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Venturing into Space: A Qualitative Method for Analysing National Space Strategies

Abstract

The Swedish society relies significantly on space based systems, from civilian telecommunication and financial systems, to military navigation and surveillance. This dependency makes these systems potential targets in today's severe security climate, highlighting a need to understand other national actors' activities and ambitions in space. This project was conducted in collaboration with the Swedish Defence Research Agency (FOI), and aimed to develop a method for systematically studying national space strategies to contribute to Sweden's resilience in the space domain. Focusing on emerging space powers comparable to Sweden in terms of Klein's (2025) space power categorisation, the first research question asked "*How can national space strategies of emerging space powers be systematically analysed?"*. A qualitative method was developed by using the framework provided by Enserink *et al* (2022) and previous studies in the field of space. The method was delimited to assess five aspects of space strategy: Participation in space regulation, industry and research capabilities, international R&D collaboration and threat images. The method was then applied on Germany's and South Africa's space strategies by utilising the large language model *Parsd*, addressing the second research question: "*When applying the developed method, what similarities and differences in the ambitions and priorities can be identified between emerging space powers?"*. The application revealed contrasts in ambition and its feasibility, particularly in the view on military and defence relevance to space, the feasibility of generating economic growth from space technology and engagement in international regulatory forums. The two research questions could thereby be answered, where assessment of the method suggested future research to further test its generalisability, and to include temporal variables to further study changes in strategic direction in space over time.

Keywords: Space strategy, space capability, regulation, R&D, global collaboration

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Utforskning av rymden: En kvalitativ metod för att analysera nationella rymdstrategier

Sammanfattning

Det svenska samhället är starkt beroende av rymdbaserade system, från civil telekommunikation och finansiella system, till militär navigation och övervakning. Detta beroende gör dessa system till en potentiell måltavla i dagens allvarliga säkerhetspolitiska läge, vilket understryker behovet att förstå andra nationella aktörers aktiviteter och ambitioner i rymden. Detta projekt utfördes i samarbete med Totalförsvarets forskningsinstitut (FOI), i syfte att utveckla en metod för att systematiskt analysera rymdstrategier för att bidra till Sveriges resiliens i rymddomänen. Genom att fokusera på framväxande rymdmakter jämförbara med Sverige utifrån Kleins (2025) kategorisering av rymdmakt, var den första frågeställningen: *"Hur kan framväxande rymdmakter systematiskt analyseras?"*. En kvalitativ metod utvecklades baserat på ramverket av Enserink *et al* (2022) och tidigare studier inom rymdområdet. Metoden avgränsades till att utvärdera fem aspekter av rymdstrategi: nationellt engagemang i rymdreglering, industri- och forskningsförmågor, internationella samarbeten inom R&D och hotbild. Metoden appliceras därefter på Tysklands och Sydafrikas rymdstrategier genom att använda språkmodellen *Parsd,* vilket adresserade den andra frågeställningen: *"När metoden appliceras, vilka likheter och skillnader i ambitioner och prioriteringar kan identifieras mellan framväxande rymdmakter?"*. Appliceringen påvisade kontraster i ambitioner och genomförbarhet av dessa, särskilt gällande synen på militär- och försvarrelevans till rymden, genomförbarheten av att generera ekonomisk tillväxt från rymdteknologi samt engagemang i internationella forum för reglering av rymden. De två frågeställningarna besvarades därmed, där en utvärdering av metoden resulterade i förslag till framtida forskning för att ytterligare testa dess generaliserbarhet, samt inkludera temporala variabler för att kunna studera strategiska förändringar över tid.

Nyckelord: Rymdstrategi, rymdförmågor, reglering, R&D, globala samarbeten

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Abbreviations / Acronyms

BRICS	Brazil, Russia, India, China, South Africa (also including Egypt, Ethiopia, Indonesia, Iran and the United Emirates)
ESA	European Space Agency
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FOI	The Swedish Defence Research Agency
NATO	North Atlantic Treaty Organisation
R&D	Research and development
SADC	The Southern African Development Community
SANSA	South Africa National Space Agency
SASIRB	South African Space Industry Regulatory Bill
UNCOPUOS	The United Nations Committee on the Peaceful Uses of Outer Space

1. Introduction

Space has long been considered a potential domain for war and conflict, a thought reflected in the first international regulatory measure for military activity in space, *The Outer Space Treaty* of 1967 (Tronchetti and Liu, 2021, pp.1-2). Despite the 1960s initial steps towards limiting the military utilisation of space, the domain is today increasingly used to support or conduct military operations, resulting in space becoming of strategic value for a nation's warfighting capabilities (Papadogiannakis *et al.*, 2023, p.9; Klein, 2025, p.31). New actors, both national and commercial, are advancing their capabilities in the domain where historically only large powers, such as the United States and Russia, had abilities to engage in. This is presenting challenges of congestion and competition in the domain, as well as increasing the threat against critical space based systems (Hoerber and Oikonomou, 2023, p.9, 97; Papadogiannakis *et al.*, 2023, p.9). There is therefore a need to enhance Sweden's resilience in the space domain (Westman *et al.*, 2023, p.94; Regeringskansliet, 2024b, p.21), a purpose which will be the overarching objective in this study. To achieve this, a method is developed and applied on two nations' space strategies. In doing so, a systematic way of analysing, comparing and assessing national space strategies will be defined.

1.1 Background

Several nations possess weapons that can be used against their current or future opponents' space based systems. The Russian cyberattack against the VIASAT space system during the initial phase of the Russian-Ukrainian war in 2022 presents one example of how the space domain is already used in terrestrial warfare. The effects of this attack did not only disable military communication in the conflict area, but also civilian infrastructure across Europe (Westman *et al.*, 2023, p.22; Racionero-Garcia and Shaikh, 2024, p.2). Another example is the anti-satellite weapons possessed by a handful nations such as the US, Russia and China. The display of these weapons during testing, have presented these nations ability to take out opponents' space systems through kinetic force (Westman *et al.*, 2023, p.22; Klein, 2025, p.95).

Today, Sweden exists in a global environment with heightened tensions. The nation faces threats of potential escalation of the Russian-Ukrainian war, an increased amount of state-funded cyberattacks against critical systems, and a heightened risk for sabotage and

intelligence operations (Regeringskansliet, 2024a, pp.28-29; Säkerhetspolisen, 2024, p.6). The target is critical infrastructure of both military and civilian significance, where space based systems are of significant value for both domains (Regeringskansliet, 2024a, p.47). Although Sweden can be considered an emerging space power due to their limited capabilities to act in space compared to a great space power like the US or Russia (Klein, 2019, p.96), Sweden uses and operates a variety of space services. The civilian sector has a dependency in its everyday life on space based systems such as telecommunications, financial transaction systems and weather monitoring (Van Camp and Peeters, 2022, p.4; Reichel and Ingemarsdotter, 2023, p.22). Moreover, the military sector additionally has a dependency on surveillance, positioning, navigation, early warning and communication, all provided by the utilisation of space (Croshier, 2023, p.11; Regeringskansliet, 2024a, p.46). There is consequently a need to protect both civilian and military space based systems from intentional and unintentional harm (Regeringskansliet, 2024b, p.24). In the work of strengthening resilience in space, Hallgren and Westman (2021, p.6) notes that a prerequisite is to observe and continuously analyse actors' activities and behaviours in space.

National space strategies, similar to military strategies, provide a framework for the objectives a nation has determined to pursue within the domain, affecting the resources and priorities allocated to achieve these (Sadeh, 2013, p.43; Klein, 2019, p.27). Space strategies serve the purpose of providing a direction of action, to ensure the nation's ability to access the domain – a view comparable to air superiority or sea superiority in military strategies (Klein, 2019, p.21). A national actor's activities within the domain is thereby not only governed by its technical capabilities, but also by political and strategic motives, many of which are expressed through their space strategies (Klein, 2019, p.49; Westman *et al.*, 2023, p.15).

1.2 Research aims

The dependency Sweden has on space based systems, both for military and civilian purposes, makes these systems a target for actors with malicious intent. Moreover, in the context of the current severe security environment in Sweden, the likelihood of space based systems to be targeted has increased (Westman *et al.*, 2023, p.43, 95; Regeringskansliet, 2024b, p.14). To strengthen the Swedish resilience against such threats, analysing other nations' strategic aims could provide insight into their capabilities, and further their ambitions in the space domain.

The Swedish Defence Research Agency (FOI) has been commissioned by the Swedish government and the Swedish Armed Forces to develop knowledge on how such threats can be mitigated and this project is conducted in collaboration with FOI. The overarching purpose of this study is therefore to contribute to Sweden's resilience for threats against space-based systems. As national space strategies can express political and strategic motives, the study of such strategies can serve as one approach to monitor other nations. However, there is limited research in the field of methodology in the scope of space strategies. This project therefore aims to develop a method used for systematically analysing national space strategies. In doing so, the result of this study could be used as a basis to bridge this current research gap.

The intended recipient for this study is primarily the researcher who wants to gather an overarching understanding of how crucial components of national space strategies can be studied and how one can map a space actor's activities in the domain to assess the direction of their future behaviours.

1.3 Research questions

The first research question of this study is delimited to:

> *How can national space strategies of emerging space powers be systematically analysed?*

In addition to this, the method will be applied to space strategies to both test its functionality and to compare two different nation's ambitions and priorities in space. Therefore, a second research question is formulated:

> *When applying the developed method, what similarities and differences in the ambitions and priorities can be identified between emerging space powers?*

1.4 Limitations and assumptions

This study examines sovereign nations, thereby excluding intergovernmental organisations and commercial actors. Furthermore, this project will be limited to developing and studying emerging space powers, as defined in Section 2.1.2 *Space powers.*

Due to many nations not implementing one fully encompassing strategic document solely for the space domain, this project will follow the definition of space strategies proposed by Sagath's *et al* (2019, p.44). Space strategies are therefore defined as government published, strategic documents, communicating space activity. These documents include broader policies of science, technology and innovation in relation to the space domain.

Additionally, all data used in this study is publicly available, where the documents for the analysis are sourced directly from national agencies and their websites. As such, one should assume that the strategic documents will be limited in depth as nations may have incentives to exaggerate, raise certain issues publicly or hide elements of their policies. The results of the analysis should therefore be viewed as 1) an output from testing the developed method, and 2) as a communicated narrative of a nation.

Finally, the term *space* will be used extensively throughout the text and will be referred to as the area above the Kármán line at 100 kilometres above the sea level on earth which separates the earth atmosphere from outer space (Dubey, 2024). In this study, the outer boundary in this definition is the moon's orbit.

1.5 Disposition

In this first chapter*, Chapter 1,* the outline of the project is defined. This includes necessary background to contextualise the aim of this study, the determined research questions, and delimitations and assumptions made, which guides the work conducted in the subsequent chapters.

Chapter 2 will describe related work relevant for the study of space strategies. This includes definitions of concepts used in the study, description of variables which are included in space activities and an outline of the current regulations for the space domain. This is followed by *Chapter 3,* where two theoretical frameworks are presented which provide guidelines and inspiration for developing methodology as conducted over the course of the study.

The following *Chapter 4* presents the design of the project, structuring the study design in two parts. Section 4.1 is structured around describing the process of developing a method and how the theoretical frameworks are used as guidelines. Section 4.2 thereafter describes how

the developed method will be applied on space strategies, including the data collection process, tools used and ethical considerations. In the following *Chapter 5,* the method is developed following the structure described in the prior chapter. Thereafter, *Chapter 6* presents the output of applying the method, where a comparison between two different national space strategies is presented.

Chapter 7 thereafter discusses the result from Chapter 5, from aspects of the generalisability of the method, its validity and suggestions for future studies. The chapter further discusses the results from Chapter 6, where the identified ambitions from respective nations are assessed based on their feasibility of being realised, including perspectives from the related work and concepts presented previously in Chapter 2. The thesis is thereafter concluded in *Chapter 8,* where the research questions are answered, and the project and its main findings are summarised.

2. Related work

In the following chapter, relevant concepts to space strategies and the space domain is presented. This includes previous work in the field of capability development, collaboration in research and development, as well as current space regulations. These theories and definitions will be used in later chapters when developing the method, as they provide guidance to what variables are relevant when studying actors' behaviours within the space domain.

2.1 Capability development

Capabilities is a concept encapsulating the ability or power to do something in a specific environment (Correia, 2019, p.24). Within the space domain, *space capabilities* refers to an actor's ability to access and utilise space. This includes the ability to place satellites in useful orbits and access to resources such as the electromagnetic spectrum required for space based communication and navigation on earth (Croshier, 2023, p.12). As such, space capabilities can be understood as infrastructure where developments on a national level are driven by political, bureaucratic and industrial structures (De Spiegeleire, 2011, p.21; Klein, 2019, p.48; Croshier, 2023, p.17).

2.1.1 Domestic capability development

The endeavour to develop capabilities domestically is uniquely motivated by each nation. The motivating factors can range from supply chain security, isolation from embargoes or economic growth, to a desire to improve national prestige (Paikowsky, 2017, p.77, 16; DeVore, 2019; Croshier, 2023, p.23). The development of space capabilities is however an expensive commitment and encompasses a wide range of structures: development of ground infrastructure, manufacturing capabilities for satellites and launch vehicles, and other supporting services (BryceTech, 2017, p.7). A nation must thereby prioritise the space capabilities to invest in. While space launch can be considered a strategic necessity for some nations, it is often unviable for smaller nations to develop and operate, due to its significant expense and complexity. Instead, emerging space nations more often, successfully, develop satellite manufacturing capabilities, as this effort can produce economic revenue (BryceTech, 2017, p.8).

In addition to this, many nations see the relation between industry and research in the early stages of capability developments as beneficial, as investments in research and academia can provide space capabilities further down the line (BryceTech, 2017, p.8). The space industry has hence become a business venture as it can be a means for a developing country to become a post-industrial society with domestic industry (Paikowsky, 2017, p.78). However, this presents a conundrum for less wealthy nations where a competition arises between space capabilities and national priorities. Nations with issues of poverty, hunger or security must address these more immediate needs, drawing resources from less urgent needs such as space programs. As a result, the economic benefits of utilising space may not be reaped by nations who are in severe need of such economic developments (Croshier, 2023, p.17).

While domestic capability development is an expensive pursuit, the exponential rise in commercial space actors providing dual-use systems – systems which can be utilised for both civilian and military purposes – has driven down costs for the acquisition of space capabilities (Paikowsky, 2017, p.178). Therefore, there has been a significant increase in nations accessing and utilising space, in contrast to the cold war era where only great space powers, primarily the USSR and USA possessed a range of such abilities (Westman *et al.*, 2023, p.75; Mattson, Guldstrand and Westman, 2025, p.15, 24).

2.1.2 Space power

Space actors, or *space powers*, can be categorised by the collection of capabilities a nation possesses (Bowen, 2019, p. 548, 553). Nations' capabilities influence the rules of space and other actors' activities in the domain, and is therefore a necessity of nations who aim to develop military capacity and prestige. Space power is as such a means to achieve strategic and political goals (Bowen, 2020, p.4; 2023, p.23). Thereby, based on a nation's capabilities in space, a differentiation can be made between emerging, medium and great space powers (Klein, 2019, p.96).

Size of power

While no clear distinction between space powers and lesser space faring nations exists, Klein (2019, p.96) proposes a categorisation based on a nation’s launch capabilities and operation of satellites. Great space powers include nations such as the US, China and Russia who

possess domestic launch capability for both satellites and human flights while also having the capability for developing, controlling and maintaining satellites (Klein, 2019, p.96).

Medium space powers, such as India and Iran, share the ambitions of great space powers in terms of independence, but are comparatively more constrained in their abilities to achieve this (Klein, 2019, p.124, 153). Generally, medium space powers have a restrained amount of material and financial resources to allocate to the ambition of exercising power beyond what is necessary to protect and nurture the interests of their territorial integrity and political autonomy (Klein, 2019, p.125). These nations possess a domestic space launch capability, as well as a domestic satellite manufacturing and control capability but lack human spaceflight capability, differentiating medium space powers from great space powers (Klein, 2019, p.96).

Emerging space powers are, similarly to medium powers, limited in their available resources. Compared to both medium and great space powers, this category of space power lacks domestic space launch capability for both human flights and satellites. However, emerging space powers can, similarly to medium space powers, develop and control satellites and can consequently still exploit space to achieve strategic ends (Klein, 2019, p.96). Klein (2019, p.151) further states that space strategies for emerging space powers are, compared to those of great space powers, generally undeveloped. However, these strategies are likely at their core of a cumulative character. This entails that an accumulation of small actions could eventually create large effects, thereby achieving the strategic end (Klein, 2019, p.156). Furthermore, for an emerging space power, the outcomes of the strategic ambitions can be either to decide on becoming stronger, keep the status quo or become weaker through military or non-military methods. The decision is based on the potential risks and rewards, where albeit recognised as rare, even becoming weaker is sometimes a strategic decision due to economic difficulties or more pressing security issues arising (Klein, 2019, pp.157-158).

Other elements of space power

The capability of developing and controlling satellites is a unifying factor for space powers, where the amount of satellites possessed by a nation can serve as an indicator for how much a nation invests in the space domain (Westman *et al.*, 2023, p.68)**.** Oberg's (1999) space power elements are considered a classic description of space power which describes aspects which enables a nation's access to and utilisation of space (Schrogl *et al.*, 2020, p.26; Wårlind,

Mattson and Johlander, 2025, p.59). These elements, some of which are presented in the list below, are factors which a space power requires to actually be able to use their space power, that is to actually access and use the space domain:

- *Facilities:* Hardware necessary to conduct space operations, such as manufacturing and launch facilities (Oberg, 1999, p.44).
- *Technology*: Basic and applied research must be conducted to develop desired space operations and must compete favourably with defence, energy and medical programs for funding. It is ideal that private laboratories collaborate with universities and support students' engagement in the field (Oberg, 1999, p.44).
- *Industry:* Commercial actors must pursue space technology for profit and fund their own research to maintain a competitive position in manufacturing and operation of space systems (Oberg, 1999, p.44).
- *Economy:* Space expenditures often lead to payoff investments, therefore should weak economies not terminate space activities. While the financial crisis may tempt us to reduce spendings, it should be strived to protect space related investments in future space power (Oberg, 1999, p.44).
- *Populace*: There must exist well educated citizens with a sufficient number of engineers and scientists. Furthermore, the taxpayers must understand the importance of state-funded space capability development. (Oberg, 1999, p.45).
- *Education:* There must exist a sufficient number of universities with relevant engineers. And science education to support the space industry. These universities must also collaborate with the government, and other institutions, to support the development of competitive space technology (Oberg, 1999, p.46).

As stated by Oberg (1999, p.47), the elements possessed by space actors vary, and can be used differently. Space actors do however often aim to create dependency from other nations for key space power elements – an ambition only attainable by actors with the broadest infrastructures (Oberg, 1999, p.48).

2.2 International collaboration

As identified by Peter (2016, p.145), international cooperation is an essential aspect of space policies, where the motivation for engaging in such relations are determined by political, economic and security factors.

Bilateral or multilateral cooperation can take various forms, where collaboration in research and development (R&D) and acquisition of space capabilities is one way for a state to rationalise their space expenditures. By collaborating on capability development projects the cost can significantly be reduced for the parties involved, while also widening the possibilities of a nation's activities in space (Peter, 2016, p.145). In turn, increasing one's utilisation of space can strengthen the image of the nation as technologically advanced, which could encourage additional actors investing or collaborating with the state in capability development (Paikowsky, 2017, pp.84-85).

The motivation for developing and engaging in space activities can therefore be found in factors such as engagement in international cooperations, further technological advancements, boosting industrial competitiveness and economic growth, as well as national prestige (Adriaensen et al., 2015, p.360; Croshier, 2023, p.23). The relation between international cooperation and space activity can therefore be considered as driven by a strategic competition between nations, which is based on the assessment of the international environment (Racionero-Garcia and Shaikh, 2024, pp.10-11).

This approach to international cooperation for capability development is in line with the idea of DeVore and Stai (2019, p.35), who argue that states produce weapon systems to secure themselves against perceived threats. A form of balance is thereby created as nations who share the same concern league themselves together. A nation's ambition to enhance international space collaboration can therefore be an indicator of larger policy objectives, such as foreign policies and innovation or trade strategies (Adams, 2019, p.410). Such cooperation can however be affected by the nation’s policy for militarisation of space, as this can influence the willingness of others to cooperate if they perceive to be potentially affected by such policy in the future (Adams, 2019, p.411). The logic behind collaboration therefore changes when a nation regards space in terms of military competition as opposed to a peaceful area of shared interests (Gallagher, 2013, p.59-60). Reaching international

collaboration agreements therefore often require a common interest between nations, where the need to protect national interests should be compatible with other nations objectives (Klein, 2006, p.140; Adams, 2019, p.411).

2.3 Regulations in space

Space, being a domain of global commons as stated in The Outer Space Treaty of 1967, is under the jurisdiction of international law, as opposed to the sovereign laws of a nation (Gallagher, 2013, p.54; Ziemblicki and Oralova, 2021, p.8). As such, collaboration in space can take the form of regulatory measures – laws – which all nations must adhere to when conducting activities in the domain.

2.3.1 International treaties and national laws

As of 2025, five international treaties regulating military activity in space, have been ratified in the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), with the most recent being the *Moon agreement* of 1979 (Ziemblicki and Oralova, 2021, p.2). As these treaties were ratified during the cold war and were negotiated mainly between the US and the Soviet Union, the context in which they were conceived differs significantly from the modern space domain. As such, the international laws of space are generally considered outdated (De Man, 2017, p.95; Ziemblicki and Oralova, 2021, p.4; Wilson and Vasile, 2023, p.3). As further noted by Wilson & Vasile (2023, p.4), technological advances have succeeded the existing space laws to the degree that there exists no legal accountability for an actor's space activities.

Attempts have therefore been made in modern time, such as in 2021 and 2023, to instate further regulations through international law to treat and mitigate threats relevant to the modern space time (Westman *et al,* 2023, pp.15-16). Albeit unsuccessful, these efforts have shown that it is not possible to merely consider technical capabilities and restrict specific technologies as traditionally proposed. Regulations must, in addition to such considerations also, encapsulate how this technology could be used (Westman *et al,* 2023, p.15).

Different approaches to understanding space laws

The failure in agreeing on additional space treaties during the last 45 years can be attributed to several reasons. Danilenko (2016, p.180) points to the increased number of developing

space nations during the last decades, where UNCOPUOS consists of member states who are both well established space powers, and emerging space powers. The interests for the domain are thereby varied. This entails that there are groups within these forums who have significant different views on space activity, presenting challenges for reaching consensus. De Man (2017, pp.92-93) further points to technologically advanced space nations and their unwillingness to change the current order of space law. This is attributed to these space power's awareness of how the existing treaties provide an advantage to themselves. As noted by DeMan (2017, pp.92-93), the basis for the space treaties is the inclusive and equal right to use space, which in practicality only provide protection for those nations which are actually capable of engaging in spacefaring activity. It is therefore in the interests of technologically advanced space faring nations to keep the status quo of current international space regulations, as further regulations may reduce these nations current freedom in space (De Man, 2017, p.92).

Instead, technologically advanced space powers are placing a larger effort on implementing domestic regulations, where they regulate their international obligations in national legislation (De Man, 2017, p.94). However, due to the ambiguous language of the space treaties of 1967-1979, these obligations are in accordance with the nations own interpretations of what the treaties entail. These national regulations can hence be a means to further benefit the nation (De Man, 2017, p.93; Ziemblicki and Oralova, 2021, pp.3-4). The purpose of implementing national space laws is foremost to benefit domestic industry, as the current treaties are considered limiting for commercial space actors (De Man, 2017, 93; Ziemblicki and Oralova, 2021, p.2). To exemplify this, two such national space laws were implemented in the US between 2015-2017, where the nation gave commercial companies the right to possess, use and sell asteroids and space resources. Moreover, these determined that private actors are not subjected to all obligations within The Outer Space Treaty as well as declaring that space is *not* a global commons (Tronchetti and Liu, 2021, p.3; Ziemblicki and Oralova, 2021, p.8).

Klein (2025, p.220) concludes that nations can use regulatory tools to enhance their position in space without military actions. This presents an opportunity for emerging space powers to advance their interests in the domain, resulting in better access to space by proposing

agreements, forming coalitions and attempting to diminish the military influence of larger space powers (Klein, 2025, p.220).

2.3.2 Efforts for sustainability

One of the main issues currently discussed in forums such as UNCOPUOS concerns sustainability (Hoerber and Oikonomou, 2023, p.118). Space debris is created and circulates in our utilised orbits anytime a system is launched into the domain, a anti-satellite weapon is tested or a satellite has been taken out of commission (Palmroth *et al.*, 2021, p.2; Hoerber and Oikonomou, 2023, p.75). This presents a significant risk towards the operational systems in space as collisions may occur between the systems and debris. Furthermore, this risk is continuously heightened as the amount of systems launched into orbit, and new space actors positioning themselves in the domain, is increasing by the year (Diserens, Lewis and Fliege, 2020, p.1; Hoerber and Oikonomou, 2023, p.75; Nozawa *et al.*, 2023, p.1). A plausible consequence of this congestion of space debris, systems, and actors, within the limited area of space, is that the domain may eventually become inaccessible (Hoerber and Oikonomou, 2023, p.75; Wilson and Vasile, 2023, p.3). The efforts of sustainable use of space thereby involves measures to ensure a continued access to space by improving the conduct of activities in space and preventing the production of additional debris (Palmroth *et al.*, 2021, p.2; Hoerber and Oikonomou, 2023, p.119).

In current space treaties, the issue of sustainability is not specifically addressed. While guidelines exist for the mitigation of space debris on an international level through the UN, these are only voluntary (Palmroth *et al.*, 2021, p.3; Hoerber and Oikonomou, 2023, p.119). Many nations do, however, bind such frameworks within their domestic space laws. Great space powers such as China, Russia and the US, all recognise the threat of space debris (Wilson and Vasile, 2023, p.3). However, these great space nations are a significant contributors to space debris through their active militarisation of space, increased space activity and possession and testing of anti-satellite weapons (Hoerber and Oikonomou, 2023, p.75; Westman *et al.*, 2023, p.16; Wilson and Vasile, 2023, p.3)

3. Theoretical Framework

The following chapter presents two frameworks used for the development of an analytical method. The first framework presented in Section 3.1 is a method for describing space actors, developed by Hallgren & Westman (2021) at FOI. Thereafter, in Section 3.2, a framework for determining scope of analysis, presented by Enserink *et al* (2022), is described. The two frameworks will in this study be used in Chapter 5 during the development of a method for analysing space strategies.

3.1 Method for describing and evaluating space actors

Hallgren and Westman (2021) at FOI developed a method to systematically describe space actors based on their technical and non-technical capabilities. Their work serves as a foundation for this project of developing a method for analysing national strategies. This provides insights into relevant variables in the domain, presenting challenges in creating methodology to study space activity, and proposing directions for future research.

The method for describing and evaluating space actors considered three categories: Applied abilities, Strategy, doctrine and organisation, and Industry and infrastructure. Each category consists of a cluster of space capabilities and are as followed:

- *Applied abilities* include the capabilities of space situational awareness, positioning, navigation and timing, satellite communication, space surveillance and reconnaissance, anti satellite weapon, and early warning (Hallgren and Westman, 2021, p.23).
- *Strategy, doctrine and organisation* entail space defence and doctrines, research and development, national strategy as well as military governance (Hallgren and Westman, 2021, p.24).
- Finally, *industry and infrastructure* include launch site, launcher programme, industrial capacity, and satellite propulsion (Hallgren and Westman, 2021, p.22).

A space actor can thereby be described by having the researcher evaluating each of these capabilities on a quantitative scale of 1-5. Each capability has a unique scale, but 5 was formulated towards the level of a great space power, and 1 was the lowest value a nation

could have (Hallgren and Westman, 2021, p.15). By utilising numeric values, a nation's maturity in the space domain could be presented along with an initial view on the actor's priorities for the future (Hallgren and Westman, 2021, p.19). However, the authors note that in many evaluations, it was challenging to assert a numeric value on a nation's capabilities where a nation could balance between two values in certain capabilities (Hallgren and Westman, 2021, p.15).

The method was tested internally in the organisation on a national space actor. The authors propose future development of the method to study the maturity of one category, and thereafter use this to assess whether the maturity could affect the enhancement of capabilities in other categories (Hallgren and Westman, 2021, p.21).

3.2 Policy analysis framework

One approach to develop analytical tools for the study of policy is presented by Enserink *et al* (2022, p.21, 53) who applies system analysis practices on the policy analysis process. While this project aims to study space strategies, the concepts of strategy and policy are interrelated. Klein (2025, pp.6-7) describes this as "*policy is the actual communication of strategy",* entailing that policy is the measures used to achieve the objectives within the strategy.

As described by the Enserink *et al* (2022, p.53), a researcher must limit their scope of analysis since complex systems, such as policies, contain many variables – making it impossible to encapsulate them all during analysis. A necessary step for the study of policy is therefore to determine the scope of analysis by setting boundaries between what is inside and outside the interest of the study (Enserink *et al,* 2022, pp.53-54). The policy analysis method will thereby be a framework during the initial phase of developing a method in Chapter 5, to determine which variables the method will study. In the following Sections 3.2.1 - 3.2.3, the three analyses used for determining the scope are described.

3.2.1 Means-ends analysis

An initial step in the scope-definition process is a *means-ends analysis,* where the overarching interest of the system is determined. Moreover, this analysis enables a researcher to then go top-down to further determine what elements are linked to the interest above (Enserink *et al,* 2022, pp.59-62). This enables the researcher to understand why such

elements are interesting to study, as well as presenting different levels of analysis to choose (Enserink *et al,* 2022, pp.63-64). This is advised to be presented in a means-ends diagram with a tree structure where each level represents one level of the issue in focus as presented in Figure 1. In this figure, each arrow represents a relation to a means-end. Enserink *et al* (2022, p.62) further states the selection of a focal objective – specific means-ends in the diagram – to further analyse in ones study, can not be one of the entities on the lowest level due to their distance to the overarching means-end, and their introduction to additional complexity.

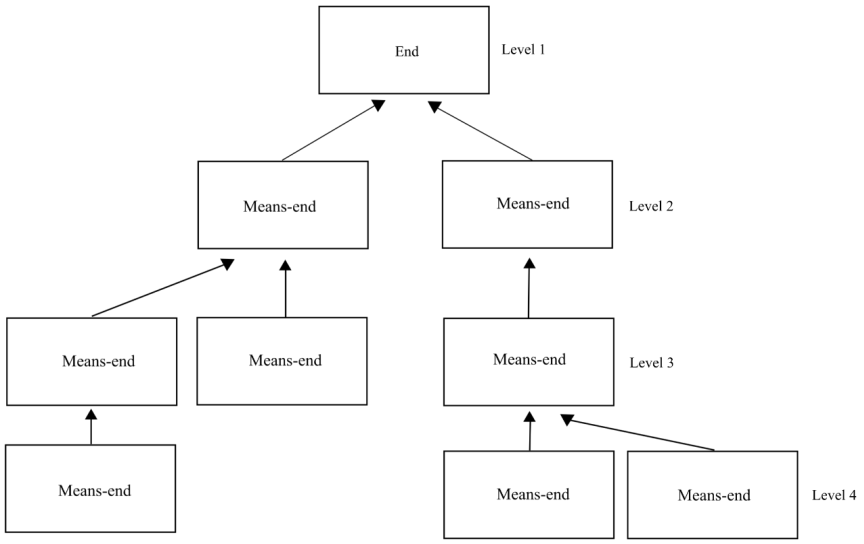

Figure 1: A means-ends diagram based on description by Enserink *et al* (2022, p.61).

3.2.2 System analysis

After a means-ends analysis has been conducted, Enserink *et al* (2022, pp.54-55) further proposes a system analysis to further narrow the scope. The system analysis is based on the results from the means-ends analysis, where the main concept is used to identify factors termed *Means, External factors, Internal factors* and *Criterias* (Enserink *et al,* 2022, pp.54-55). The relation between the different variables are presented in Figure 2. These factors are furthermore described by Enserink *et al* (2022, p.55) as followed:

- *Internal factors* can be viewed as the system under study. This system is affected by the means, but will through its internal factors influence the outcome of these effects.
- *Means* are policy elements which can be used to do something, thereby influencing the system. Such means can for example be used to improve the system's outcome.

- *External factors* are elements that cannot be influenced by the system but will influence the outcome regardless.
- *Criterias* are measurements of the realisation of an objective, that is how to measure if the purpose of the system has been achieved.

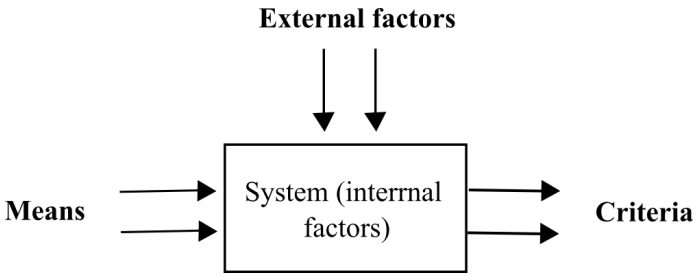

Figure 2: System diagram, based on illustration by Enserink *et al* (2022, p.55).

3.2.3 Map of causal relations

Finally, Enserink *et al (*2022, p.70, 73) propose the researcher to map the causal relations between means, external factors and criteria and additional affected elements which will represent the internal structure of the system of interest. This identification will provide factors which the researcher must consider during their policy analysis and is illustrated in Figure 3. The causal relations in the map either strengthen or decrease the value to another element, where '+' denotes an increase of value and '-' denotes a decrease in value.

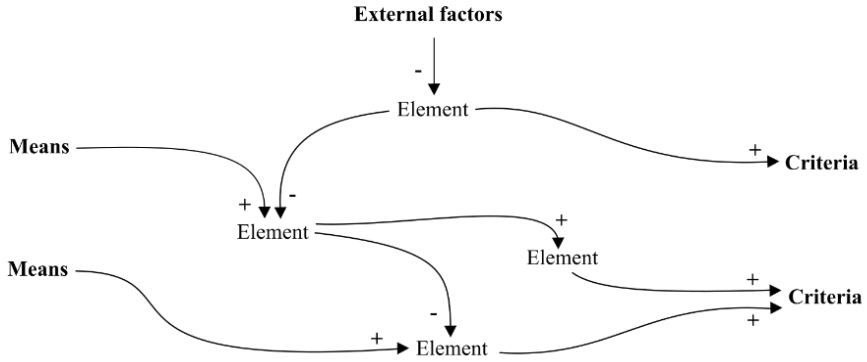

Figure 3: Map of causal relations, based on the description of Enserink *et al* (2022, p.71-74).

The basis on the claims of causation should be based on a combination of mental modelling made by the researcher, complemented with relevant literature. Furthermore, the authors limit the amount of elements to a maximum of 20 factors in total to keep the scope of analysis comprehensible. (Enserink *et al,* 2022, p.70)

4. Project design

The following chapter will provide an overview of the structure of this study. The first section presents the approach which will be used in the process of developing a method, as conducted in Chapter 5. Following this, the approach of applying the method on space strategies is presented, with its results presented in Chapter 6.

4.1 Process of method development

The purpose of developing a method in this study is to be able to analyse national space strategies. This means that the method will be applied on textual – qualitative – data from strategic documents, where such type of data can often become extensive (Säfsten and Gustavsson, 2020, p.218). To study qualitative data, it is therefore required for the researcher to first reduce the amount of collected data so that it is manageable, and then structure it into clusters so that the relevant data can be analysed (Säfsten and Gustavsson, 2020, pp.216-220). This will thereby be the aim of the method – to provide a framework which a researcher can use to reduce and structure the data in national space strategies – so that a space strategy can be analysed.

Previous chapters have presented a wide range of variables which are directly, or indirectly, involved in a nation's abilities to access and use space. In Chapter 3, the presented study by Hallgren and Westman (2021) used three different categories of factors to evaluate space faring nations capabilities. Moreover, studies by authors presented in Chapter 2, which includes Adrianssen (2015, p.360), Oberg (1999, pp.44-46) Paikowsky (2017, pp.84-85) and Peter (2016, p.145), presents several factors behind the development of space programmes and capabilities. National space strategies could therefore include a vast amount of factors which can be studied. To manage this complexity, the first stage in developing a method is therefore to determine the scope of interests. As proposed by Enserink *et al* (2022, p.53), this is conducted through a means-ends analysis, system analysis and mapping of causal relations as presented in the previous chapter.

The result of these analyses is the scope of the method which encapsulates a set of factors necessary for an emerging space power's access and use of space – thereby providing a structure which a researcher can sort qualitative data into.

The output from these three analyses will further present a list of criterias, which defines how these factors could be measured. In the following stage of the method development, these criterias are further developed. Each criteria is broken down into more narrow measurements, termed *measurables*. As the interest of this project lies in understanding and assessing the meaning of space strategies, as opposed to measuring space capabilities, it is determined that the measurements used in the method will be qualitative. This decision is furthermore supported by the difficulty identified in the *Method for describing and evaluating space actors*, as discussed in Section 3.1, to assign quantifiable values to national space capabilities. The result of this process will thereby be a framework for a researcher to reduce the collected data with.

After these measurables are formulated, a pilot study is conducted on the Australian space strategy. The purpose of the pilot study is to assess whether the measurables do sort out the relevant data. During this process, the measurables are either removed, reformulated or unaltered. By conducting a pilot study, uncertainty regarding internal validity can be reduced, as this process enables the method to be assessed on whether it actually generates relevant data for the purpose of the project, its research questions and the scope of the method, or not (Säfsten and Gustavsson, 2020, p.227).

4.2 Analysis of space strategies

Following the development process of an analytical method, as described in the previous section, the method is applied on space strategic documents from two different nations.

4.2.1 Selection of nations

The selection of the two nations to analyse and one nation to use during the pilot study is conducted by a two step process. First, a list of emerging space powers are produced, so that the two nations analysed are comparable in terms of space power. Second, the strategic documents are considered, where each nation's space strategy must fulfill a set of criterias.

By utilising FOI's internal database for global space capabilities, *El Corazon*, this study accessed data concerning current and historic space activity. The database is compiled of open sources, sourced and organised by FOI (Wårlind, Mattson and Johlander, 2025, p.220). First, a query is used to sort out all nations which currently – as of March 2025 – have active

satellites in orbit and which have been launched between the period of January 2020 and March 2025. This generates a list of 55 nations who thereby currently possess active space capabilities.

Following this, a query is conducted where all nations which have ever had a domestic space launch capability for satellites, were removed. In doing so, nations defined as medium and great space powers according to Klein (2019, p.96) are removed. The remaining 43 nations, shown in Appendix A, are thereby emerging space powers as the nations possess control over satellites and are actively engaging in space activity but lack domestic capability to launch such systems.

The final stage of selection is based on the strategic documents each nation possess where the nations had to fulfill three criterions:

1) The space strategy documents must be written in English.
2) If the documents are translated from their original language into English, such translation must be directly from the concerned nations government or a governmental agency.
3) The document must be published on websites governed by the national governments or agency.

The ambition is to choose three nations with a significant geographical distance from each other. However, the selection of nations is limited due to most nations only providing non-english strategic documents. The selected nations are hence decided upon due to fulfilling the criterias for the strategic documents, being published in English from a governmental source, and being located on three different continents. The two nations which are analysed through the lens of the developed method are Germany and South Africa. Additionally, Australia is used in the development process of the method, during the pilot study.

4.2.2 Data collection and organisation

The study uses textual data sourced from governmental websites of each of the nations respectively. As national space strategies are not always presented in one singular document

and can instead be included in other defence of innovation strategies, this project source documents of the national defence strategy, the national defence industry or innovation strategies, as well as any governmental policies directly aimed at space activity (Sagath *et al.*, 2019, p.44). The documents used in this study address space to some extent, and have been published within the last 5 years, or are a strategic framework for the year 2025 or later. In Table 1, the documents used when applying the method are presented where each document is assigned an acronym which will be henceforth used to refer to the document. The table further presents the documentation's origin, title of the document, the year of publishing and publisher.

Table 1: Documents used for respective nation

Nation	Title and acronym	Year	Source
Germany	National Security and Defence Industry Strategy (NSDI)	2023	The federal government of Germany
Germany	The German Federal Government's Space Strategy (GSS)	2023	Federal Ministry for Economic Affairs and Climate Action
Germany	Future Research and Innovation Strategy (FRIS)	2023	The federal government of Germany
Germany	Integrated Security for Germany; National Security Strategy (NSS)	2023	The federal government of Germany
Germany	Defence Policy Guidelines (DPG)	2023	Federal Ministry of Defence
South Africa	Science, Technology and Innovation Decadal Plan 2022-2032 (STI)	2022	Department of Science and Research
South Africa	Ten-year innovation plan: 2018-2028 (IP)	2018	Department of Science and Technology
South Africa	South African National space Agency, strategic plan revised 2020-2025 (NSA)	2020	Department of Science and Innovation
South Africa	Department of Defence - Strategic plan 2020-2025 (DoD)	2020	Department of Defence

Sorting data

This project utilises the large language model *Parsd*. This tool is used both during the development process of the method, as presented in Section 5.2.1 and during the application on the strategic documents as presented in Section 4.2.3. By using Parsd a vast amount of

textual data can be sorted within the time frame of the project. Furthermore, the tool can reduce the risk of researcher bias during the sorting of the data which could affect the result of the study, thereby increasing the reliability of the data collection process (Gorard, 2013; Säfsten and Gustavsson, 2020, p.235; Rillig *et al.*, 2023, p.3465).

Many large language models face the issue of fabricating information when the model can not find an answer to a prompt, which would introduce significant harm to the study's validity (Liu, 2024, pp.24-25). However, *Parsd* only considers input injected by the researcher and solely organises this data thereby reducing the risk of fabrication. Additionally, all outputs made by *Parsd* have track source reliability by presenting reference markers pointing to where the data was found in the documents. Thereby, all presented organised data is validated.

4.2.3 Applying method

The method can be used both manually, where a researcher searches through space strategic documents to answer each measurable, or by utilising tools to aid this search. This project applies the method on strategic documents by using *Parsd*. In the language model programme, two projects in the model are created, labelled "Germany_data", and "South Africa_data". The purpose of this is to isolate each nation's strategic document from each other, so that the language model only considers the documents for one country at a time when sorting data, thereby eliminating potential interfering factors.

Within each project, the respective nation's strategic documents are inserted by the researcher in textual form. Each measurable are used as a prompt in the function "ChatDoc" where the model responds to the prompt by providing an output which includes a segment of the text relevant to the prompt, as well as a reference to the page number in the document. The measurable – or prompt – is inserted in one strategic document at a time, and the output is documented. Once a measurable has been asked to all of the documents within Germany_data, the next measurable is inserted onto each document. This continues until all documents in a project have answered to every measurable and then the same process is repeated for South Africa_Data. Figure 4 illustrates the input and output of *Parsd.*

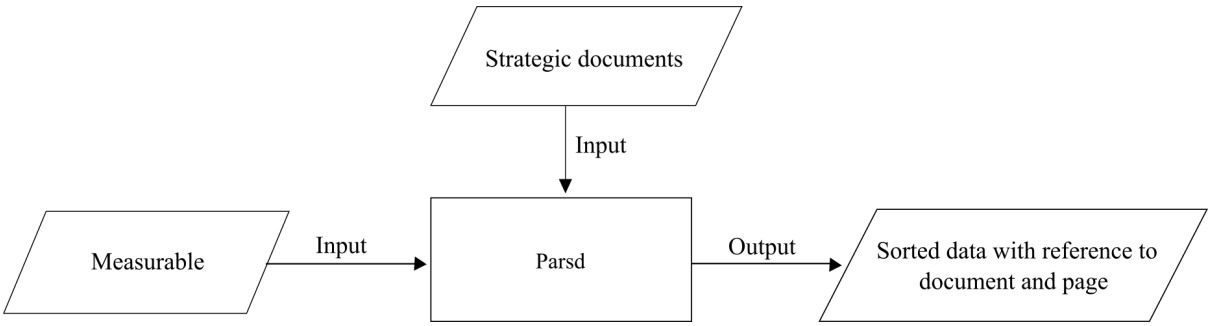

Figure 4: Process of utilising Parsd

Once all strategic documents for respective nations has provided output, each output is assessed. As all outputs referred to the page where this data was identified, this is validated by reviewing the information on the referred page number. All referrals were correct, however in a few cases the models summary lacked context which was found on the referred page. In those cases the additional information is added into the documentation of results. Some output from *Parsd* were related to the measurables and categories, but did not directly address the space domain but instead the overall defence ambition or aims for all domains within the defence sector. In such instances, this is stated in the results shown Appendix C.

4.2.4 Ethical considerations

This project accounts for research ethics, both internal and external, to ensure the quality of the study and its results, as proposed by Säfsten and Gustavsson (2020, pp.242-243). As such, the ethics of using a large language model in this study, the collaboration with FOI, and the used data, is considered from an ethical perspective.

Large language model

All usage of *Parsd* in this project is accounted for in Section 4.2.2-4.2.3, for transparency of the study and its results. The model is solely used to organise data, both during the pilot study and during the application of the method on the space strategic documents. All data organised by *Parsd* is validated by the researcher of this study to ensure its completeness and correctness, and is presented in Appendix C.

Utilising large language models such as *Parsd* have a direct environmental impact due to the required energy and water consumption by computing facilities behind such models (Rillig *et al.*, 2023, p.3464). Therefore, to reduce this harmful effect, the utilisation of the model will

be conducted sparingly by being mindful of the inputs, such as typing errors which would require additional prompts.

Collaboration with FOI

As this project is conducted in collaboration with FOI, the researcher of this study have assessed the risk of conflict of interest, as the agency possesses ownership of this project's results. The entirety of the project has been conducted independently, from the choice of literature and theoretical framework, to selected nations and evaluation of the study, has solely been decided upon, and conducted by, the author of this thesis. As such, no conflict of interest has been identified.

Data

All data used in this study is open source material. As previously reasoned in Section 1.4 *Limitations and assumptions*, it is assessed that there is a high risk that the data is not a complete reflection of reality. This study is therefore emphasising that the results are merely reflecting a narrative from the studied nations. For transparency, the studied space strategies are presented in Section 4.2.2, and the output from applying the method on the two tested nations is shown in Appendix C where each statement is presented with a reference to document and page number.

5. Development of Method

The following chapter presents how this study is developing a method for analysing space strategies, based on the structure described in Chapter 4. The first Section 5.1 conducts three analyses to determine the scope of the method. The second Section 5.2 presents how the results from the previous section are used to formulate measurements to study the scope. Finally, in Section 5.3, the finalised method is presented and described.

5.1 Determining boundaries

Due to the intrinsic complexity of studying multivariable systems, the framework of Enserink *et al* (2022) is utilised in the initial stage of the method development process. By using this framework in this study, the boundaries of the method can be defined which will serve as a foundation for the finalised method in later sections of the chapter.

5.1.1 Means-ends analysis

The overarching end of national space strategies, as determined by Klein (2019, p.21), is to *secure nations access and utilisation of space.* In this study, this aim will serve as the top level of a means-ends analysis, where all levels below will reflect on ways to achieve this highest aim. Based on the overarching end, a four level means-ends diagram was created as presented in Figure 5. The basis for each means-end within the analysis is the presented theories and related work from Chapter 2.

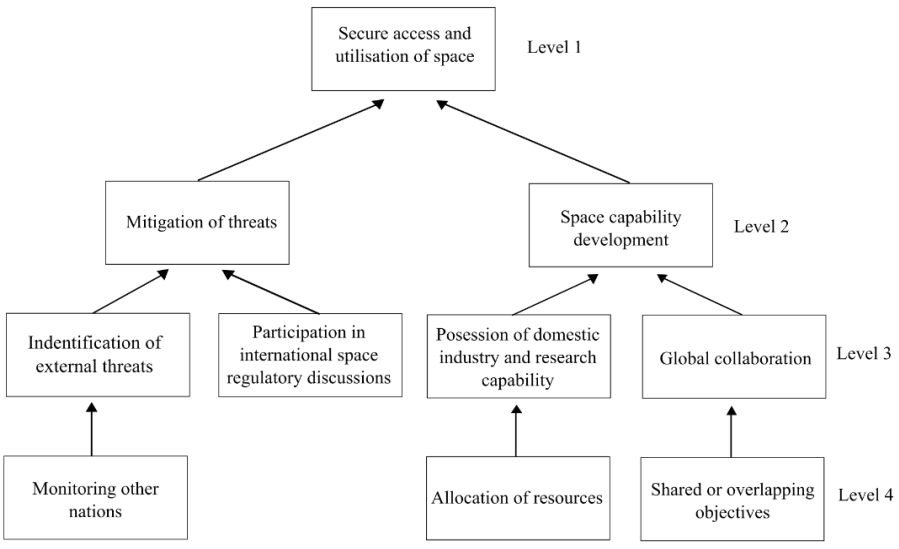

Figure 5: Four level Means-ends diagram for the access and utilisation of space.

The second level in the means-ends analysis determines that the means of achieving the overarching end of *securing nations access and utilisation of space* is influenced by the means of *mitigating threats* and *developing space capabilities* (Adriaensen *et al.*, 2015, p.360; DeVore and Stai, 2019, pp.23-25).

The third level determines that *Identification of external threats* and *Participation in international space regulatory discussions* are means to achieve the end of mitigating threats (Palmroth *et al.*, 2021, p.2). Furthermore, *Possession of domestic industry and research capability* and *Global collaboration* are determined to be means to achieve the end of *Space capability development* (Oberg, 1999, pp.44-46; Peter, 2016, p.145).

The fourth level of the means-ends analysis determines *Monitoring other nations* to be a means to the end of Identification of external threats. The mean *Allocation of resources* is connected to both the ends of *Possession of a domestic industry and research infrastructure* as well as *Global collaboration* (BryceTech, 2017, pp.7-8; Croshier, 2023, p.17; Peter, 2016, p.145). Finally, the mean *Shared or overlapping objectives* is connected to the end *Global collaboration* (DeVore and Stai, 2019, p.35).

5.1.2 System analysis

Following the first analysis to determine the scope conduction in the previous Section 5.1.1, the scope is further narrowed through a system analysis. Continuing on the proposed structure of Enserink *et al* (2022, pp.54-55) as described in Chapter 3, the *external factors, means, internal system* and *criterias* are defined, as shown in Figure 6. The determination of what each of these variables entail is based on 1) The identified means-ends from the means-ends analysis in the previous section, 2) Aspects from the means-ends analysis which overlap factors studied by Hallgren & Westman (2021) in their method for describing space actors presented in Chapter 3, and 3) Related work as presented in Chapter 2.

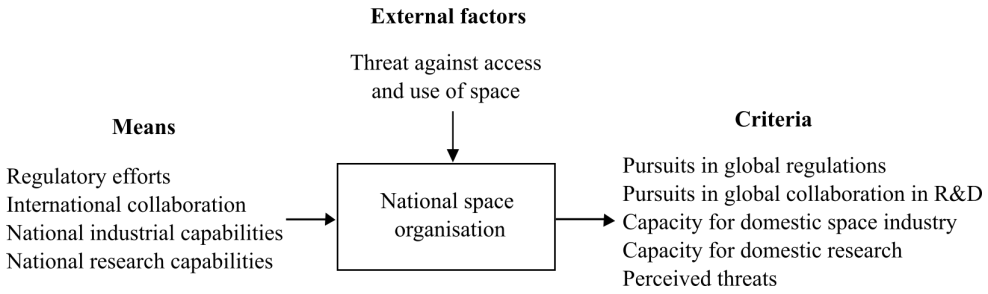

Figure 6: System diagram for the scope of the method

The nations *means* – instruments which the national space organisation own and can use to change themselves with – are set as the following:

1. Regulatory efforts
2. International collaboration
3. National industrial capabilities
4. National research capabilities.

Moreover, the *external factor* – variables which cannot be directly influenced by the national space organisation – is determined to be threats against the access and utilisation of space. Finally, *criterias* –how the national space organisations means can be measured – are set to the following:

a. Pursuits in global regulation
b. Pursuits in global collaboration i R&D
c. Capacity for domestic space industry
d. Capacity for domestic research
e. Perceived threat

5.1.3 Map of causal relations

The third and final step in defining the scope of the method is to continue on the findings in previous system analysis in Section 5.1.2, by mapping the causal relations between the different variables. As proposed by Enserink *et al* (2022, pp.70-71), as described in Chapter 3, the map will further illustrate different *elements* and their relations to each other and the means, external factors and criterias. The purpose of this is to support the understanding of how national space organisations affect different aspects of space activity (Enserink *et al.*,

2022, p.70-71). The means, external factors and criteria are, albeit reformulated to further specify what they entail, are based on the system analysis in Section 5.1.2. The elements are based on literature presented in Chapter 2. In Figure 7, the map of causal relations are presented.

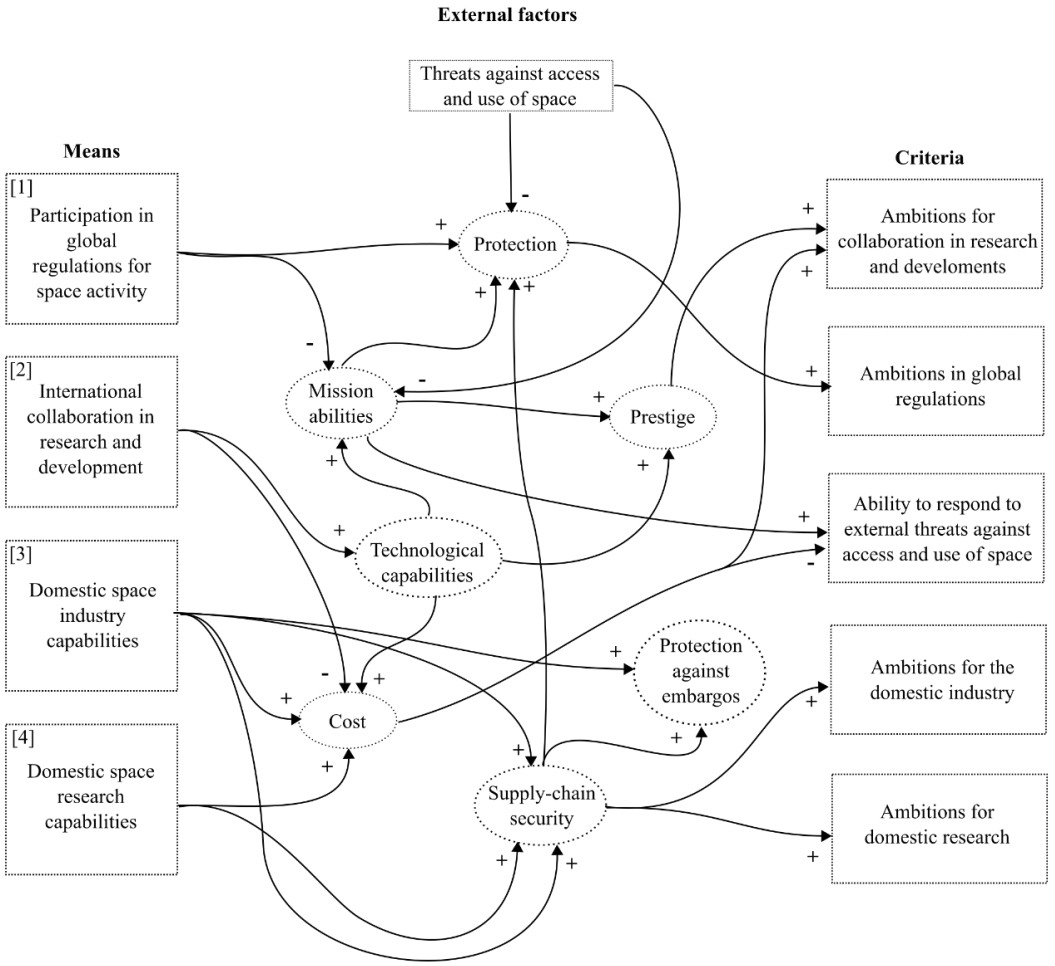

Figure 7: Map of causal relations for the scope of the method

The mapping presents four different means, sharing character with the means from the system analysis in Section 5.1.2, but reformulated to further specify each purpose. The final formulation of the means are:

1. Participation in global regulations for space activity
2. International collaboration in research and development
3. Domestic space industry capabilities
4. Domestic space research capabilities

These means are tools a nation can use to either enhance, maintain or weaken their space organisation, as in line with the ideas of Klein (2019, pp.157-158). To measure how the space organisation would like to use these means, which can serve as an indicator of future behaviour and activities, five criterias as presented in the map of causal relations in Figure 7, can be used:

a. Ambitions to increase collaboration within research and development
b. Ambitions in global regulation
c. Ability to respond to external threats against space access and utilisation
d. Ambitions for the domestic industry capability
e. Ambitions for domestic research capability

Furthermore, the map of causal relations also defined the external threat from the system analysis in Section 2.5.1. This variable is *a threat against access and use of space,* and due to the variable being external, this is something which the space organisation can not directly influence.

The three steps of defining scope of the method for this study, as outlined in Chapter 3, is thereby concluded. The method will consider the means 1-4 presented above, along with the variable of threat. Henceforth, these 5 variables will be termed **Categories.** Furthermore, the criterias a-b defined above, will in the following sections be used as a basis to determine how the categories can be studied.

5.2 Setting measurements

Based on the five criterias determined in previous Section 5.2.3, each of these will now be broken into several sub-criterions. The purpose of this is to further develop measurements which can be used to systematically analyse space strategies. In this study, this process is conducted as follows.

As shown in Figure 7, each mean – category – has a relation to one or more criterias, entailing that each category has at least one way of being measured. Through a brainstorming session, the researcher of this study took one category at a time and took its related criterias and broke these into sub-criterions. During this process, the related work presented in

Chapter 2, was used as a basis to reason on what aspects of the assessed category are interesting in this study. Once an aspect was identified, such as *challenges in the domestic space industry*, this sub-criterion was reformulated into a question, such as *What challenges exist in the domestic space industry?*

Once this process is complete, every category has multiple sub-criterions in the form of questions which encapsulate one aspect of its related category. Henceforth, to differentiate these sub-criterions from the formulated questions, these will be called **Measurables.** These will serve a critical function of the final method, presented later in Section 5.3, as these measurables will guide the user of the method to collect and organise relevant information from a space strategy.

The final step in the process of defining these measurables is to conduct a pilot study. In this process which is described in the following section, the relevance and formulation of each measurable is tested.

5.2.1 Pilot study

Once an initial list of measurables is defined, these measurables are tested through a pilot study where the method is applied on the Australian space strategy. The pilot study is carried out with the same structure as the appliance of the finalised method, as specified in 4.2.3 *Applying method*. However, while the application of the final method serves the purpose of generating an output to compare different strategies with, the pilot study is used to formulate wordings in the method before it is finalised.

Preparation

The pilot study is conducted by utilising the large language model *Parsd*, as previously presented in 4.2.2 *Data collection and organisation,* and in 4.2.3 *Applying method.* A project within the software was created and labelled “Pilot-Study_Australia”. Thereafter strategic documents for the space domain, published by Australian government websites are inserted into *Parsd*. These documents, used for the pilot study, are stated in Appendix B.

In the chat function of *Parsd*, each measurable is computed into the model one at a time. For each measurable, *Parsd* presents an output which references a specific strategic document

within the project and how this document answers to the measurable. For each output, the referred document is reviewed to see whether the model is referring to documents which actually provide information on the measurable. The output from the pilot study is not presented in this study.

Assessment of measurables

Each measurable is assessed based on the provided answer and its relevance to the category it is intended to provide information for. If it is assessed that the measurable requires reformulation, the wording of the measurable is changed and the measurable is then tested again. If the measurable, however, is assessed to provide irrelevant information for the scope of the method, it is removed.

5.3 Finalised method

The finalised method is first presented on an overarching level and then presented in further detail in the following section.

5.3.1 Overarching description

The overarching aim of the method, which is illustrated in Figure 8, is to identify a nation's priorities, ambitions and limitations within the space domain. The method does this by considering five **categories**, which each encapsulate an aspect of space strategies:

1. Participation in global regulations for space activity
2. International collaboration within research and development
3. Domestic space industrial capability
4. Domestic space research capability
5. Threat image

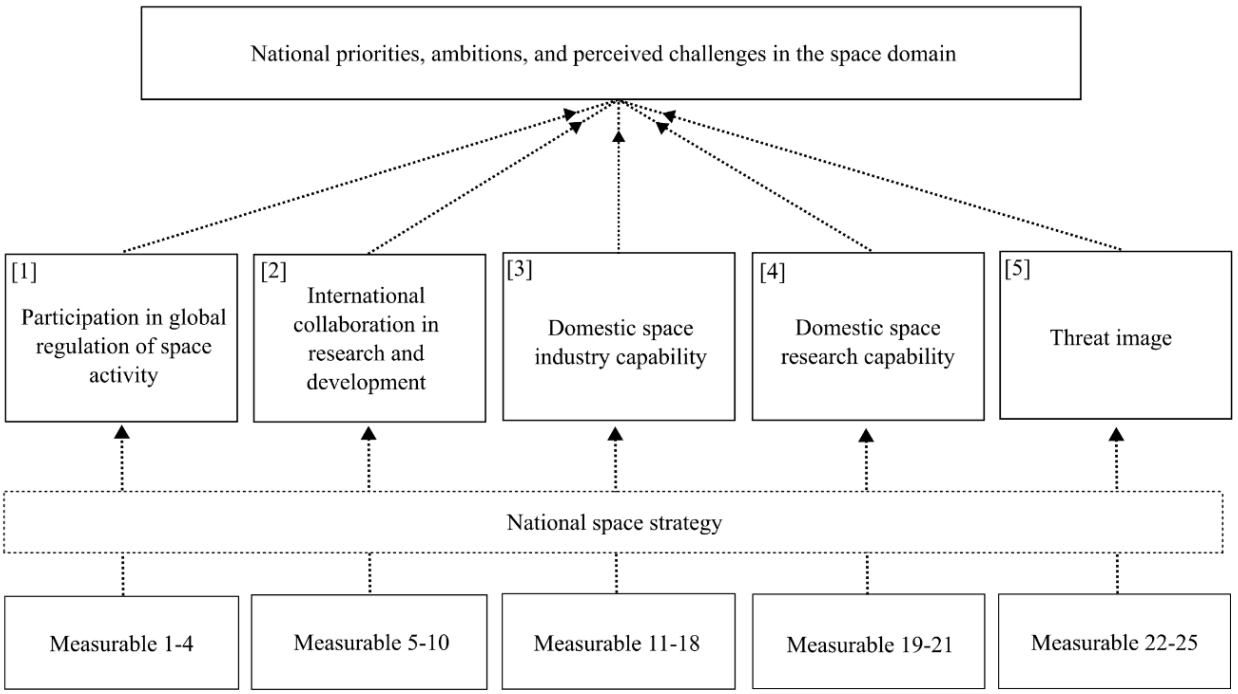

Figure 8: Structure of the developed method for analysing space strategies

Each category clusters an amount of **measurables** that are questions which the researcher can use to search for categorical-specific information within space strategies. By organising information based on these clusters of measurables, the researcher can thereby analyse the priorities and ambitions in individual categories. Thereafter the categories can be resonated and compared against each other, to assess whether the expressed ambitions are feasible based on the information provided from other measurables.

5.3.2 Detailed description

The five **categories** of measurables studied through the method are defined as followed:

1. *Participation in global regulations for space activity:* The nation's engagement in discussions concerning further regulating militarisation of space or enhancing sustainability in space. This includes whether the nation is actively engaging with UNCOPUOS and what intentions the nation expresses for the regulation of the domain.

2. *International collaboration within research and development*: Multilateral collaborations between two or more nations, or between a nation and an intergovernmental actor, in capability development, either in research or development of systems.

3. *Domestic space industrial capability:* The nation's infrastructure for developing space systems. This includes competence, resources, as well as structural manufacturing capabilities.

4. *Domestic space research capability:* The nation's infrastructure for conducting research for the development of space capabilities. This entails academia, such as research institutes, universities as well as educational competence within the nation.

5. *Threat image:* The nation’s communicated threats against the nations access and utilisation of space. This could entail a specific threat actor or a specific type of threat against the nation's space capabilities.

The method employs a total of 25 **measurables** distributed over these five categories as presented in Table 2 below. Each measurable encapsulates an aspect of each category, however some measurables could be used to understand other categories due to the interconnectedness of the categories.

When the researcher has sorted data based on the measurables in Table 2, the nation's position for each category can be determined based on the identified ambitions, priorities and challenges. Thereafter, the researcher can, based on what is of interest for their specific study, assess the organised data. One approach is to compare two different nations' ambitions, priorities and limitations against each other, where the categories can serve as a framework for structuring such comparison, as conducted in Chapter 6. Another approach, as is further conducted in this study and presented in Chapter 7, is to assess the feasibility of achieving the stated ambitions. During this assessment, the researcher can reason on the feasibility based on presented challenges and limitations and potential contradictory ambitions and priorities.

Table 2: Measurables for respective category

Category	Measurable
Participation in global regulations for space activity	1. Is the nation actively engaging in UNCOPUOS (the United Nations Committee on the Peaceful Uses of Outer Space) regulatory discussions of space?
	2. What strategies is the nation implementing to address the issue of global space militarisation?
	3. Is the nation addressing a need to further regulate space activities through international agreements and regulations?
	4. Does the nation implement national space legislation with the purpose of supporting international regulation?
International collaboration within research and development	5. Are there specific strategies communicated to enhance international partnerships in space-related research and development?
	6. What are the communicated challenges hindering effective global collaboration in R&D within the space sector?
	7. Does the nation participate in any global space programs?
	8. Is the nation explicitly engaging or aiming to engage in military space_capability development through global collaboration?
	9. Has the nation extended or decreased global collaboration within space defence issues since the last 5 years?
	10. What partnerships within the space domain, to other sovereign nations are highlighted or emphasised as important?
Domestic space industrial capability	11. What are the nation's overarching ambitions for its domestic space industry?
	12. Is there a need to enhance or change the current domestic space industry?
	13. What currently motivates the national domestic space industry?
	14. Has the nation set a clear goal regarding the advancement of its space launch capabilities?
	15. What communicated factors are challenging the growth of the domestic space industry?
	16. Is the nation implementing policies to enhance self-sufficiency within its space capabilities?
	17. In what ways is the national government planning to facilitate growth in the domestic commercial space sector?
	18. Does the nation currently implement or plan to implement national space regulations to benefit commercial companies?

Domestic space research capability	19. How does the nation plan to enhance its space research capability?
	20. What primary research areas within the space domain are communicated?
	21. What limitations are stated for the current space research capabilities?
Threat image	22. What types of threats are perceived as the greatest within the space domain and what are they directed towards?
	23. What types of threats against the nation's access and utilisation of space are communicated?
	24. What military alliances does the nation engage in?
	25. Does the nation prioritise space as a domain for military activity?

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6. Comparing output

The previous chapter presented the development process, and final product, of a method for analysing space strategies. The following chapter presents the results from applying the method on Germany's and South Africa's space strategy, a process described in 4.2.3 *Applying method.* The entirety of the output is presented in Appendix C, while this chapter presents the differences and similarities between the two nations for each category.

6.1 Participation in global regulations for space activity

Both Germany and South Africa emphasise the importance of peaceful and sustainable use of outer space where both nations align their domestic space legislation and policies with international obligations and commitments. Both nations will enact a national space law – the German Weltraumgesetz and South Africa's Space industry Regulatory Bill (SASIRB) – to introduce stricter licensing requirements for the space industry, and monitor requirements for space operations.

Ambitions for international regulation

Only German strategic documents state their membership and participation within the UNCOPUOS where they position themselves as possessing a significant role in shaping the legal framework for space activities. South Africa, in comparison, does not state their participation in UNCOPUOS, but does state their ambition to partake in international and regional forums. Another difference can be found in how the nations address the need to further regulate space activities on an international level. Germany communicates their intent to continue their work in developing a rule-based order in space, establish recognised principles of responsible behaviours in space, partake in the development of an international legal framework and facilitate agreements for safe space exploration. In comparison, South Africa does state an intent to meet the international commitments, but does not state an intent in changing or developing the current order of regulations.

Militarisation is strongly addressed by Germany, where the nation wants to prevent an arms race in space by advocating for a rule-based international order. Furthermore, they engage in negotiations with global partners and are committed alongside allied partners, such as the US, to avoid destructive testing of anti-satellite weapons. Additionally, they intend to draw up a

space security strategy to determine how to engage in space for protection and defence, and to use space to strengthen military capabilities and support national resilience. In contrast, South Africa focuses on their compliance to their international commitments regarding the peaceful use of outer space but does not state any further strategies to address militarisation of space.

6.2 International collaboration within research and development

Both Germany and South Africa state an intent to enhance international partnerships in research and development. Germany will focus on expanding their capabilities through European organisations, such as EU (European Union), EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) and ESA (European Space Agency), while also building relations outside of Europe to reduce technological and economic dependencies. South Africa prioritises partnerships with BRICS and ARMC, aiming to foster collaborative R&D projects and implement a cost-benefit framework for global partnership. The nation aims to be positioned to take advantage of arising opportunities.

Germany further holds key positions in ESA, EUMETSAT and EU space programs such as Galileo and EGNOS. Germany additionally participates in the space programme Artemis Accords with the US. South Africa similarly aims to engage in partnership with the US, where discussions are ongoing with NASA to be involved in an upcoming project. Furthermore, South Africa states that the African space strategy of SADC is in line with their own policy in the domain and their policy to lead development on the continent.

Germany also emphasises defence-related space cooperation within NATO (North Atlantic Treaty Organisation) frameworks, unlike South Africa who only lists defence among one out of 20 priorities for the South African Space Agency. Germany states an intention to increase R&D collaboration on defence relevant space technology to strengthen Europe's technological base. In terms of key partnerships, Germany highlights the US as the most important non-European partner, where Japan and France are further stated as important in regards to their shared space programmes. South Africa highlights its ties to the BRICS member nations.

Challenges

Germany and South Africa both face challenges for collaboration for R&D, albeit differing. Germany faces external obstacles, including the loss of Russian partnership due to the Ukraine-Russian war, complications after Britain's exit from the EU, and stricter export control. South Africa faces internal challenges, stating issues inside the space organisation of insufficient funding and budgetary cuts, competition with other agencies and competing government priorities, lack of strategic direction and dependency on external resources hindering traction for projects.

6.3 Domestic space industrial capability

Both Germany and South Africa have an ambition to enhance their domestic development capability, where both nations have an ambition to facilitate launch-programmes in collaboration with other space faring actors. Furthermore, their respective newly implemented space laws – Weltraumgesetz and the South African Space Industry Regulatory Bill – are both in support of local industry.

Ambitions and strategies for domestic space industry

Germany's space strategy communicates a strong ambition to maintain and expand its technological position on both a European and global level. This will in part be achieved by fostering a domestic space market towards innovation and competition, with a focus on microlaunchers and small satellite value chains. They will further issue national initiatives to intensify the interaction between the public-sector and providers of space services, as they need to foster a space market where private capital can take a prominent role. Germany will also support their domestic industry by financially supporting start-up companies in the space sector, attract and retain highly educated personnel in the sector and promote self-sufficiency in key technologies to ensure national and European sovereignty. The document highlights the German government's plans to facilitate attractive conditions for German space companies, where they intend to use their entire repertoire of funding instruments.

Similarly, South Africa also aims to strengthen their domestic space industry but place themselves as a consumer of technology. An ambition is therefore to create systems which support their own requirements and their local industry. They further aim to take a growing share of the global satellite industry, where they will focus on revitalising existing industries

and stimulate R&D led industrial development. They further aim to introduce policies to support grassroot innovation and local innovation systems In doing so, they will reduce the outflow of local capital to foreign markets, provide growth opportunities for the space sector and contribute to the governments needs. Furthermore, South Africa aims to become a leading nation in the use of space technology, as a means to promote economic growth and sustainable development. Industrial growth should be leveraged to fulfil broader development goals, such as poverty, unemployment and inequality. Thereby, unlike Germany's emphasis on defence and industrial sovereignty, South Africa positioned space technology to support socioeconomic development.

Challenges

Both nations present challenges in the context of enhancing the national industry. Germany expressed competition between the rapidly developing defence industries as a challenge, as well as their domestic market could be insufficient for sustaining long-term value chains. Furthermore, strict export control laws are challenging start-uops and small enterprises in accessing public procurement contracts and financing, where the competition for skilled personnel is challenging all technological sectors. Furthermore, German space industrial companies are primarily focused on institutional users which are in contrast to the trend of commercialisation where Germany must adapt more to global trends such as this.

South Africa highlights the space organisations operational expenses and budgetary constraints, where they state that the agency must focus on revenue generating activities. Furthermore, they point to how the nation has not been able to secure sufficient global market shares, where the national space sector does not keep pace with the global sector. With limited support from SANSA (South Africa National Space Agency) and other state-institutions, the local industry is stagnated and faces unstable financial conditions where there is a limited number of small and medium enterprises, and new companies in the South African industry.

6.4 Domestic space research capability

Both Germany and South Africa are planning to enhance their research capability within the field of space, where both nations plan to promote research both on a national and international arena. Germany intends to promote innovative technologies and involve

research institutions more closely in the space security architecture on a national and European level. For example they will continue to support work sharing between science and industry in contributions for European and national space exploration. South Africa has started several space programs to enhance their research capabilities and intend to support R&D through financing and enhance collaborative partnerships between research and application. In doing so, this can attract international astronomy projects, and promote national infrastructure for research production as well as attract international partnership and funding. South Africa also intends to develop the national space science skills by having SANSA provide opportunities for post-graduate students and run internships.

Primary research areas and challenges

Space exploration is a primary research area for both nations, where Germany related this to risk prevention, disaster management and protecting and sustainably using space. South Africa relates exploration of space and mission driven space science and projects of strategic interests for the region. They aim to use space applications to address challenges within the socio-economic environment, as well as water resource management, protection of ecosystems, and developing civilian applications such as telecommunication.

Germany however further states that major space missions and explorative activities are only feasible through international cooperation due to the costs, complexities and scientific breach. Furthermore, similar to challenges presented by South Africa, Germany states that their technological sector is facing competition for skilled personnel. Similarly, South Africa states a limitation in the nation's higher education system, resulting in a deficiency in PhD competence. South Africa further points to the failure to commercialise the result of scientific research, and SANSA having to focus on revenue generating activities due to them exceeding their funds.

6.5 Threat image

Germany and South Africa have differing threat images, where Germany highlights external threats while South Africa focuses on internal ones. Germany warns of attacks from cyberspace and space, with effects comparable to the impact of armed conflict, necessitating collective action. They further emphasise a need to protect infrastructure, counter espionage, reduce dependency on key technologies and economic dependency to maintain strategic

sovereignty as well as space debris and orbital traffic risks. In comparison, South Africa mainly cites governance issues, including competing government priorities and limited funding, bureaucratic delays, skill loss due to lack of opportunity for personnel, and competition from other African nations' space programmes.

Military alliances and militarisation

Germany is firmly committed to NATO, France and EU defence clauses while South Africa aligns with the Southern African Development Community (SADC) mutual defence pact, and the African Union Non-aggression pact. Space is regarded as a strategic military domain by Germany who aim to expand their military space capabilities and plans to place a larger focus on space as a strategic dimension, further incorporating space into the military domain and enhance the installment of a space command conducted in 2021. South Africa places less emphasis on militarisation compared to Germany, but does relate space activities as a means to defence and peacekeeping.

Germany states that military operational capacities depend on secure access to space satellite communication and navigation and earth observation data. There is thereby a plan to place a larger focus on space as a strategic dimension, to expand their space capabilities, and to strengthen military capabilities via space based systems. Furthermore, they reference the installment in 2021 of a Space command in the German armed forces, further incorporating space into the military domain.

7. Discussion

The results from applying the developed method on Germany's and South Africa's space strategies, as shown in Chapter 6, presents a wide range of ambitions and planned measures to achieve these. In the following sections, the two results of this study – the developed method and the output from using it – are discussed. First, in Section 7.1, ambitions for the two studied nations are discussed from the perspective of their feasibility of being achieved. This discussion is based on the results from applying the method on the two nations strategies and presented literature from Chapter 2. Thereafter, in Section 7.2, the method developed in this study is assessed based on its generalisability and data completeness resulting in suggestions for future research.

7.1 Feasibility of achieving ambitions

Developing space capabilities is a complex pursuit, as it entails possession of adequate infrastructure for development and research of advanced technology, as well as a highly skilled personnel, all of which requiring significant economic resources (Oberg, 1999, pp.44-46; BryceTech, 2017, pp.7-8). This may be why neither Germany nor South Africa have a stated intention to develop domestic space launch capability, as the cost and complexity could be too high for an emerging space power (BryceTech, 2017, p.7). Instead both nations aim to gain access to such capabilities through collaboration with other nations, an effort which could reduce such challenges as in line with the ideas of Peter (2016, p.145). As in line with the analysis of BryceTech (2017, p.8), these emerging nations instead focus on the potential revenue found in the space industry, where both countries discuss their aim of developing space technology for the global market.

7.1.1 South Africa: Economic growth and global collaboration

South Africa aims to take market shares on the growing global satellite industry and go from consumer to *producer* of space technologies. To achieve this, they intend to revitalise existing industries in the nation, stimulate R&D developments and introduce policies to support local innovation systems. In doing so, the economic revenue can be leveraged to decrease socio-economic issues in the nation, such as poverty and unemployment.

However, when these ambitions are reviewed with the stated challenges of the South African space organisation, the feasibility of such ambitions can be questioned. Their main issues are related to governance and funding, where the strategy continuously highlights economic issues – both funding and budgetary – as well as issues in the educational system and lack of direction and sufficient governance. Even if the introduction of some policies may not be a massive cost in itself, their other strategic means to strengthen their industry arguably are. Their intent to revitalise industries and increase R&D developments requires personnel with adequate competence and education. However, this is a communicated deficiency, due to both the insufficient education system, and the current inability to keep key competence within the space organisation due to the lack of opportunities to apply these skills on. Additionally, to achieve these objectives of revitalisation and strengthening of industry will likely require large economic resources - another communicated deficiency. Therefore, while stating an awareness of the potential economic benefits, and do possess some base infrastructure to revitalise, South Africa seemingly lacks the prerequisite resources – economy and skilled personnel – to actually achieve this ambition. Based on this, the feasibility of winning against the global competition to become a key player in the development of advanced technology, seems low.

The stated issues above may be a reason as to why South Africa has a strongly communicated ambition to increase global collaboration in capability development. Primarily, South Africa communicates an intent to strengthen collaboration in BRICS, including nations such as Russia and China. However, they are presenting that they are in *discussion* with the United states through NASA. Perhaps they are willing to disclose such early collaboration with the US to send a message that they are not only tied to BRIC nations, which many western nations may have complicated relations to. By being open about discussions with an external nation outside of BRICS, other nations who are more lenient towards the US as opposed to Russia or China, may be incentivized to also consider collaboration with South Africa. If this is the case, this would be in line with Klein (2006, p.140) and Adams (2019, p.411) who states that collaboration between two nations often require a common objective, and the ideas of Paikowsky (2017, pp.84-85) that the increase of opportunities through collaboration may encourage other nations to also consider partnership.

The feasibility of increasing global collaboration does not seem as unlikely as the first ambition to develop space technology. In this matter, they seemingly do already have a strong basis of partnership to great space powers, such as China and Russia, and moreover are in works to enter collaboration with the US. However, the feasibility of furthering collaborations could be affected by the same issues as the previously assessed ambition. If the South African space organisation continues to face the stated issues of insufficient funding, limited abilities to secure new opportunities, lack of strategic direction, and other threats to resource mobilisation with international stakeholders, this could harm their aim to increase collaboration. With such issues, South Africa may not be regarded as a technologically advanced nation, thereby potentially discouraging other nations from collaborating with them, as proposed by Paikowsky (2017, pp.84-85). If the nation is perceived by others to be unable to contribute financially or with competence to a project, the incentives to engage with such a nation on these factors alone would arguably be low. However, due to their foundational collaboration with BRICS, one could argue that there may instead be political or strategic incentives to engage with South Africa.

7.1.2 Germany: Regulating space and military development

Germany has a strongly communicated ambition to be a driving actor in further regulating space activities. As stated in the documents, they are partaking in the development of new legal frameworks, facilitate agreements on guidelines, provide input in the UNCOPUOS subcommittee, and engage in commitments against destructive tests of anti-satellite weapons. One stated motivator for this is to increase sustainability in the domain, where debris is presented as a significant threat against their access and use of space. Another stated motivator for increasing regulations in space is to prevent an arms race in the domain. As stated by Danilenko (2016, p.180) and De Man (2017, pp.92-93), reaching consensus on these questions is for a variety of reasons difficult. However, as further stated by DeVore and Stai (2019, p.35), nations who share concerns and objectives can create coalitions, which arguably could increase the likelihood of passing proposals, guidelines and regulations in global forums. From this perspective, Germany's stated strong partnerships with NATO as well as their key positions in ESA, EUMETSAT and EU, do introduce the possibility of Germany gathering support from other member countries.

However, it is noteworthy that while Germany is a wide proponent for regulating space activity, they are simultaneously placing large emphasis on the strategic value space holds for their military capabilities. As stated in their strategies, they place efforts in strengthening their military capabilities in space, intend to develop dual use space technology, and aim to contribute to the technological superiority of German and NATO's armed forces. Furthermore, while the nation has committed against *testing* anti-satellite weapons, the strategy does not state a commitment against *possessing* them. As stated by Adams (2019, p.411), cooperation can be affected by military ambitions in space, as other nations may be unwilling to cooperate if they deem such ambitions potentially affecting themselves in the future. As space regulations do serve the purpose of decreasing nations mission abilities in space, nations – even those in current alliance or partnership with Germany – may be discouraged to support such efforts, as Germany themselves are strengthening their military presence in space. Based on these stated aspects, the feasibility of Germany achieving their ambitions of a rule based order in space through further international regulations in space, can be considered low.

From the perspective of an emerging space powers engagement of regulating space, one can theorise on the potential motivator behind the ambition to regulate space, as proposed by Klein (2025, p.220). The author argues that space regulations can be used as a tool for emerging space powers to reduce the power of stronger space powers, as their freedom of activity is further limited. One could thereby regard Germany's ambition to create a rule based order in space, as serving more strategic aims than communicated in their published space strategy. While Germany may very well be aware of the low feasibility in achieving this, it is a non-military tool and arguably does not require the same resources as developing technological space capabilities. Therefore, these efforts could be a small, relatively low cost, action which in the end serve a larger purpose, as in line with Klein's (2019, p.156) view on emerging space power's strategies in space.

7.2 Assessing the developed method and future research

This study developed a method to fulfil a research gap consisting of a lack of methodology to systematically analyse national space strategies. During the method development process in Chapter 5, variables of validity and reliability were acknowledged, where measures were taken to strengthen these: While the function of the developed method is not reliant on using

Parsd, this study's utilisation of the large language model reduced researcher biases, thereby strengthening the reliability of the data collection process. Moreover, a pilot study was conducted to strengthen the internal validity by assessing the functionality of the method before applying it on the space strategies. In the following sections, the variables of *generalisability* of the method – if it can be applied on other space powers – and the *completeness of data* will be discussed. By assessing these variables in relation to this study, suggestions for future research are identified.

7.2.1 Generalisability

The scope of the developed method in this project was emerging space powers. Space powers of this size could have the ambition to increase their power in the space domain (Klein, 2019, pp.157-158). Therefore, it was of interest to study factors of domestic infrastructure and collaboration in R&D as such variables can be a prerequisite to expand one's activities in space (BryceTech, 2017, p.7; Oberg, 1999, p.44; Peter, 2016, p.145). With that said, the definition for *emerging* space power is not firmly established in literature, where the distinction between different sizes of space power is not clear (Klein, 2019, p.96). This project made a categorisation based on Klein's (2019, p.96) criterias on what constitutes the level of space power, determining Germany and South Africa to be emerging space powers. However, the comparison and the subsequent discussion between the two nations in Chapter 6 and 7, illustrate that such emerging powers can have widely different conditions to evolve from, and varied degrees of ability to further develop. As such, the method has presented good results in being used on two different emerging space powers, increasing its generalisability for other emerging space powers.

The method was not developed for, nor applied on, Klein's (2019, p.96) defined great or medium space powers. However, the lack of differentiation between the different sizes of power introduces a possibility of further generalisability of the method, as there is potential of the method having applicability on these sizes as well. While a medium or a great space power may not have the same incentives as an emerging nation to develop satellites as opposed to investing in space launch as stated by BryceTech (2017, pp.7-8), such nations do arguably possess and will continuously require the same prerequisite infrastructures as emerging nations, to maintain or strengthen their current mission abilities in space. Therefore, it would be of interest to test the wider applicability of this project's developed method. One

suggestion for future studies is therefore to apply this method on varying levels of space powers.

7.2.2 Data completeness

A limitation persists when studying national space strategies. As emphasised in Section 1.4 and again in Section 4.2.4, published national strategic documents are likely skewed, and arguably only communicate well considered statements. If the intention is to study space strategies, this issue will arguably always be a factor. Results from solely studying such strategies will therefore likely never hold as a complete, or necessarily true, picture of the strategic intentions of a nation. One suggestion for future studies is therefore to apply this method on strategic documents, and compare the output to the actual behaviour of the nation in space. One approach to this could be to involve protocols from UNCOPUOS forums, providing data on what proposals the studied nation actually is voting for. In doing so, the discourse between what a nation says and what they actually do can be assessed, presenting a more complete picture of the strategic direction of the nation.

Finally, all but one measurable of the method could be answered by the German and South African space strategy. This one measurable, "*Has the nation extended or decreased global collaboration within space defence issues since the last 5 years?",* is notably the only temporal variable in the method. While such a variable was deemed an interesting factor to consider as it can indicate the direction of ambitions and progress over time, the method developed in this study is not sufficient to answer this. This issue is arguably linked to the strategic document's character of guiding the current and future direction of the space organisation instead of the past. The final suggestion for future studies is therefore to apply the method on strategic documents from two different time spans. In doing so, the researcher could compare how the output for each measurable and category differs between the years, providing potential insight into whether the nation is progressing or regressing in relation to their ambitions.

8. Conclusion

This project was conducted for the purpose of contributing to Sweden's resilience for threats against space based systems. It was identified that a prerequisite to achieve this was to monitor space faring actors activities and behaviours in space. As national space strategies often communicate a nation's objectives in space, and moreover their political and strategic motives (Klein, 2019, p.27. 49; Westman *et al.*, 2023, p.15), it was of interest in this study to analyse such strategies . It was further identified that in the field of methodology for studying space strategies, there is limited research. Therefore, a research question was formulated to bridge this research gap: "*How can national space strategies of emerging space powers be systematically analysed?"*

To answer this question, a method was developed. The first stage of the development process of this method used a framework by Enserink *et al* (2022), where three analyses were used to narrow and define the scope of the method. During this process, related work in the field of space from authors such as Klein (2019 and 2025), Oberg (1999), Hallgren and Westman (2021), Peter (2016), and Paikowsky (2017), was used to map variables involved in nations space activities. After a scope had been defined, five categories was determined to be the focus of the method:

1) *Participation in global regulations for space activity*
2) *International collaboration within research and development*
3) *Domestic space industrial capability*
4) *Domestic space research capability*
5) *Threat image*

For each of these categories, a set of questions were formulated and termed *measurables,* where each were tested in a pilot study conducted on the Australian space strategy. These measurables serve the purpose of guiding a researcher during data collection where each measurable can be used to organise data into its related category. Once this step has been conducted, a researcher could thereafter – based on the purpose of their own study – either study one nation's ambitions and limitations in a specific category, or assess the overall strategic direction and feasibility of the space organisations ambitions based on all five

categories. Furthermore, a researcher could compare the capabilities from one or several categories to another nation's results. Thereby, a method has been developed which can be used to systematically analyse emerging space powers space strategies.

This study wanted to further test the method on two national space strategies, and toidentify differences between the two strategies. Therefore another research question was formulated: "*When applying the developed method, what similarities and differences in the ambitions and priorities can be identified between emerging space powers?"*.

To answer this, the developed method was applied on Germany's and South Africa's national space strategies by using the large language model *Parsd.* All measurables of the method, except for one, could be answered by the two space strategies.

The output from using the developed method presented many findings, which included: a similar ambition to develop space launch capabilities through collaboration with other actors, produce and sell satellite technology and implement policies to support indigenous space capability development. Further differences identified included: varying communicated engagement in further regulating space activity, differing view of threats against their space activities, and a comparably contrasting focus on military utilisation of space.

These results were further discussed from the perspective of the feasibility of some of the main identified ambitions. This assessment theorised that South Africa's ambition to generate economic growth through developing space technology is challenged by issues of governance, economy and insufficient educational system. Furthermore, it was argued that these issues affecting South Africa's domestic industry capability, could further challenge their ambition to increase collaboration with other nations. The feasibility of South Africa achieving their ambition of gaining shares on the global market for space technology was therefore deemed low. The feasibility of increasing collaboration with other nations was, albeit facing potential challenges, however determined to be higher.

Similarly, the feasibility of one of the main ambitions for Germany – to create a rule-based order in space through international regulation – was also assessed as low. This is in part due to the intrinsic difficulty in reaching consensus in UN space forums as identified by Danilenko (2016, p.180) and De Man (2017, pp.92-93). Furthermore, it can also be attributed

to Germany's aim to increase military incorporation in the space domain and develop military space capabilities. Such ambitions could have a discouraging effect on nations who otherwise could support Germany's propositions in the UN, as nations may not desire to restrict their own freedom in space while Germany is strengthening their own capabilities.

Conclusively, this study was able to answer the two research questions. The result points to the methods' applicability on nations with varying capabilities, as Germany and South Africa – albeit both considered emerging space powers – are different. As the distinction between varying sizes of space power is diffuse in literature, the method could possibly work on medium and great space powers as well, presenting one suggestion for future studies. Furthermore, this study proposes future researchers to include data from the actual behaviours of nations such as how a space power actually has voted in UNCOPUOS. By including this, one can study the discourse between their communicated strategic aims compared to their actual behaviors. A final suggestion for future studies further propose applying the method on strategies from two different time spans, thereby also considering a temporal variable. This could present an additional dimension when assessing a nation's ambitions, and potential future behaviours in the space domain.

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Appendix A - Emerging space powers

Nations used in the selection process. The listed nations are countries who between 2020-01-01 to 2025-03-07 have had active satellites, as well as no current nor historic satellite launch capability.

Land code	Amount of satellites
DEU	27
ESP	25
ARG	22
FIN	20
AUS	18
TUR	18
CAN	18
CHE	13
SGP	11
NOR	11
TWN	8
BEL	8
RWA	6
BRA	5
BGR	4
THA	4
EGY	4
POL	4
LUX	4
NLD	3
LTU	3
ARE	3
CZE	3
IDN	2
SVN	2
SWE	2
MAR	2
MYS	2
DJI	2
PRT	2
AGO	1
ZAF	1
PAK	1
KWT	1
HUN	1
HRV	1
DNK	1
COL	1
CHL	1
AUT	1

Appendix B - Pilot study documents

Documents used in pilot study.

Nation	Title	Year	Source
Australia	Space Power eManual	2022	The Australian government Department of Defence
Australia	The 2020 Force Structure Plan	2020	The Australian government Department of Defence
Australia	The 2020 Defence Strategic Update	2020	The Australian government Department of Defence
Australia	Lead the Way: defence Transformation Strategy	2020	The Australian government Department of Defence
Australia	Australia’s Defence Space Strategy	2022 (updated 2023)	The Australian government Department of Defence
Australia	The Australian Civil Space Strategy 2019-2028	2019	Australian Space Agency

Appendix C - Output from applying method

(1) Is the nation actively engaging in UNCOPUOS (the United Nations Committee on the Peaceful Uses of Outer Space) regulatory discussions of space?

[**Germany]** Germany is an active member of UNCOUPUS, where the nation is partaking in the development of an international legal framework for space activities and facilitating agreements on guidelines, standards and norms for sustainable space exploration and use (FGSS, p.17). Germany is furthermore providing input to the UNCOPUOS legal subcommittee in the established space resource working group, and addresses the responsibility of enhancing the international use of space within the UN framework (FGSS, p.43, 54).

[South Africa] The document does not specifically address the UNCOPUOS forum, but they do state that they intend –through their national Space Affairs Act– to meet all the international commitments and responsibilities of the nation in respect to the peaceful utilisation of outer space, and to be recognised as a responsible and trustworthy user of the outer space (NSS, p.15-16).

(2) What strategies is the nation implementing to address the issue of global space militarisation?

[**Germany]** Germany is working to strengthen and further develop the rules-based order in space based on international law, where the nation seeks to establish internationally recognised principles of responsible behaviour in space (NSS, p.63). Additionally Germany seeks to establish internationally binding rules and measures that support the peaceful and sustainable use of space, reducing hazards space activities and preventing arms races in space, and is therefore actively partaking in relevant negotiations and working groups within the UN alongside its partners and promotes dialogue in regards to security (FGSS, p.37). Germany has, in cooperation with the US and other partnering countries, committed itself voluntarily against the destructive tests of ground based, air based or sea based anti-satellite missiles (NSS, p.63; FGSS, p.37).

The government will draw up a space security strategy to set down future strands of action for protection and defence in space, as well as on measures to support national resilience and describing ways to use space to strengthen military capability (NSS, p.63).

Additionally, Germany is establishing a space situational awareness, which is considered a joint civilian-military task which will set up a network of sensors spanning the globe in collaboration with international partners (NSS, p.63). Germany further supports the development of an EU approach for a Space Traffic management system, and is enacting a national space act to enhance sustainability in the space sector by establishing permit and monitor requirements (FGSS, p.44, 46).

[**South Africa]** The document states that the South African Space Affairs Act is updated to meet international commitments and responsibilities regarding the peaceful use of outer space (NSS, p.15-16).

(3) Is the nation addressing a need to further regulate space activities through international agreements and regulations?

[**Germany]** Germany is working to strengthen and further develop the rule based order in space based on international law, and seeks the establishment of internationally recognised principles of responsible behaviour in space to mitigate the risk of escalation and conflict (NSS, p.63). Furthermore, the nation is partaking in the development of an international legal framework for space activities, and facilitating agreements on guidelines, standards and norms for safe, sustainable space exploration and use (FGSS, p.17, 37, 40, 44).

[**South Africa]** South Africa intends to meet all the international commitments and responsibilities of the Republic in respect to the peaceful utilisation of outer space and control the development, transfer, acquisition and disposal of dual-use technologies in terms of international conventions, treaties and agreements entered or ratified by the government (NSA, p.15-16). Additionally, the text mentions strategic cooperation and collaboration through international and regional forums and established scientific protocols (IP, p.30).

(4) Does the nation implement national space legislation with the purpose of supporting international regulation?

[Germany] The nation is aiming to enact a national space act – Weltraumgesetz – which would enhance sustainability in the space sector by establishing permit and monitoring requirements for space activities. This includes provisions for Germany's fulfillment of its legal obligations under the Outer space treaty, will help prevent the creation of space debris and will contribute to the sustainable and safe use of space. (FGSS, p.44, 46).

[**South Africa]** The nation has implemented the Space affairs act, which is currently updated, to meet all the international commitments and responsibilities of the government in respect to the peaceful utilisation of outer space (NSA, p.15-16). Furthermore, The South African Space Industry Regulatory Bill will be promulgated to limit liability to the state in terms of UN treaties and conventions by imposing new licensing requirements on local industry, increasing the national space agency (NSA, p.17).

Finally, SANSA (the south african national space agency) is under the SANSA act of 2008, which provide power to the relevant department to implement agency for the space programme, where one of the agencies objectives is to promote peaceful use of outer space (NSA, p.16; IP, p.25).

(5) Are there specific strategies communicated to enhance international partnerships in space-related research and development?

[**Germany]** The government will, at national and European level – ESA and EU – further increase its development of space technologies and the establishment and operation of space infrastructures and services in regard to dual-use applications (NSDI, p.9).

The nation further wants to expand its international cooperation and partnerships with selected partners which include partners outside of ESA, EUMETSAT and the EU, with the aims of reducing technological and economic dependencies on certain key technologies and facilitating joint research activities (FGSS, p.17). To this end, they are strengthening the development of bilateral and multilateral cooperation between Germany and important partner countries (FGSS, p.17) Germany is working to ensure that ESA retains its independent status as a space agency for its members, and should be strengthened for the future role as a provider for Europeans space systems and technologies where Germany supports the organisation's ongoing development (FGSS, p.16). It is further stated that international cooperation supports countries that are seeking to build space programmes, as it enables them to participate in the development of the global space economy, and of cross-sectoral use of space data (FGSS, p.17).

Finally, some documents discuss research and development collaboration strategies within a general defence domain – therefore not space specific but where space is considered a domain.

It is stated that the government is committed to promoting transatlantic start-ups within the scope of NATOs innovation initiatives to strengthen defence-oriented start-up and venture capital ecosystem therefore making a sustainable contribution to securing the technological superiority for german and NATO armed forces (NSDI, p.13). Furthemore, Germany will intensify its worldwide defence cooperation with proven partners specifically in the Indo-pacific, through defence diplomacy, military presente and reliable armament cooperation and capability building (DPG, p.15, 32).

[**South Africa]** The documents state that SANSA will focus on partnership frameworks such as BRICS (Brazil, Russia, India, China and South Africa) and ARMC (the African Resource Management constellation), where such are strong strategic partnerships SANSA is currently engaged in (NSA, p.45). Furthermore SANSA will engage in collaborative projects and resource sharing with the international community through formal memorandums of understandings or agreements. The organisation will work with DSI to ensure the nation is positioned to take advantage of any other opportunities that arise with regional or global partners, where this include piggybacking on pre-existing and new bilateral agreements interagency and intergovernmental (NSA, p.45-47). SANSA will also position their experts to take seats on international committees that respond to global challenges ensuring South Africa's reputation in the global arena (NSA, p.47; IP, p.30).

One key enabler is to develop a clear partnership strategy and enter formal strategic partnerships aligned with such a strategy, to actively participate in multinational forums, enter into long-term funding agreements with partners and to develop and implement a cost-benefit framework for partnership and ensure monitoring and reporting of all partnership engagements (NSA, p.66).

(6) What are the communicated challenges hindering effective global collaboration in R&D within the space sector?

[**Germany]** A bilateral cooperation is no longer possible with Russia in the light of its war of aggression in violation of international law against Ukraine (FGSS, p.8).
Additionally, the UKs departure from the EU in 2020 has affected the European space sector where new forms of association with the UK, which now has a third-country status, must be found (FGSS, p.7-8). Furthermore, it is stated that in an effort to counter uncontrolled access to security relevant security relevant key technologies, we are continuing to apply restrictive export controls, on the basis of existing international export-control regimes and national foreign trade law (FGSS, p.40).

[**South Africa]** One communicated challenge towards global collaboration is the underperforming economy and resultant budgetary cuts which pose a significant risk to SANSAs collaboration and resource mobilisation efforts with local and international stakeholders (NSA, p.29). Furthermore, challenges of insufficient funding to achieve full mandate, lack of common identity and strategic direction, lack of capability and limited capabilities to secure new opportunities, competing government priorities along with unhealthy competition within NSI (national system of innovation) and finally external dependencies hindering gaining traction for key project are also communicated as current hindrances for the organisation, (NSA, p.43-44).

(7) Does the nation participate in any global space programs?

[**Germany]** Germany is a key partner with ESA and the largest contributor and participator in major joint research and development programs (FGSS, p.16). The nation is working towards ensuring ESA independence status as a space agency for its member states (FGSS, p.16). Germany also collaborates closely with EUMETSAT to help retain its important role in provision and support of applications based on Earth system observation and is the biggest contributor to the organisation (FGSS, p.15-16). They collaborate closely in contracting for operating Earth observation satellites (FGSS, p.15). Germany also intends to continue taking an active role in the EU SST programme, and is currently involved in EU space programmes such as Galileo, EGNOS, Copernicus and IRIS². Germany additionally participates in global space programs such as the US initiative of Artemis Accords, the Franco-german MERLIN climate mission, the GRACE experiment with the US, and programmes with the ECMWF (FGSS, p.17, 28, 40).

[**South Africa]** South Africa is a member of SADC (the southern African development community) where its implementation of the African space strategy and space policy are fulfilling the nations foreign policy to lead development on the African continent (NSA, p.3,6). Additionally the nation is a member of BRICS (Brazil, Russia, India, China, South Africa partnership), and ARMC (the African resource management constellation) (NSA, p.45). Furthermore, the nation is engaged in discussion with NASA to be engaged in the establishment of a DSN site, which would strengthen South Africa's ground station (NSA, p.78), and involved in the superDarn network which provides SANSA with access to a global network of instruments (NSA, p.77). Finally, South Africa is bidding to host the Square Kilometre Array, a large radio telescope and developed the Astronomy Geographical Advantage Programme to attract international astronomy projects (IP, p.14).

(8) Is the nation explicitly engaging or aiming to engage in military space capability development through global collaboration?

[**Germany]** The German government will further increase its development of space technologies and the establishment and operation of space infrastructures and services with regard to dual-use applications at the national and European level via EU and ESA (NDSI, p.9; FGSS, p.23). Germany takes the opportunity to cooperate on development of defence relevant space technologies, and thereby help strengthen Europe's technological industrial base in the framework of the European Defence Fund (FGSS, p.15).

The document further states that Germany aims to expand its space capabilities and further work towards developing the international order in space (NSS, p.15-16). Additionally it is stated that the allied defence encompasses cyberspace and space, and attacks in or from these dimensions can have the magnitude and impact of an armed conflict (NSS, p.32). Furthemore, the expansion of space capabilities can play a major role in collective deterrence and defence in NATO (NSS, p.33).

The strategy calls for the government to establish guidelines, in the framework of a space security strategy for protection and defence in space, and for greater national resilience within this domain and to define measures for strengthening military capabilities via space-based systems (FGSS, p.37). Contribution to the national situation picture in space is a part of the national and multinational approach to security (DPG, p.14).

Albeit stated in the context of the entire German defence domain, and not specifically space, the government is committed to promoting transatlantic startups within the scope of NATOs innovation initiatives to contribute to securing the technological superiority of the German, and NATOs armed forces (NSDI, p.13). Additionally, there is an aim to retain and further develop key technologies, as well as promoting cooperative, especially European and transatlantic partnerships within the research, development and use of capabilities (DPG, p.19).

[**South Africa]** The nation's document does not explicitly communicate global collaboration in relation to military capabilities. They do mention that one of 20 priorities for the national space programmes are defence, peacekeeping and treaty monitoring (NSA, p.24). Additionally, they aim to provide products and services developed mostly for defence, aviation and energy sectors where they mainly serve communication and navigation applications (NSA, p.76).

(9) Has the nation extended or decreased global collaboration within space defence issues since the last 5 years?

[**Germany]** No data.

[South Africa] No data.

(10) What partnerships within the space domain, to other sovereign nations are highlighted or emphasised as important?

[**Germany]** The United States is Germany's most important, non-European partner (FGSS, p.8). Furthermore, Japan is mentioned in the context of the joint DESTINY+ and MMX missions and France in relation to the MERLIN climate mission (FGSS, p.18, 54, 16). Additionally, India, Australia, New Zealand, and Singapore are listed as nations that have expanded their space activities, and are thereby regarded as attractive partners for cooperation (FGSS, p.8).

[**South Africa]** The documents state that partnerships (within BRICS) with India, China, Russia and Brazil are important

(11) What are the nation's overarching ambitions for its domestic space industry?

[**Germany]** The overarching goals are to further increase the development of space technologies and establish and operate space infrastructures and services in regard to dual-use application at national and European level (NSDI, p.10). Germany aims to maintain and expand its leading technological position and competitiveness of its space industry on a national, European and international level (FGSS, p.15). They will foster a space market oriented to competition and innovation with the ambition of German companies being able to successfully position themselves within the international competition in the value chain for small satellites and microlaunchers (FGSS, p.21-22). Furthermore, they aim to develop new types of financing to support space sector start-up companies (FGSS, p.22). Additionally, Germany aims to attract and retain highly trained personnel to the space sector which includes scientists, engineers, IT specialists and public administrators (FGSS, p.9).
There is an ambition to expand space situational awareness capabilities as a joint civilian-military task (NSS, p.33, 63).

Additionally, there is an aim to draw up a space security strategy determining the future strands of action for protection and defence in space, as well as measures to enhance national resilience and ways to use space to strengthen the military capability (NSS, p.63).

Germany further states a desire to develop international order in space (NSS, p.16). It is stated they aim to define guidelines for the responsible use of new technologies to ensure that ethical and legal standards are upheld at an international level (NSS, p.32). Furthermore, as Germany prioritise sustainable and safe use of space, they aim to reduce negative impacts of space activities, and plan to make their space activities ambitious needs-oriented and respond appropriately to the growing challenges in the area such as resilience and protection of their space based system (FGSS, p.5-6).

[**South Africa]** Several ambitions for the national space industry are communicated. The nation aims to become a key contributor to global space science and technology with a growing satellite industry, along with an aim to develop a range of innovations in space sciences, earth observations, communications, navigation and engineering (IP, p.13; NSS, p.20). One aim is to have independent earth observations- high resolution satellite data available for all of Africa, as well as undertake at least one launch from their territory in partnership with another space nation (IP, p.15). Furthermore, the nation aims to be a leading nation in the innovative utilisation of space technology and science to enhance their economic growth and sustainable development to improve life for everyone (NSA, p.20). This goal includes to capture a global market share for small-medium size space systems through fostering and promoting innovation and industrial competitiveness, to empower decision making through integration of space based and ground based systems (NSS, p.20, 5).

Finally, an aim is to contribute to the issues of poverty, unemployment and inequality where one strategic outcome of the space agency in this regard is to utilise knowledge for economic development, with a focus on revitalising existing industries and stimulating R&D led industrial development (NSS, p.3). The nation aims to reduce the outflow of local capital to foreign markets and increase the market share of the global space industry (NSS, p.6).

(12) Is there a need to enhance or change the current domestic space industry?

[**Germany]** The document states that there is a need to further increase the development of space technologies at a national and European level (NSDI, p.10).

The government plans to expand its space capabilities, such as its space situational awareness capabilities and their SSA centre, so that these can be utilised within the collective deterrence and defence of NATO and to enable appropriate response to incidents in space (NSS, p.33, 63). It is further stated that the German space sector needs to adapt to global trends towards commercialism and digitalisation, where there is an ambition to foster a space market oriented to competition and innovation, with a more prominent role for private capital (FGSS, 13, 21). The government is additionally facilitating the trend toward small satellites via the NewSpace Small Satellite Initiative (FGSS, p.22), and plans to initiate a space innovation Hub to intensify the interaction between public-sector consumers and providers of space services (FGSS, p.23). Finally, the government calls for a new approach in the development and procurement of launch services in Europe, Emphasising greater intra-European competition between private companies (FGSS, p.18).

[**South Africa]** The document states that South Africa has to date primarily been a consumer of space technologies, and there is a need to develop systems and subsystems which support their requirement and grow the local industry (IP, p.13). The aim is that by 2028, South Africa should be an important contributor to global space science and technology (IP, p.13). A core objective is to win a growing slice of the global satellite industry, but earth observations, communication, navigation, engineering services and expertise development are targeted space programs of developing (IP, 13-14). Furthermore, changes are implemented to change the current situation where South Africa has a limited capability to effectively address all the needs of the country, by building an indigenous space capability to fulfill their own, and the continent's needs (NSA, p.5).

The document further states that SANSA needs to chart a new trajectory to ensure that the sector is able to develop and compete globally - while also responding to the critical needs of the citizens. This includes reducing the outflow of local capital to foreign markets and an increased market share of the global space industry as well as possessing a broader spectrum of products and services that assist in facing the nation's socioeconomic environmental challenges (NSS, p.6). There is therefore a need to direct efforts to transform the space sector to increase the pace of the industry, have a healthy number of SMEs and new entrants as opposed to the current limitation, less reliance on international data vendors and create a robust financial sustainability of the industry (NSS, p.40).

(13) What currently motivates the national domestic space industry?

[**Germany]** The documents state that free and unimpeded use of outer space is vital for the nations security, where especially satellite communication, navigation and earth observation satellites are indispensable for both civilian and the military sphere (NSS, p.15, 62, FGSS, p.38). Space, and its programmes and space-based infrastructure play an important, and increasingly important role in national security (FGSS, p.37). It is further stated that space is of strategic relevance for the German military capability (DPG, p.11). Furthermore, space is seen as a growth market where it is stated that the value of the global space market will exceed 1.1 trillion us dollars by 2040 where Germany aims to support german space companies to be well positioned for international competition (FGSS, p.9, 21). Furthermore, the space sector and its emerging high-tech developments are among the research and economic areas that make Germany "future proof" (FGSS, p.9). To invest in the domestic space industry is a way to retain and further develop national key technologies and further promote cooperation, especially European and transatlantic partnerships within R&D, and space programs further inspire more young people to engage in STEM fields (FGSS, p.5,9).

Finally, the documents state that for the entire German defence sector, not specifically for space, a strong national (and European) defence industry is essential for the armed forces' preparedness for the future (DPG, p.32). Furthermore, it is stated that to help retain and further develop national key technologies is one of the missions of the armed forces, and that there is a need to maintain strategic sovereignty including a dependency on foreign suppliers for key technologies (DPG, p.19; NSDI, p.8).

[**South Africa]** The government has proposed a national space agency for South Africa to address environmental and resource management, safety and security, and innovation and economic growth (IP, p.13). Albeit not specifically for the space sector, it is stated that science, technology and innovation can help their society navigate geopolitical shifts, climate change and other growing trends, as well as addressing challenges (STI, p.11, 15).

As the space agency is an entity of the government, they have a responsibility towards the citizens of South Africa, and should therefore address poverty, unemployment and inequality by promoting South African development (NSA, pp.3-6). To ensure sustainable development, economic growth and improvement of life for everyone, efforts in delivering space data and technology to improve decision-making through the integration of space-based systems with ground-based systems for providing the correct information products at the right time to government and the private sector, are therefore made.

(14) Does the nation have an ambition of developing an independent space launch capability?

[**Germany]** Document emphasises that unhindered and independent access to space is a key element in Europe's strategic sovereignty and is indispensable for achieving political, economic and societal goals related to space programs (FGSS, p.18). Germany is therefore working with ESA to facilitate a competitive approach to launch-vehicle procurement, as well as support the Ariane 6 (launch system), and has initiated a micro-launcher competition to promote the developments within the micro launcher sector (FGSS, p.18, 23).

[**South Africa]** South Africa has stated that by 2018 the nation should have undertaken at least one launch from their territory in partnership with another space nation, and have in place a 20 year launch capability plan (IP, p.15).

Additionally, the documents state that it is necessary that strategic facilities in the space value chain reside in SANSA and that the aspiration of developing facilities has a strategic alignment to the strategic requirement in terms of independence from other launch providers (NSA, p.79). Finally, the nation states that they aim to be among the leading nations in the innovative utilisation of space science and technology with the purpose to enhance economic growth and sustainable development (NSA, p.20).

(15) What communicated factors are challenging the growth of the domestic space industry?

[**Germany]** For the overall domestic defence industry, not explicitly stated for the space domain, it is stated that the domestic market could be inadequate for sustaining long-term value chains (NSDI, p.6). Furthermore, competition from other nations is expressed, where national industry is in competition with other rapidly developing defence industries (NSDI, p.6). It further stated that strict regulations could restrict the expansion of sales markets, SMEs and start-ups are facing challenges in accessing public sector procurement and financing (NSDI, p.6).

For the domestic space industry, the documents state that germany companies are strongly focused on institutional users which is in contrast to the global trend toward commercialisation (FGSS, p.10). There is additionally a global competition for skilled personnel where all technological sectors, including space, is facing this challenge (FGSS, p.9).

[**South Africa]** The document states several factors which are challenging the local space industry, where they state that South Africa has primarily been a consumer of space technologies, but they need to develop systems and subsystems to support their own requirements and to grow their local industry (IP, p.13). However, this is hindered by the space organisation not being able to provide the support expected of it to the broader South African space sector which has resulted in less than optimal growth and the development of the industry (NSS, p.6).

Furthermore, the documents state that SANSAs operational expenses have exceeded its parliamentary grant which implies that they now must generate their own revenue sources to ensure the continuation of operations and must focus on revenue generating activities (NSS, p.6). However, The South African space sector has not been able to secure an appreciative level of the global market share. While the global space sector has grown steadily, the South African space sector has not kept pace (NSS, p.6, 40). Additionally, the local industry is stagnated with a limited support from SANSA and other public sector institutions, the financial sustainability of the industry is unstable, the reliance on international data vendors result in limited local benefits, there is a slow pace of transforming South African industry and finally there is a limited number of SMEs and new entrants (NSS, p.40).

(16) Is the nation implementing policies to enhance self-sufficiency within its space capabilities?

[**Germany]** It is stated that space technologies is a key security and defence industrial technology and whose national availability is in the interest of national security, where one aspect is maintaining the security of its supply (NSDI, p.8). The documents further emphasise the importance of unhindered, independent access to space for European sovereignty (NSS, pp.18). It is further stated that Germany (and Europe) need to have their own capabilities for launching satellites, protecting communications and obtaining real-time space information (FGSS, p.2). Germany therefore supports European space programs to support Europe's technological and strategic sovereignty (FGSS, p.16). An example is the European launcher competition approach within launch vehicle procurement in collaboration with ESA to prepare for independent access to space (NSS, p.18)

Furthermore, germany want to reduce technological and economic dependencies on certain key technologies and facilitate joint research activities, and state that their strategy aims to promote basic conditions for german space companies to foster a space market oriented to competition and innovation, with a significant role for private capital alongside the public sector (FGSS, p.21). However, the document further emphasizes the importance of cooperation to address challenges for example through its space situational awareness establishment which will link global partners (NSS, p.63).

[**South Africa]** The nation aims to develop systems and subsystems to support their requirements and local industries, such as independent earth-observation satellite data available for all of Africa, launch from their territory in collaboration with other nations, co-build domestic and regional communications satellite and construction of a radio-astronomy telescope (IP, p.13, 15). They also aim to develop applications for telecommunication, timing, geospatial and positioning products and services to help position the national space program in the forefront and contribute to the national space policy in accordance with the government's needs (NSS, p.5).

Furthermore, the primary objective of the national space policy is to promote capacity building initiatives to develop capacity in space science and technology, facilitate the provisions of adequate space capabilities to support their domestic and foreign policy objectives, and to promote the development of a competitive domestic commercial space sector to provide the industrial base to meet the nations need for space technology (NSS, p.18).

(17) In what ways is the national government planning to facilitate growth in the domestic commercial space sector?

[**Germany]** The document states that the german government plans to create attractive basic conditions for german space companies to facilitate a space market oriented to competition and innovation, where private capital plays an important role alongside the public sector (FGSS, p.21). Additionally, it states that to address the dynamic trends and the needs of new companies trying to establish themselves within the space market, it is necessary to use the entire repertoire of funding instruments, and to expand it as appropriate. An example of this is by using functional specifications for tenders giving companies opportunities to capitalise on their agility, or by using approaches such as "anchor customers" which can provide entrepreneurial security and facilitate access to private capital (FGSS, p.21)

There is also an aim to ensure the availability of a complete financing chain, including venture capital from start up to market access for example by bringing in capital from german and European investments and expanding the existing early-phase support existing within germany to include suitable instrument and federal investments for the growth phase (FGSS, p21). It further states that the government wants to support space-sector startups in developing new types of financing especially from private sources, as well as in acquiring public sector funding (FGSS, p.22). The government will also promote the transfer of knowledge and technology from German space research to benefit the space industry and other sectors, where the space industry learns from other sectors which can make use of new technologies and become more effective and efficient. (FGSS, p.22).

Finally, the government states the desire of German companies successfully being able to position themselves within the international competition in the value chain for small satellites and microlaunchers (FGSS, p.22). Albeit not directly referring to the space domain, but the general domestic defence industry, the government intends to promote innovative technologies, at national and European level and opening up instruments for start-ups and innovative companies for dual-use applications such as financial support (NSDI, p.9-10).

[**South Africa]** The nation is aiming to shift South Africa's position from a consumer of space technology to a developer of domestic systems and grow the local industry (IP, p.13). To achieve this several thematic areas are in focus of development:

- Space science: where they are planning to host a large radio telescope (Square Kilometer Array), and they have developed the Astronomy Geographic Advantage Programme, to attract global astronomy projects, and attract international investment (IP, 14).
- Expertise development: where they aim to develop critical mass in expertise from radio-frequency engineering, system engineering and software or propulsion development given as examples (IP, p.15).
- Energy and economy: where energy supply infrastructure must be increased to facilitate the growth rate of the space economy which include a more structured planning process between the government and private sector where the government intends to place greater reliance on nuclear power, natural gas and renewable energy.

SANSA further states that in order to promote innovation and industrial competitiveness on a global market they introduce several policy shifts such as enhancing the innovation in society and government, will develop a more enabling environment for innovation, local innovation systems and support grassroot innovation (NSA, pp.20-21). Additionally, South African space organisation has established programmes, such as “The space engineering program” which drives satellite building with primary contractors, R&D institutions and private sector partners to facilitate the private space industry partnership (NSA; p.73), and the ZASpace Inc. to be used to collaborate with industry and provide opportunities for the growth of the space sector. (NSA, p.48).

(18) Does the nation currently implement or plan to implement national space regulations to benefit commercial companies?

[Germany] The German government is aiming to enact a national space act (Weltraumgesetz) that would enhance sustainability in the space sector by establishing permits and monitoring demands for space activities. This would provide guidelines and support innovation and competition among space companies (FGSS, p.46).

[South Africa] The nation's newly reviewed South African Space Industry Regulatory Bill marks a policy shift from the control of dual-use technology to the stimulation and support of the local industry (NSA, p.17). The Act limits the liability to the State in terms of UN treaties and conventions, and this will be done through imposing new licensing requirements upon the local industry, including SANSA (NSA, p.17).

(19) How does the nation plan to enhance its space research capability?

[Germany] The government plans to promote innovative technologies at national and European level and plan to involve research institutions and private stakeholders more closely in the space security architecture (NSDI, p.10; NSS, p.63).

It is further stated that Germany will continue to pursue excellent space research and support the production and use of research findings (FGSS, p.50). Furthermore, the German government will continue to support effective work sharing between science and the space industry in the development and construction of instruments for space-based telescopes, detectors, and scientific probes where they aim to make an important contribution to European and national space exploration (FGSS, p.50). Additionally, they want to ensure that the thematic structure of ESAs new Voyage 2050 science program considers Germany's interests within science and to continue Germany's leading role in the development of scientific instruments (FGSS, p.50).

Finally, when the ISS programme ends, germany plan to establish an expert group which will develop various option for the post ISS scenario to ensure that the interests of future users are considered within decision making of ESA, where the government can participate and create opportunities for german industry and research (FGSS, p.51).

[**South Africa]** The nation has started several space programmes to enhance their research capability. The Astronomy Geographical Advantage Programme and the Square Kilometre Array, and use local talent and viewing conditions to attract international astronomy projects (IP, p.14). Furthermore, programmes within areas such as space science, earth observations, communication, expertise development and navigation have been established by SANSA to develop competence (IP, pp.13-15).

The strategy further states that in order to increase the space research output, they will, amongst many examples, develop and implement a clear national space R&D plan, promote research production and provide national r&D infrastructure platforms such as data centres and facilities (NSA, p.61). They will furthermore make sure that there is a stronger connection between research and application, support R&D through funcing, collaborative partnership from the space agency, and supervision and attract international partnership and funding (NSA, p.61). Finally, SANSA states that they will develop the national space science skills base by providing opportunities for postgraduate research support to students, run internships programs, partner with international and national universities and provide the necessary infrastructure (NSA, pp.63-64).

(20) What primary research areas within the space domain are communicated?

[**Germany]** The document state that exploring, protecting and sustainably using space are some key research areas where research within astronautics and exploration of space and its impacts on emergence of new value chains on earth, environmental protection, risk prevention and disaster management is studied (FRIS, pp.9-10; FGSS, p.10). Other key research areas within the space domain are communications and navigation, quantum technologies, robotics, application oriented research for the industry and innovative data processing technologies (FGSS, p.10).

[**South Africa]** Several areas of research are stated in the documents. Earth observation is one area where an aim is to increase knowledge and expertise in the development of such space applications to address challenges within the socio-economic environment (NSA, p.71). This is one programme their research strategy focuses on, where the necessity of earth observational information is found in all public policy decisions such as water resource management, to protection of ecosystems (IP, p.14).

They further state that Space Exploration is a key area and they will foster knowledge generation (fundamental and applied research) as well as mission driven space science and exploration projects which are of strategic interests to the region (NSA, p.71). Additionally, communication with a focus on telecommunication development with promising applications in e-commerce, distance learning and telemedicine, and navigation and positioning which can be found in a growing number of civilian applications (NSA, p.71; IP, p.15).

(21) What limitations are stated for the current space research capabilities?

[**Germany]** The document states that major space missions and explorative activities are only feasible through international cooperation due to the expenditures, complexities and scientific breadth (FGSS, p.15, 53). It is also stated that Germany's technological sector is facing increasing competition for skilled personnel, where the space sector needs highly trained personnel and a society open to new technologies to thrive (FGSS, p.9). Finally, it is stated that the growing demand for broadband frequencies and the use of frequency spectrum require international agreements for management (FGSS, p.9).

[**South Africa]** The strategy states that South Africa has primarily been a consumer of space technologies and that there is a need to develop systems and subsystems to support the country's requirements and to grow the local industry (IP, p.13).

While the document does not state these limitations of research to be space specific, the document raises the issue of the national research capabilities to several factors. The document states that the higher education system has limited capacity to enroll and supervise PhDs and there are constraints within individual institutions resulting in a significant PhD deficiency (IP, pp.25-26). Additionally they state that there is a failure to commercialise the result of scientific research, and existing institutional arrangements are not sufficient for migrating the economy from a resource-based to a knowledge-based one, requiring more rapid technology transfer and learning (IP, p.2, 23). Furthermore, as operational expenses for the space organisation have exceeded their funds, they have to focus on revenue generating activities (NSA, p.6).

(22) What types of threats are perceived as the greatest within the space domain and what are they directed towards?

[**Germany]** It is stated that attacks in or from cyberspace and space can have an impact of an armed conflict and thereby necessitate collective action (NSS, p.32). It is then stated that there is a need to further increase the resilience of critical space infrastructure, such as satellite communication and navigation and earth observation satellites (NSS, p.62). There is thereby an increasing risk for space-based systems from cyber threats (FGSS, p.37). There is also a stated risk from growing orbital-traffic densities, space debris, and space weather, such as solar storms and radiation bursts, which can cause disruption and damage to space based systems such as satellites, radio links, spacecrafts and ground systems (FGSS, p.37).

Finally, it is stated that the space industries global supply chains are threatened by unlawful influence, espionage, unauthorised leading of knowledge and sabotage (FGSS, p.39).

[**South Africa]** The strategic document states that competing government priorities which could reduce funding streams, unhealthy competition within the National system of Innovation, and competition from outer african nations who are establishing their own space programs are threats (NSA, p.43). Furthermore, they state that external dependencies makes it difficult to gaining traction to key projects, there is a slow pace of government bureaucracy which could hinder their response to key opportunities, and there is a loss of key skills to the external environment to a lack of opportunities to apply their skills (NSA, p.44). Finally, the document states that radio and magnetic interference could hamper their operations (NSA, p.43).

(23) What types of threats against the nation's access and utilisation of space are communicated?

[**Germany]** The documents state that attacks in or from space can have the same impact and magnitude as an armed conflict, where they further point to the risk of escalation and conflict in space (NSS, p.32, 63). Germany states that cybersecurity threats against space-based systems where the risk is continuously growing (FGSS, p.37). It is further stated that both unintentional and intentional actions by other actors can cause disruption and damages to the space based systems, which can result in significant economic damages for an entire country (FGSS, p.37). Space debris is further identified as a significant threat to the access and use of space (FGSS, p.37, 43). Furthermore, the lack of independent access to space is a stated threat, where the document stresses the importance of independent, reliable and cost-effective access to space (FGSS, p.18). Additionally, the uncontrolled access to security relevant key technologies is also stated as something which needs to be countered, as well as the dependency on key technologies and economic dependencies needs to be reduced to maintain strategic sovereignty (FGSS, p.40, 17).

[**South Africa]** The documents state that competing government priorities could reduce potential funding streams and further states that many African countries are establishing space programs which impact their competitive advantage (NSS, p.43). The document further states that the slow pace of government bureaucracy could delay the implementation of space-related initiatives and projects and hinder the nation's ability to respond to key opportunities (NSA, p.44).

(24) What military alliances does the nation engage in?

[**Germany]** Germany engages in NATO where the document states that Germany's commitment to the alliance is unshakeable, and stands resolutely by the defence pledge under Article 5 of the North Atlantic Treaty (NSS, p.13, 31). Additionally Germany has a mutual assistance commitment with France under the Treaty of Aachen, and has a mutual assistance clause in Article 43 of the Treaty on European Union (NSS, p.31).

[**South Africa]** The document states that the "South African National defence force" will continue its commitments in partnership with the Southern African Development community member states (DoD, p.6). They further state that an armed attack against a state party within the "Southern Africa development community mutual defence pact", shall be considered a threat to regional peace and security and will be met with immediate collective action (DoD, p.17). The text further stipulates their commitment to the "the African Union Non-Aggression and Common Defence Pact", where State Parties undertake to provide mutual assistance towards their common defence and security vis-à-vis any aggression or threats of aggression. (DoD, p.17).

(25) Does the nation prioritise space as a domain for military activity?

[Germany] The document states that space technology is an important security and defence industrial technology whose national availability is in the interest of national security and states that military utilisation of space is increasingly significant to the armed forces (NSDI, p.8; NSS, p.62). They further state that military operational capacities depend on secure access to space, satellite communication and navigation, and Earth observation data (FGSS, p.37). The document states a plan to place a larger focus on space as a strategic dimension, and expand its capabilities within this domain, and calls for strengthening military capabilities via space-based systems (FGSS, p.37). Furthermore, in 2021, the German armed forces commissioned a space command which highlights the need for protection of space-based systems and further states that an allied defence encompasses the space (FGSS, p.32, 38).

[**South Africa]** The document states that The National space agency has to address three strategic objectives which include safety and security (IP, p.13). It further states that Defence, peacekeeping and treaty monitoring are needs related to the users health, safety and security (NSA, p.24) and further state that their operational space weather centre will provide services developed primarily for defence, aviation and energy sectors (NSA, p.77).