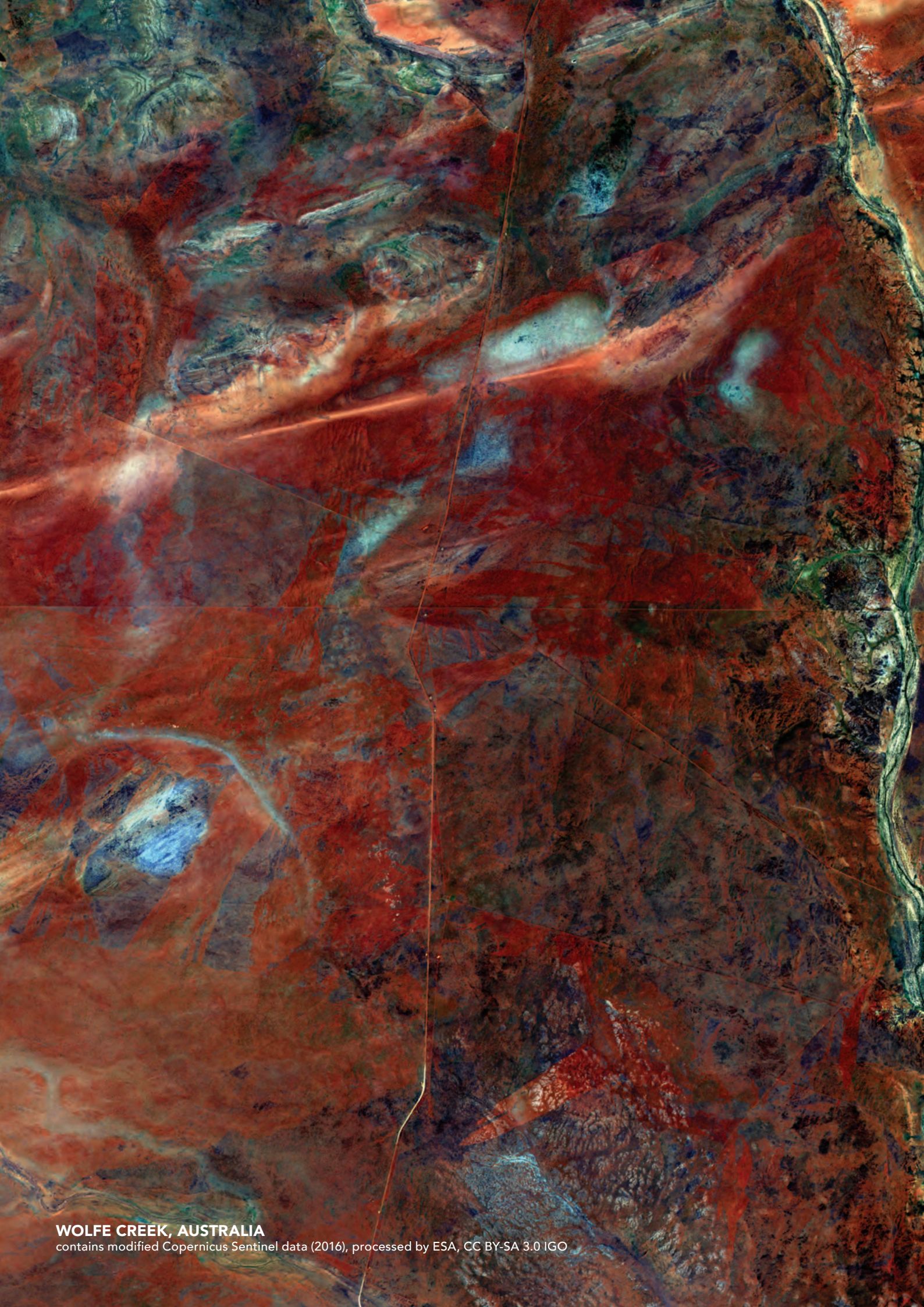

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