The Commercialisation of Space as an Information Source: An Enquiry into Potential Implications for Geospatial Intelligence

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Abstract

This dissertation is looking into the question of how the entrance of the private sector has affected the security network in space. To do so, this thesis provides a temporary reality of today's space ecosystem in accordance with its congested and contested characteristic factor developed by the introduction of the private sector in space. This is to be done through the analysis of one of the major space actors, the United States and its impact on space activities and transformation on their own space capabilities towards a private monopoly of the resources of the domain. Providing therefore, the changing factor that characterises states as their own propellant of security and their own insecurity in the domain. For that matter, this dissertation operates with numerical data provided by organisational, non-organisational and different studies providing the picture of the reality of space and its short-term future predictions. Therefore, lastly, providing a possible impact on the private monopolisation of space activities, ecosystem and technologies into the security network and its use for intelligence purposes.

Key words: Space Security Network, Mega-Constellation, Miniaturisation, Big-Data, GEOINT

CONTENTS

LIST OF ABBREVIATION

APSCO	Asia-Pacific Space Cooperation Organisation
COPUOS	The Committee on the Peaceful Uses of Outer Space
COTS	Commercial Orbital Transportation Services
CSLA	US Commercial Space Launch Act
EO	Earth Observation
ESA	European Space Agency
FAA	Federal Aviation Administration
GEOINT	Geospatial Intelligence
GPS	Global Positioning Systems
HTS	high-throughput satellite
ISS	International Space Station
ICG	International Committee on Global Navigation
LEO	Low Earth Orbit
NASA	National Aeronautics and Space Administration
OST	Outer Space Treaty
PE	Private Equity
PPPs	public-private partnerships
R&D	Research and Development
SATCOM	global satellite communications market
SSA	Space Situational Awareness
SWF	Secure World Foundation

UCS	The Union of Concerned Scientists
VCs	Venture Capitals

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I. INTRODUCTION

In the present day, the security landscape is constantly transforming throughout various domains. One of these domains is the space atmosphere. Since the Cold War, the securitization of intelligence and international relations has extrapolated the intellectual picture from Earth to Space. Over the years, the use of space has exceedingly rotated from a central focused earth observation and exploration towards a resource utilisation playground. Currently, from a sociological stand, outer space has become a social system under which power relations are being established (Maciel & Wallendorf, 2021). Showing, therefore, the transition marked by the end of the Cold War, from the so-called 'Old Space' distinguished by nations' control over the space industry, to the 'New Space', marked by businesses and organizations opening the space frontier through economic development (Denis, et al., 2020). Moreover, this acknowledgement of the potential benefits of space applicability and exploration has generated a transition towards a commercialised space, both technical and business oriented. In addition to the governmental-funded traditional activities, companies started developing space missions driven primarily by economic profit. For that matter, the services provided by the space system are comprised of positioning, navigation, timing data, remote sensing and communication that could impact a nation's operations (Croshier, 2023). New Space stipulates a paradigm shift of new actors and stakeholders in reference to the market. The broadening of actors in space from States to Non-Governmental Organisations or Private

Companies such as SpaceX, Blue Origin or OneWeb, have constructed a new security network in space. Within this network, satellites have become the most reliable source of information in this domain and, along with it, the driving factor under which nations tend to invest in space activities, leading to the marketization of space. Moreover, the development of states' space capabilities provides the opportunity for states to widen the options and tools for a broader economic growth and technological independence, making of space an increasingly expanding economic domain. This led to increase states' competition over space, with a focus on access, operations, and resources.

Resulting, space endeavours by states have shifted in focus from a sole geopolitical interest, towards providing opportunities for private companies to provide global connectivity, geo-information systems, business intelligence and satellite imagery for mining exploration, weather forecasts, food resourcing or communication amongst others. However, to understand the significance of the commercialisation of space, it is of great importance to comprehend its meaning. Private companies have always been active actors in space. Traditionally, they participated in space as mere contractors in project financed by the National Aeronautics and Space Administration (NASA). Though, this phenomenon has not evaporated in the current landscape recognised as the New Space, with the main difference being the progress achieved by private companies in space. At present, private enterprises have managed to introduce their own private space systems under which the de facto services are used as a selling product for governments and other private consumers such as Dura-Line Corp or Axiom. However, the emerging technologies for space operations are characteristic of this generation; these, comprise:

commercial ground segments, launches, and cube satellites permits that unprecedented revisit time with reduced capital requirements (Sheik, et al., 2022), lowering the entry barriers for non-state actors into space. The innovative technologies manufactured by private companies have led to decrease costs for investing in space. Along with the development of reusable rockets, private companies' technologies have led to the miniaturization of satellites that characterise today's generational system in space (Rapp & Topka, 2021). As a result of, the development of constellations formed by those small satellites, the space infrastructure is becoming increasingly private and, international, and outside the control of states. Furthermore, the characteristic miniaturization taking place in space is a changing factor of the economic dimension of the global market of space activities, as it multiplies the number of satellites launched every year, encouraging the emergence of new activities in the space ecosystem with the renewal of the more traditional ones. For that matter, it could be noted that states have been the driving factor in the greater utilisation, exploitation, and exploration of space. Paradoxically, however, the increased use of space for security aims by states and the consequent expansion of the security network that resulted from it, have also become an increasing source of insecurity for states in the New Space area.

Space products are so integrated into our daily lives that often remain unnoticed by the human eye. The information revolution perceived as a driving factor of the space activities today, is a transformation element for both company activities and global commerce dependence on communications, remote sensing, precision timing, navigation, and weather satellites. The increased miniaturisation of technologies in space has led to a growth of Big Data from the ever-increasing channels today.

However, the application of the Big Data tools has gained a positive impact on the area of national defence, as real-time processing of data is a driving factor of security nowadays (Bognár, 2020). Therefore, it could be said that the utilisation of information has become a weapon. Every space activity is organised around the collection of information, making the newest technologies the most threatening and reliable source for information processing and acquisition. The computerised command and control, along with the reconnaissance systems, facilitate the collection of high volumes of data. However, as acknowledged in the past, information could become misleading (Dolce, et al., 2020). Therefore, space-based information and communication services can become a reservoir of reliability of the information, as there are no longer a few numbers of potential actors in space. Moreover, the reliance on network-centric operations from states have led to a greater focus from governments and state agencies into the ability to collect and analyse data efficiently, as today the main problem is not the access or the collection of the data but the reliance and extraction of the needed data from its volume. Moreover, the data providers of the commercial space industry not only have transformed space information and intelligence collection into the domain of so-called Geospatial Intelligence- but also-, its access and, in the near future, most likely state relations as we know them in space today.

Therefore, over time the role of states in space security has been increasingly accompanied-when not supplanted- by that of private security companies. The so-called security intelligence networks- comprising of a multitude of private and public actors- have developed organically in both a formal and informal manner, as agents created relationships aimed at offering enhanced information. The rapid rise of both these formal and

informal security networks has also posed several questions for scholarship, such as ‘to what extent is intelligence part of the activities of private security?’, ‘how the rapid development of security network can be managed?’, ‘how multiple databases can be brought together?’ or ‘how extensive is the conflict or convergence of interest?’ (Gill & Phythian, 2018); but these questions have addressed the domain of space to a lesser extent, where informal intelligence security networks have also been developing. Therefore, this dissertation is concerned with the study of informal security intelligence networks that have been developing in space in the last 9 years. In the specific, it asks, how the entrance of the private sector has affected the space security network? To answer this question, the research will focus on the case of the space use of the United States from the year 2015 till the year 2023, as it has consistently been one of the main actors in the space security network; starting with the launching of Explore 1 on 1958 for space research and exploration. As my research will show the space security network has changed as states’ reliance on space has shifted from a state-centralised focus to private company reliance. This would be done through a focused case study of one of the main dominant US companies in space, SpaceX. This study would not only provide the visualization of state reliance on private enterprises but also the increase in the number of satellites and therefore, the data and information reliable to everyone. Therefore, revealing that space commercialisation along with the introduction of new technologies has provided a new use for space. Thereafter, increasing with this the number of activities and objects in outer space. For that matter, the conclusion of the dissertation will follow a speculation about the future of space security considering the increasing role of the private sector. These speculations are based on the impression of the likelihood of the

increasing trend shown by satellite communications and its considerable number of data, or -Big Data, - in the New Space era; that has led to an overflowing amount of information. This information could be expected to have collateral damage in the long run. One of the sectors that could be seen impacted is the intelligence community. It is known that intelligence services make use of space for the recollection of information through what is known as Geospatial Intelligence or GEOINT. Therefore, the overflow of information and data would pose a challenge to the analysis of the data generated by the private companies that would also become unreliable and accessible by every state if desired. Finally, this commercialisation and new security network could most likely provide a new relational environment that would impact negatively on the complete use of these resources.

II. Literature review

Outer space, commonly known as space, is referred to as the expansive and seemingly limitless realm that expands beyond Earth's atmosphere; under which its exploration and use shall be carried out for the benefit of all countries in accordance with international law (UN, 1966). The Outer Space Treaty primarily focuses on the establishment of guiding principles and the legal framework for space activities, and the cooperation among states on the peaceful use of the space domain (Galloway, 1979). However, it is of importance to denote the absence of an explicitly agreed definition of "outer space". Hence, when considering a definition for the term, it is of need to depend on the broader scientific comprehension and context under which the term is employed, acknowledging the Outer Space Treaty to be the authoritative legal

framework governing activities in the domain. And therefore, becoming this, the understanding and context for the development of the space definition. Therefore, to attempt to answer where airspace ends and space begins, as established by Dr. Everett Dolman, “The two most prevalent approaches for defining outer space have been spatial and functional. The spatial approach explains that space begins just below the lowest point at which an object can be maintained in orbit…about 52 miles” (Catledge & Powell, 2009, p. 29). Moreover, another perspective on the matter of defining outer space is based on the functional approach provided by the propulsion systems of the air/spacecraft, which is defined by the 1919 and 1944 International Air Conventions as “any machine that can derive support from reactions of the air” (Catledge & Powell, 2009, p. 29). Thus, space starts beyond the maximum altitude for aerodynamic flight. However, as no binding definition of space has been agreed upon, the question of sovereignty and space law arises. Nonetheless, having sovereignty in space does not signify owing the control of space. Thus, basing space sovereignty solely on space law becomes problematic. Furthermore, as noted by Dolman

> “in contrast to sea law, aircraft have the additional requirement of holding the nationality of the state in which they are registered…The requirements for registration of objects in space are stricter than those for sea or air, with the justification that such registration is necessary because of the greater potential for global physical and/or environmental damage…The most compelling reason for registration of spacecraft, according to policy makers, is to enhance national security” (Astropolitik, 2001, p. 30).

In connection with the 1967 Outer Space Treaty ratification, as established by UN Ambassador Arthur Goldberg “This is a matter of national security.

We believe that when there is a registration of launchings this gives us an opportunity to, and the world community to, check up on whether the launchings are, indeed, peaceful or whether they are for some other purposes" (Astropolitik, 2001, p. 30).

For that matter, considering the similitudes and contrasts between the three domains; the air, sea, and space this could be applicable for the development of a Space Power Theory. However, it is of importance for theorists to approach space as its unique environment to develop a theory for space power. As raised by Lt Col David E. Lupton, space power could be clarified as the ability to use the space domain in the pursuit of national objectives or purposes such as military for the collection of surveillance data or non-military for resource data collection and civilian communications. For instance, Admiral Mahan introduces the nature of a country's political institutions as a compelling factor to consider in space power. Therefore, "space power is the ability of a nation to exploit the space environment in pursuit of national goals and purposes and includes the entire astronautical capabilities of the nation. A nation with such capabilities is termed a space power" (Catledge & Powell, 2009, p. 32).

In recent decades, there has been a noticeable expansion in the application of the concept of security and the range of the issues it covers. Previously, security was primarily associated with military threats and concerns. However, it is now being used frequently to address non-traditional issues such as environmental degradation or migration amongst others. This trend has become evident from an academic and policy standpoint, having policymakers referring to non-military issues as "security" issues. For that matter, even space has not been able to

maintain itself unaffected by this broader shift (Peoples, 2010). Therefore, as established by the Copenhagen School, security issues tend to be attempts of securitization, the process under which non-military issues become security ones and therefore, being securitized “treated with the same degree of urgency as military threats to the very existence of a state” (Peoples, 2010, p. 206). Attempts at securitization are thus a rapidly growing feature of the contemporary space policy dialogue. Consequently, it is important to denote the fact that the securitization of outer space, in association with security is not a novel phenomenon.

Throughout history, there have been numerous instances where professedly civilian activities in outer space have been connected to national security functions, either explicitly or implicitly. This is well-documented, as seen in the space race between the United States and the Soviet Union, where it serves as a substitute for direct military confrontation (Evangelista, 1995). Similarly, the Sputnik launch in 1957, portrayed a great danger by the space technologies as a potential threat to the United States. Moreover, it is important to note the securitization and emphasis on security measures in national space policies. As an example, the Space Security Index report of 2009 acknowledged that “national space policies consistently emphasize international cooperation and the peaceful uses of outer space” (Anon., 2009, p. 12) but also there happens to be a “growing focus within national policies on the security uses of outer space” (Anon., 2009, p. 12). Evidenced by Japan’s space law of 2008 with the lift of its previous ban on the military and national security activities in space, China’s development of its space program and the renewed priority of the space security of the European Union’s space policy (Anon., 2009). In the same way, in the recent US Space Policy,

there has been a noticeable emphasis on securitization that has become well-established. This is particularly important considering the ongoing dominance of the US in space exploration. Moreover, by 2007 approximately 50 countries, intergovernmental consortia, and non-governmental organizations possess at least one satellite in space, primarily for economic Earth Observation purposes rather than military intentions (Gallagher & Steinbruner, 2008).

The space ecosystem has evolved significantly, rooted in the Space Security Power Theory with the pursuit of dominance and control in outer space, towards the contemporary space characterised by the current pluralization of security governance, due to the privatization along with the rise of a more interconnected and interdependent space environment. Moreover, the private concerns enabled by property law, have generated the adoption of a nodal approach instead of a state-cantered one as argued by Johnston and Shearing (Gill & Phythian, 2018). Therefore, recognising the significance of the Space Security Network today. The idea of networks is “of informal relationships between essentially equal social agents and agencies” (Gill & Phythian, 2018, p. 52). There are two important factors to consider within the description of the security network, informality, and essential equality. Informality is crucial as it is the basis on which these networks have initially formed, as the connections between the security agents for the purpose of information sharing. On the other hand, essential equality is also of vital importance as, unlike traditional hierarchies in security organizations or agencies, what holds significance in a network is trust and possessing valuable information to exchange (Gill & Phythian, 2018). Despite the significant advancements in technologies for building large-scale networks and network services, there has been a

lack of new ideas or principles for network management, particularly around security management. The existing tools, which were primarily designed for static security, are insufficient to address the current requirements of user mobility and diversity, leading to reconfigurations (Burns, et al., 2001).

There are different sectors of concern regarding the Space Power Theory that could offer valuable insight into the space security network. These include the Outer Space Treaty (OST) authority and other measures aimed at promoting transparency and confidence, Space Situational Awareness (SSA), and space weaponization. As a result of several factors including the increasing presence of actors in space, the rising number of active satellites and recent events involving debris from deliberate and accidental incidents, there has been a growing trend in the safety of spaceflight (Adriaensen, et al., s.f.). This has led to a strong motivation to improve the development and sharing of SSA data in a more timely and consistent manner to benefit more users. To provide context, the Chinese ASAT test in January 2007, the collision between Iridium and Cosmos satellites in February 2009, and the Indian ASAT test in March 2019 have all contributed to this heightened concern. Specially, the Chinese ASAT test resulted in 2,378 debris pieces with diameters greater than 5 cm by the US Space Surveillance Network. Additionally, there are currently 400 debris objects being tracked that have not yet been catalogued. Moreover, it is estimated that the test created over 150,000 debris pieces, of which less than 2% have re-entered the atmosphere. However, many of these pieces are expected to remain in orbit for decades or even over a century (NASA, 2009).

Nowadays, for the understanding of the space ecosystem, it is of need to discuss the term ‘Network’ as it is one of the most widespread concepts in the social and political sciences today. However, it is a concept used in different manners. On the one hand, it has become a metaphor that refers to relationships between actors. On the other hand, it is referred to as an analysis method. And finally, it could be noted as a unit of analysis. Thus, the concept of network could be defined as “a set of actors (or ‘nodes’) that have relationships (or ‘ties’)” (Whelan, 2016, p. 9). The actors and relationships are defined by the researchers. Actors cover from people to groups or organisations; and relationships can be seen at any type, which becomes defined as a separate network. Thus, theoretically, a set of actors can have variable relationships, understood as separate correlated networks. Moreover, the term network can also be used in a form of organisation or governance, as opposed to ideal types of hierarchies and markets. The market is controlled through competition, and the law is used as a tool to resolve disputes between parties. Furthermore, network organisations are not controlled by administrative means or laws, but by relationships created on reciprocity and trust (Whelan, 2016).

Conversely, as of interest to this domain, the term Security networks, “a set of institutional, organizational, communal or individual agents or nodes that are interconnected in order to authorize and/or provide security to the benefit of internal or external stakeholders” (Dupont, 2004, p. 78) has gain relevance on the ecosystem. This impact of security networks on individual and collective organisational performance, as well as their potential achievements, has received limited attention thus far. This can be partly attributed to the prevalence of a hierarchical mindset among

evaluators, as well as the inherent complexity of what Stinchcombe refers to as ‘conditional network effects’. Assessing the effects and casual relationships under such premises is relatively complicated. However, this typology of security networks is incomplete and based on limited information. Therefore, further empirical, and systematic investigations are needed, focusing on aspects such as the differentiation or integration of interests and resources, stability, exclusivity, and specialisation. According to Castells, it has been observed that networks consist of various institutions and internal divisions within those institutions. The density of security networks differs significantly across different settings, and only certain nodes can fully take advantage of the opportunities provided by this new form of governance. The existing literature on security networks typically categorizes them into local, institutional, and visual security networks (Dupont, 2004). Johnston and Shearing argue that security networks offer opportunities for transforming existing relationships in ways that could lead to fair and democratic outcomes. However, they also acknowledge that power imbalances persist and certain must be met. Therefore, taking a normative approach that could be beneficial in terms of adapting the security authorization and provision to various contexts (Dupont, 2004). At the national level, states or corporations may seem to hold a prominent role in these networks. However, as proposed by Johnston the most constructive view on the matter would be “a changing morphology of governance in which partly fragmented states interact with commercial, civil and voluntary bodies both within and across national jurisdictional boundaries” (Gill & Phythian, 2018, p. 63). For instance, on the contrary, Crawford has highlighted the negative impact that shared anxieties and ideological differences can have on inter-agency

cooperation. For that matter, the current conditions hinder the ability to effectively manage nodal governance (Dupont, 2004).

In close relation to the informational connection that ties the security networks, it is of importance to highlight the role that the security national agencies play and the part of the intelligence network as a safeguard of national interests, protecting national interests and promoting global stability even in the space ecosystem. Therefore, generating questions such as ‘how to make sense of the mass of information and possible competing analyses?’ or ‘the extent to which intelligence is a specific part of these activities?’ (Gill & Phythian, 2018). Moreover, in order to make sense of the emergence and shared interest to bring actors within the network, it has been argued that “multilateral networks for intelligence sharing have become more significant in Europe in large part because of the increased perception of a common threat” (Gill & Phythian, 2018, p. 63). It is recognizable the common interest that is shared by many Western states and corporate security providers. This interest can be summarized as the preference for market-based security provision, along with other services, while being regulated by states. An evident illustration of this can be seen post 9/11, or as Shorrock argues, an ideology for the intelligence industrial complex was created from a “blend of patriotism, national chauvinism, fear of the unknown and old-fashioned war profiteering, all of which have played into the corporate demand for new markets and fresh sources of capital and profits” (Shorrock, 2008, p. 357). However, it is of importance to validate the actual nature of the relationships through empirical evidence, as conflicts may arise between the nodes within the security network. These conflicts can occur due to various reasons. For instance, within the state sector, agencies may have

different mandates and objectives that occasionally overlap. Similarly, corporations may enter into agreements for joint projects, while also maintaining the competitive relationship (Gill & Phythian, 2018).

Today, one of the driving elements to be considered for the understanding of the topic of space, is globalisation. This is referred to as the characteristic factor of the current landscape that has not only greatly influenced the security sector but also the space one. This includes changes in their roles due to evolving perceptions of threats, advancements in communications, and shifting expectations on their operations. This phenomenon is evident by the increased interaction among national and international actors, the broadening of actors that become involved in governance, and the global reach of the developments that have an impact at a worldwide level (Gill & Phythian, 2018). Therefore, having this global rapid development a direct impact on the security networks, formally and informally. Thus, raising many questions, especially ‘how the security network can be managed?’. Kickert and Koppenjaan suggest that network management is characterised by network structuring and game management. Game management involves the important task of activating a network of actors and facilitating their interactions by arranging solutions to the problems as they appear. However, due to the high value placed on source protection and the general hesitancy to share sensitive information, there are several obstacles presented to the sharing of information and operational cooperation. It is, therefore, the reason why the US and European officials often express frustration over the lack of willingness to share information. For the purpose of the matter, in this case, information is referred as sensitive data intelligence-collected by countries or agencies for national

security purposes. Therefore, given the acknowledged problems or barriers posed by intelligence sharing. Not only have agencies been actively pursuing additional powers for technical collection, but they are also currently seeking enhanced access to electronic data collection by others in both the US and Europe. However, it is important to note that combining multiple databases presents numerous complex technical challenges, unlike accessing specific databases. The concept that has gained traction since the events of 9/11 is the utilisation of interconnected public and private data warehouses for data mining purposes (Gill & Phythian, 2018). However, because of the sensitive data recollected, the networks are hard to manage without their self-regulatory capacity.

In the same manner, it is important to highlight the fact that cooperation is more likely to occur when previous contacts have resulted in an enhanced level of trust and a greater willingness to reciprocate. In cases that involve multiple jurisdictions and agencies, the likelihood of requiring a formal agreement to be negotiated between the contributing agencies increases. If challenges cannot be effectively resolved within the existing organizational structures, it may become necessary to consider restructuring networks (Gill & Phythian, 2018). Network structuring also occurs on an international level. For instance, in Europe, the Berne Group, established in 1971 by 6 internal security agencies from European counties. Over time, this group has expanded to include 17 agencies, with Greece being the most recent addition. On the one hand, the growth of the corporate sector can be partly attributed to the fact that major private security companies operate as transnational networks. This enables them to offer a level of flexibility that state agencies, constrained by national sovereignty, often cannot provide (O'Reilly & Ellison, 2006). Therefore, as

space is considered to be a strategically important domain in which powerful and emerging space powers are seeking for a position; countries are actively working to maintain their presence in space in the 21st century due to the advantages it offers in terms of both military and economic benefits. Since the end of the Cold War, there has been a gradual increase in the space capabilities of countries such as Japan, India, or South Korea apart from the already dominant states-US and Russia- in the domain. Not only this but also these nations are forming international partnerships to assist other states with the launching of satellites into space, therefore, generating a competitive environment. However, there are several challenges that need to be addressed to ensure the safety and security of space. These include the growing number of actors involved in space activities, the commercialisation of space, the expansion of military space programs, and the lack of a universally agreed treaty to prevent an arms race in space. These challenges are increasingly impacting the international space governance and network, along with the ability to maintain a safe and secure environment for commercial and scientific purposes (Adriaensen, et al., s.f.). Currently, space-based services such as communication networks are evidence of ongoing international cooperation among the space actors that contain the space ecosystem. However, the intrinsic as denoted by Ken Booth and Nicholas J. Wheeler “ambiguous symbolism” of technology, form an intensified security dilemma as other states may see this as offensive or defensive actions, depending on their own interpretation (Booth & Wheeler, 2008).

The growing complexity and interdependence of space activities have underlined the importance of cooperation networks in ensuring sustainability, responsible exploration, and security in space. It

emphasized the collaborative exchange of technology, knowledge, data, and resources to achieve shared goals while promoting the maintenance of peace and a responsible use of outer space. The applicability of cooperation, on the one hand, creates a collective share of scientific data, findings, and research for scientific advancement with a leveraging shared of resources due to the involvement of significant financial and technical resources. On the other hand, the cooperative network becomes a crucial role to address the challenges related to space debris, traffic management, and the long-term sustainability of the space ecosystem (Anon., 2022). Therefore, as an example, given the potential significance of Sino-American relations, particularly in the context of space, it is important to give special attention to proposed cooperative space ventures or the transparency and confidence-building measures (TCBMs) between both countries. For instance, the US could extend more specific and public invitations to China, inviting them to participate in the International Space Station program and other major international space initiatives. Additionally, as suggested by Philip Baines, both countries could collaborate on the development of non-offensive defences (Adriaensen, et al., s.f.).

Lastly, the private sector's increasing involvement in the space ecosystem has brought about a transformative impact on the space security network. As commercial entities play a more relevant role in space exploration, satellite operations, and technology development, their participation has introduced new dynamics in space security. The changes and increasing capabilities of smart devices give rise to a new type of public sphere that raises questions about the freedoms it offers, as well as the limitations it imposes in the digital realm. As a result, both businesses

and customers find themselves operating in an environment that necessitates the use of digital tools and applications. Consequently, the utilisation of technology and understanding the potential of networks is becoming increasingly crucial in establishing and nurturing relationships (Krawczyk-Sokołowska & Caputa, 2023). Therefore, enhancing space security capabilities and contributing to a more efficient and effective space infrastructure. Encouraged by the increased investment provided by the private sector's additional funding into space, its exploration and security network; not no mention the diversification of the space services and solutions such as the SSA or the Space Traffic Management promoted by the introduction of these actors into space. Despite it, there tends to be a negative or challenging side to the introduction of the private industry in the space ecosystem. Accounting with; the dual-use concerns about the potential military use and the risk of its negative exploitation, the privacy and data security concerns generated by the collection and management of space-related sensitive information, the possible regulatory challenges presented by the evolving nature of today's space activities, the control of the space market in the hands of a few major private companies may lead to concerns, limiting choices for government and organisations seeking for space services, and threat considerations for national security produced by the increased reliance on private companies (Anon., 2022). Therefore, as argued before the importance to study or acknowledge how the introduction of the private sector in space has impacted the space security network, and the possible future impacts that could pose for several disciplines such as the use of space as an information source.

III. Research design and methodology

This dissertation aims to provide an outline of the impact posed by the entrance of the private sector in space and its consequential effect on what is denoted as the space security network. Providing in addition, an assessment of the enquiry on the possible impact in the near future of the intromission of the private sector in space and its impact or challenges posed towards the intelligence recollection methods through space or known as Geospatial Intelligence (GEOINT).

Firstly, a brief introduction to contextualise the framework of space as a domain will be provided. Within this section, the terms referred to space- “Old Space” and “New Space” would be put into context. Moreover, providing the context and characteristics of the shift generated in space, its activities, actors, and network. The second part will be more focused on the change in the space market, its transformation in accordance with the growing trends of the private space sector led by the increased commercialisation due to the growing innovation of technologies, the lowering of barriers to access space, the low cost of production of the service etc. Therefore, highlighting the transformational factor in the space ecosystem and its security network; the replacement of a geopolitical-driven motivation to interfere in space activities by the state nations, towards a merely economic-driven pursuit of the use of space as a source.

The thesis will be looking more in-depth into the main source of information and the driving factor of all the activities provided in space; satellites, and the services that they provide. On the one hand, the different services that are delivered by the space domain over time, along with the gaps or opportunities that these ones created. For example, the

use of space for military and governmental activities used to be of more importance and reliance two decades ago; however, during the last decade the commercial sector has become the driving factor of space activities. Accordingly, the technological edge has played a vital role in the development of space activities and the strong almost monopolising role of the private companies nowadays in this domain. The characteristic element of the growing trend in outer space, the miniaturisation of satellites, a component that has made possible the increased number of satellites and activities in the mega-constellation that the private sector is generating in the domain.

On the other hand, to answer the research question posed -How has the entrance of the private sector affected the space security network? - the dissertation will employ qualitative research methods but also be substantiated in quantitative data. Consequently, the methodology suited for this is a case study, as case studies allow for a detailed and comprehensive examination of a particular phenomenon, context, or situation; providing an in-depth understanding of the context as it explores the different factors and dynamics. For this instance, a case study of the increased entrance and use of the private sector in space would be done. The case study will be based in the United States as they remain one of the most important actors in outer space, not to mention the big technology supremacy that they still hold. Moreover, in the case of the private sector the US portrays the predominance in space as 52% of the enterprises in outer space are American. Moreover, the study would be done by analysing the last decade, as in 2015 the US launched -the United States Commercial Space Launch Competitiveness Act- that launched the commercial sector into space. This law was created to

generate a pro-growth environment for its commercial space industry, encouraging private companies to engage in the commercial exploration and exploitation of space resources. Even though the so-called New Space Revolution took place in the 2000s, the case study would be directed towards the positive or negative use and shift of governmental resources to private companies, which has been more noticeable since 2014. Furthermore, the actors, the use of space made by them, and the security network generated previous to the year of study would be also briefly mentioned to provide a visible transition of the use of space and its security network till today. Lastly, a more depicted study of the most powerful commercial enterprise, SpaceX, would be provided to showcase its impact on the governmental use of space today.

The case study method primarily relies on data recollected from the Union of Concerned Scientists, Morgan Stanley Research Analytics, SpaceTech Analytics, SkyQuest Technology Group, Private Companies or Governmental Agencies such as NASA. Moreover, the gathering of the data primarily is original from secondary data analytical resources. However, these sources have been triangulated with other resources and databases for the reliability of the information. Furthermore, this research could encounter some limitations during its analytics as it is an ongoing, more or less recent topic, and some of the data and information is remains classified for the public eye.

CHAPTER 1: SPACE AS A DOMAIN

1.1. Old Space VS New Space

Throughout time the space ecosystem has encountered various changes and challenges. Emanating from the engagement of mainly two states-the United States of America and Russia- monopolising this domain; to current, expansive space programs from countries such as India or China. However, outer space as a domain has always posed some challenges in accordance with the establishment of boundaries for its control, exploration, and exploitation. As space is an unmeasurable resource unlike Earth, the main confrontation encountered with the incrementation of state actors in itself; is the lack of a centralised body (Oduntan, 2012). At present, there happens to be no overarching authority or international treaty that regulates the activities performed in space. The Committee on the Peaceful Uses of Outer Space (COPUOS), constructed by the General Assembly in 1959, to control the exploration and the responsible use of space in relation to humankind's for-security, peace, and development- is an attempt for the development of a binding international space law (UN, 2023). Nonetheless, the Outer Space Treaty of 1967 has become the primary legal framework that rules space activities, under which as established in Article I of the treaty

"The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind" (UN, 1967, p. 13).

Yet, being the scope of the treaty overly limited and broad to address the entanglements posed by the modern space sphere; and as space activities expand, new legal questions arise.

To assess the space ecosystem in the 21st century, space as a domain along with its changing security network must be understood first. For that

matter, the space domain is referred to or associated with the terms “Old Space” and “New Space”, to denote the ecosystem under which the evolution and transformation of the space industry has materialised. It is of significance to highlight the fact that “Old Space” is closely associated with the Cold War era, as the period under which it originated and shaped. In fact, at present, we find ourselves in a phase where both sets of ecosystems coexist. As defined by Paikowski, “Old Space ecosystem refers to space activity that is being controlled by national activity and is mainly a state-only playground” (Paikowsky, 2017, p. 84). Therefore, being the key participants in the early stages of space exploration in the ecosystem, primarily the superpowers and their trusted partners, driven by their national interests. Thus, the space security network became limited to a few major actors such as the United States or the Soviet Union. Initially, both superpowers diligently developed and utilized space-based intelligence-gathering capabilities to acquire crucial information about their adversaries, as well as to vigilantly monitor arms control agreements (Paikowsky, 2017). Therefore, becoming the utilization of space assets, in this case, military satellites, is essential for the safeguarding of national security. Secondly, the superpowers aspired to redirect any potential conflicts into peaceful public competitions by engaging in a race to space with a focus on technology and scientific advancements, what would be known as, space exploration. Therefore, in this regard, the space domain has emerged as a strategic and prestigious area under which nations have exerted dominance and influence, and commercial activities have remained limited.

Gradually, marked by the end of the Cold War, the space security domain was affected by the arising of new technologies, shifting the

network of the environment. Advancements in space technology, along with the lifted restrictions on the proliferation of those, led to increased reliance and opportunity to utilize these technologies for various military and civil applications. Therefore, becoming this development the principal factor that paved the way for what is known today as public-private partnerships (PPPs) (Paikowsky, 2017). Thereafter, generating an emphasis on international cooperation and diplomatic efforts to strengthen space security, creating forums such as the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) for the purpose of space-related negotiation of the treaties. Thus, leading towards a more specified formation of space security initiatives such as the European Space Agency (ESA) or the Asia-Pacific Space Cooperation Organisation (APSCO), for the purpose of the generation of measures for cooperation and resolution measures (Anon., 2016). For that matter, the increased cooperation; along with the produced commercialisation and the growth of the space market, has provided a consequent rise of new players in the space arena. This including developing and small countries that have never before had the chance to be part of the space ecosystem; as well as the emerging private sector as will be shown later on more in-depth in the case study analysis.

Additionally, the New Space ecosystem is characterised by the introduction of innovative models of Research and Development (R&D), management and finance that became the grounds for the introduction of new actors in the space domain. Due to this factor, the conservative approach to the R&D, on the targeted mission, its length, the funded by cost plus model, and the limited capabilities that heighten the importance to ensure a successful operation in orbit that characterises the Old Space

ecosystem; has been transformed and referred to as the New Space due to not only the new actors introduced into space, but also characterised by the cost-benefit driven factor of the space security network that moves the New Space security and activities. Therefore, becoming New Space a domain distinguished by a more risk-taking activities, cheaper and shorter in time (Paikowsky, 2017). Additionally, becoming one of the main new trends of the space domain the growth and development of smaller satellite services, known as the miniaturization of the resources, to perform space activities. Therefore, forming a space ecosystem marked by the creation of mega-constellations encouraged by the miniaturization of the satellites, the removal of space debris, and the use of reusable low-cost launchers amongst others (Quintana, 2017). Thus, the growing involvement of commercial entities in space activities in New Space, has added a new dimension for the defence and security community and consequently, the space security network. As both military and civil services become of great reliance on space, it becomes a necessity to implement measures and regulate space activities to ensure successful ongoing and responsible access to space by all space actors, public or private. In addition, international law such as the Laws of Armed Conflict and International Humanitarian Laws, should be updated to better address the new space activities (Quintana, 2017). Thus, as perceived during the last years, several international efforts to establish rules and agreements aimed at promoting sustainability in the space environment have been developed: as seen in 2014 with the fourth draft of the International Code of Conduct for Space Activities. However, strategic tensions among influential actors such as the US, China or Russia and other less powerful countries have hindered these processes, turning the achievement of an international agreement on the matter uncertain (Paikowsky, 2017).

Hence, on the one hand, Old Space was formed by government governance, with a state-centric approach, heavy reliance on public funding, limited commercial involvement, and an emphasis on national capabilities. On the other hand, New Space is founded by the emergence of private companies, commercialisation, venture capital and private investment, technological innovation and cost reduction, collaboration and partnerships, and regulatory challenges. Therefore, becoming the New Space ecosystem a more creative, dynamic, and energetic domain.

1.2. Space market with the growing trends of private companies due to commercialisation

The last two decades have been characterised by the appearance of new business models in the space sector. The growth of those companies is significantly visible from the 1990s onwards, with the so-called New Space sector. New Space, as previously mentioned, encompasses the technical and business aspect of the space mission. Therefore, generating a new paradigm in the reference market, showing a growing trend of the number increase of private capital funding directed to companies such as Blue Origin or Virgin Galactic; instead of primarily taxpayer-based funding previously done by government agencies such as ESA, JAXA or NASA (Golkar & Salado, 2021). It is worth mentioning that since the shift of focus of activities in outer space from a merely motivated geopolitical interest to the generation of a private business hub, space ventures have developed space missions mainly motivated by economic profit. These circumstances have marked the trend in the space arena during the last decades. Although today's outer space is marked by what is denoted as the rising commercialisation of space, commercial space has been

present since 1962 with the launching of commercial satellite Telstar, an AT&T by-product for TV broadcasting (Golkar & Salado, 2021). In this sense, space activities have attracted a predominant number of new entrepreneurs as seen for example by SpaceX or Blue Origin. Therefore, what was once dominated by a few actors has become a diverse ecosystem regarding business models, geographic locations, and company sizes. Thus, the growth of start-ups, space ventures and the development of the commercial space have become the most visible trends in the 21st century (Denis, et al., 2020).

During the space liberalisation taken place in the 1980s, authorities reshaped space resources from a military focus purpose to economic assets that led to the prompt extension of satellite communications. The space industry no longer progresses following an independent trend, the sectors that exploded are based on economic profitability and assets. Therefore, the creation of the value is dependent on commercial goods and services instead of technology based. Thus, the activities that are predominant in outer space are focused on satellite miniaturization, launchers, and electric propulsion of those satellites. Thereafter, the trends generated by New Space are the new businesses and private investors developing space activities, the opportunities generated by the digital technologies for space data, and the transformation generated in other economic sectors such as health care or agriculture (Bousedra, 2023). The trends in the space arena can be explained in three different waves. On the one hand, the first wave of the new players in the space security network can thus be embodied by Elon Musk, owner of SpaceX, or Jeff Bezos with Blue Origin. Both companies are providers of transportation and commercial spacecraft. Similarly, following the path of

these companies, from 2000 to 2018, more than 200 space companies were created worldwide (Bousedra, 2023). On the other hand, the second wave in space is marked by the lowering of space entry barriers, under which companies such as Unseenlabs have benefited from creating nanosatellites for maritime surveillance in the Earth Observation (EO) constellation. Finally, the third wave characteristic of the New Space ecosystem concentrates on the economic value generated by the space value chain. This area creates opportunities for the development of markets such as geo-information systems, global connectivity, and machine-to-machine networks (Bousedra, 2023). For this matter, contemplating the previous information, future opportunities in the New Space ecosystem could be emerged by the following macro-trends; autonomy, the miniaturization of technology, the emergence of platforms, and the approaches taken into space by the space product designs and lifecycle management (Golkar & Salado, 2021).

Space is essential for the national security and the ability to detect emerging threats, conduct operations, support diplomatic efforts, project national power, and enable global economic applicability amongst others. Therefore, the future strategic domain is driven by the following trends: space as a contested, congested, and competitive domain (Defense, 2020).

1.3. The Transitional Interest of Space: from Geopolitical to Economic

Throughout space history, the connection between space exploration as an activity only able to perform by states has been undertaken. Despite it, the increased commercialisation and privatization of space generated

by the shifts in the spatial industry has emphasised the predominant role of states in outer space (Cobb, 2021). Nowadays, the space program is to be of noticeable growth due to the great interest generated by its activities. However, it is of significance to highlight the variety of the correlation among science, technology, and democracy, under which the intrinsic relationship constructed bases the information network even in space.

Space capabilities could be noted as another form of state infrastructure for the pillar of beneficiary state activities such as military, connectivity, research, human capital, and new market growth (Croshier, 2023). Today, however, the space arena has been overcome by a commercialisation factor, shifting the more centred authoritarian focus to a multiverse sphere with an increased access. Therefore, with a growing trend in players and policy arenas in the space. Historically, private efforts were derived towards communicational efforts. However, over the last few years, the economic profit driven by space missions have generated the growing investment of private enterprises in space funded by public capital and driven by the economic returns (Golkar & Salado, 2021). The Public-Private Partnership (PPP) model utilized by the National Aeronautics and Space Administration (NASA) has provided a far more rapid acceleration of the privatization of the space industry. Therefore, clearing the way for private companies such as SpaceX to create their own space in the spatial atmosphere since the beginning of the 2000s. Traditionally, in space contracts in the case of the United States as an example, the state would operate under a cost-plus agreement with the customer; under which the private entity would get reimbursed for the costs of the project along with the profit. However, now in the New Space ecosystem, the price of the project is previously fixed. Therefore, at all events, Private Equity (PE) and

Venture Capital (VC) are driven by economic profit for the performance of space activities. Showing a paradigm shift in the product and services ventured into space (Golkar & Salado, 2021).

Though private companies are becoming one of the main actors in the space, it is of importance to highlight that space activities must remain as a state-based governed act. This is manifested in the Outer Space Treaty, under which it is stated in Article VI:

> "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty" (UN, 1966, p. 14).

Thus, the presence of governments remains fundamental for the positive use of this resource by private companies. However, the economic dimension of the space marketplace is being affected by the miniaturization of space activities that has allowed the renewal of traditional activities, the emergence of new and the multiplication of the number of satellites; as the availability of resources have increased (Rapp & Topka, 2021). Therefore, as time passes the industrial ecosystem dominant since the beginning of the use of space has been gradually replaced by a constellation formed of small satellites, making space a dematerialised and privatised sphere (Rapp & Topka, 2021).

This so-called miniaturization of satellites is becoming a silent revolution in the spatial industry, turning this sphere into a mass production system that

diminishes space techniques used for terrestrial means (Rapp & Topka, 2021). Yet, space competencies can appear as a new style of infrastructure, one based on greater connectivity, data, research and development, and market access for economic growth. Moreover, it is important to highlight that nowadays outer space is experiencing what could be referred to as the golden hour, as trillions of dollars of economic activities are being directed to the usefulness of Low Earth Orbit (LEO) and over (Sadat, 2020). As competitive access to LEO and geo-stationary orbits have become a reality motivated by the economic and technological factors provided by the space resources. New and innovative space technologies developed by space entrepreneurs are fuelling and decreasing the cost of access to this domain. Therefore, generating an environment that conducts an expanded opportunity beyond the traditional aero spatial companies used by the governments for space missions. These new and growing comers are funded principally by “visionary billionaires with rockets and public R&D” (Sadat, 2020, p. 8). Furthermore, there are few to any entirely commercial-focused space entities constructed without any government or research purposes; organizations such as DirectTV, ImarSat or IntelSat (Hendrix & Routh, 2017).

The economic efficiency generated by companies in the New Space at the end of the economic value chain, relies on the concept that the increase of space launchers and systems would have a direct impact on the disruption of the already existent markets; having therefore, a correlative impact on the creation of new mass markets (Bousedra, 2023). Though this is not to say that space development is only reliant on technological progress but also on potential users. Therefore, making the new marketplace not only directly associated with the appearance of the digital sector such as

geo-information systems or global connectivity; but also, the shift from end-user to business to consumer service of the value chain (Bousedra, 2023). The commercial sector market activities have increased by around $100 billion from 2006 to 2015. Implying an increased investment in efficiency, innovation, and economic return (Hendrix & Routh, 2017). However, there is a noticeable difference within the main applications of the space market; Earth Observation (EO), Satellite Communication and Navigation amongst others. On the one hand, although the EO services are the least grown out of all the applicable, the revenues added in 2021 in the sector reached 2.8 billion euros opposed to 199 billion euros for the navigation market or 115 billion euros for the telecommunication services (Bousedra, 2023). On the other hand, the satellite imagery market is controlled by a reduced number of companies. This marketplace is composed on one side by bigger space participants such as Maxar holding 30% of the global EO market by 2017 or Airbus Defence and Space holding 12% in 2017. Moreover, the space market also comprises non-space players such as Altos representing 36% in 2018 amongst other. Furthermore, more than 65% of the EO is comprised of smaller player that own less than 23% (Bousedra, 2023). However, by 2022, according to the Global Commercial Satellite Market Report: the commercial imagery satellite market size stands at USD 3,754 million. With a projection of a growth rate of 11.20% CAGR during the period of 2022-2030. Therefore, reaching by 2030, USD 8,777 million (Anon., 2023). Despite it, still 60% of the data and services found in the EO emerge from the public sector such as national bodies or international institutions (Bousedra, 2023). Nonetheless, the satellite communication market tends to be the most evolved service in space, comprised of enterprises such as SES, Eutelsat, Inmarsat or Intelsat. This market is

comprised of broadcast services which have generated around USD 13 billion dollars in 2015. However, over the years this utility has experienced a decline, accounting from 25 commercial satellite orders in 2014 to 5 orders in 2017 for example (Bousedra, 2023).

The shift of activities within the spatial marketplace pertains to the rise of a new market characterised by the growth of satellite broadband activities generating a mega-constellation of private projects such as Starlink or OneWeb conducted by the private sector. It could therefore be said that the spatial industry no longer evolves only focused on the sector of the activity, but on the economic asset gained by the performance of the digital entrepreneurs. Consequently, the value creation in outer space rotated from a technological-focused approach towards commercial production of the services generated and provided by technology (Bousedra, 2023). Thereafter, the recent decade's motivation for the growth of actors in space is linked is directly correlated with the increasing demand of the space market motivated primarily by the space-based economic opportunities provided by this sector and the aspiration to colonize celestial bodies (Hendrix & Routh, 2017).

In the near future, the space industry is expected to have a positive impact on various sectors that could reach space, being this, the IT Hardware, and Telecommunications, in addition to the already present Aerospace and Defence sectors. Based on Morgan Stanley's analysis, a US multinational finance enterprise, the global space industry has the potential to generate over USD 1 trillion dollars in revenue by 2040, which poses a significant increase from the USD 350 billion dollars generated in 2020 (Stanley, 2020).

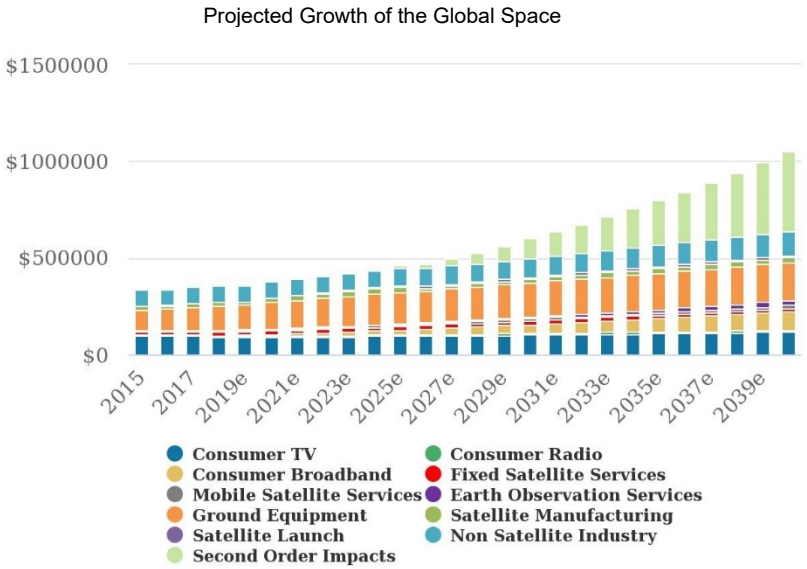

Figure 1.1. Source: Haver Analytics, Morgan Stanley Research forecasts

As provided by Figure 1.1 the most promising opportunities in the short-medium term are most likely to arise from satellite broadband Internet access, referred as “Second Order Impacts”. It is predicted within Morgan Stanley’s analysis that satellite broadband will contribute around 50% to 70% of the projected growth of the global space economy by 2040, reducing therefore, the cost of the data as demand continues rising (Stanley, 2020). However, even though state demand for data is increasing, the cost of accessing space and therefore, the data contained in it; is significantly decreasing. In fact, due to the increasing demand for data, it is estimated that the cost per megabyte of wireless data will be significantly lower, amounting to less than 1% of the current levels. Reusable rockets will play a significant role in reducing expenses, along with the advancement of satellite technology and the growth in the production of satellites. By 2020, the price of launching a satellite had

already decreased approximately USD 60 million dollars from 200 million dollars due to the ability to use reusable rockets. Moreover, there is potential for prices to lower even more, reaching USD 5 million dollars for the price of launching. Furthermore, the mass production of satellites has already decreased the cost per satellite from USD 500 million dollars to 500,000 dollars (Stanley, 2020).

CHAPTER 2: SPACE AS A SOURCE

In recent years, the space ecosystem has undergone a remarkable transformation. This significant change has been driven by the miniaturization of satellites and the introduction of cutting-edge technologies. These developments have had a profound impact on various aspects of the space ecosystem, including space exploration, commercial applications, scientific research, and global connectivity. The following sections will explore the significance of satellite miniaturization and new technologies in the space domain, as well as their potential effects on the space security network. It also considers the opportunities they offer and the challenges they pose in ensuring the security and sustainability of space activities.

2.1. The Transformational use of Space: From a military/governmental monopoly to a commercial domain

The current legal system has not effectively prevented the advancement of military technology to be extrapolated into space. Although there is the existence of some applicable limitations, this, tend to

be expressed in broader terms. Therefore, becoming a difficulty for the understanding of the terminology on what they specifically restrict. Unsurprisingly, given the close ties on the initial development of space-related technology, to military power, both in reality and in meaning of influencing others; it is not coincidental that the space race emerged during the Cold War when both the US and the USSR aimed to demonstrate their technological capabilities. The early stages of human space exploration occurred during a period of significant tension, with the constant underlying threat of a large-scale and highly destructive military conflict between the major space powers (Freeland, 2016). However, in spite of the potential humanitarian benefits, the successful launch of Sputnik in 1957 caused a general concern in western countries due to its resemblance to a ballistic missile technology (NATO, 2001). Therefore, given the delicate nature of the situation, it was imperative for the international community to take steps in regulating this new domain to prevent the accumulation of weapons and armed conflicts in space. This is commonly referred to as the Prevention of an Arms Race in Outer Space (PAROS) in contemporary terms (UN, 1981). As mentioned, the current principles of international humanitarian law are, as a fundamental component of international law, theoretically applicable to the military utilisation of outer space. “There is no specific territorial limitation to the laws and customs of war, which apply both to the area where the hostilities actually take place, as well as to other areas affected by those hostilities” (Freeland, 2016, p. 46). If, for instance, direct military action occurs in a specific region, but it has unintended consequences on civilians in other areas, it becomes important to consider whether such action aligns with principles like proportionality. Consequently, any military operation in outer space will naturally be subject to the rules of jus in hello,

not just regarding the immediate action itself but also its broader effects, including on Earth (Bourbonniere, 1999).

Since the dawn of the space age, outer space has been considered the ultimate high ground from which Earth could be controlled. The use of space for military and governmental purposes has been a significant driver in shaping the space domain since its inception. The strategic advantages offered by space capabilities have pushed governments to invest in space systems to enhance their operations. As nowhere else is competition more nebulous and strategic than in outer space. Space power “the use of space for military purposes, whether those purposes include transit of objects (missiles) or the sue of satellites for surveillance or communications” (Farley, 2020, p. 2). Thus, it is important to highlight that the final years of World War II became the introduction of the militarisation of space due to the increased use of space as a military source, initiated by Germany attacking Britain with V-2 ballistic missiles. Consequently, after the war, the US and the Soviet Union established and developed their own militarisation of space, making use of German technology and scientists. And generating their own space program, culminating in a space race. Thereafter, towards the end of 2001, the US had emerged as the leading power with approximately 110 operational military spacecraft, accounting for more than 2/3 of all military spacecraft orbiting the earth. Russia ranked second, with around 40 spacecraft, while the rest of the world had a mere 20 satellites in orbit (Pike, 2002). In the past, when satellite launches were frequent and operational durations were short, it made sense to prioritise annual launches. However, as launch rates have decreased and spacecraft lifetimes have been extended, it is now relevant to provide an update on the current operational spacecraft (Pike, 2002).

The initial military satellites, such as the CORONA Project by the US and the Zenit satellites by the USSR, were primarily used for capturing images of enemy territory, particularly military installations. To reduce dependence on vulnerable undersea cables, communication satellites like the Soviet Molniya satellites and the US Milstar were subsequently developed. Early warning satellites, like the US Missile Defence Alarm System (MIDAS) and the Soviet Oko satellites, were also created to detect the launch of ballistic missiles or satellites, as well as nuclear explosions. The first Gulf War in 1991, known as Operation Desert Storm, marked the emergence of both the information and space war, highlighting the increasing reliance on space-based assets by militaries worldwide (Skinner, 2020). The US-led operation against Iraq notably showcased the innovative use of the Navstar GPS satellite constellation for navigation, enemy target detection, and precision strikes. This reliance on space-based military systems has now extended to numerous other countries, with three global navigation satellite systems providing military services: the US GPS, Russian Glonass, and Chinese BeiDou. Advanced militaries have integrated space-based data and services into almost every aspect of military operations, including precision targeting, command and control, communications, intelligence, surveillance, and reconnaissance (C4ISR) capabilities. Ultimately, space has become an indispensable element in facilitating military activities across all domains (Skinner, 2020).

Although some states may prioritise space activity as an indicator of national status and prestige, it is highly unlikely that they would incur the significant expense of military space programs unless they perceive a proportional military benefit. Therefore, ‘why is it the case that most

militarily significant states around the world engage in at least some form of military space activity?' (McLean, 2000). The reason is simply because it holds considerable value for them. Since the early days of space exploration, space-based assets have served various military purposes, such as communications, surveillance, reconnaissance, and navigation. In certain cases, the utilisation of space for such objectives provides an enhanced capability, such as in navigation or reconnaissance. In other cases, such as the need for global real-time communications, space is the only effective means to achieve specific goals like these (McLean, 2000). The present-day military landscape heavily relies on space assets for surveillance, communications, and navigation. However, it should be noted that space may not complete sanctuary from weapons in the present times. It is important to acknowledge that almost every nation with the capability to launch a nuclear weapon into a low earth orbit (LEO) also possesses a rudimentary, albeit unsophisticated, anti-satellite (ASAT) capability (O'Hanlon, 2004). Despite the steady increase shown over the last 30 years of space military purposes, today, the situation has undergone a change. The loss of various civilian satellites would result in significant economic disruption, while the loss of military satellites would have a much more substantial impact on day-to-day military operations compared to a couple of decades ago. This is due to the increased reliance on satellite systems in today's world. The US still considers itself a global leader in the domain, maintaining the emphasis on the indispensability of US space capabilities for global leadership (McLean, 2000).

Many states desire strategic independence in space. European countries, for example, are pursuing independent as well as cooperative capabilities

in space to ensure access to essential resources. The adoption of the European Union Global Strategy for Foreign and Security Policy resulted in the establishment of Permanent Structured Cooperation (PESCO) on security and defence. This joint military program invests in equipment, research, and various space activities such as ballistic missile early warning systems and military SSA capabilities (Skinner, 2020). It also includes the utilization of the European Space Agency's civilian GNSS system for military purposes. The changing military priorities also play a crucial role in driving these developments. Several countries, including Canada, Norway, Russia, Denmark, and the US, have deployed military satellites in the Artic to address capability gaps caused by global warming (Skinner, 2020). These satellites primarily focus on communication and Earth imaging capabilities. Furthermore, advancements in technology have made it easier to deploy advanced capabilities on smaller satellites, leading to their increased usage. The US military, for instance, is focusing on utilising more smaller satellites that can be easily replaced and updated. This shift also makes outer space more accessible for military users. In 2019, Mexico and Sweden launched military CubeSats, which are miniature satellites consisting of cubic units measuring 10cm x 10cm x 10cm. The current regional geopolitical tensions have led to an increase in the utilization of space by military actors, particularly in Asia and the Middle East. In recent years, both Japan and India have expanded their space programs to include military capabilities and organizations, in addition to civilian users. The growing competition among powerful states and the significance of space systems in various military domains also contribute to the development of military space capabilities (Skinner, 2020).

Commercial satellite communications play an increasingly vital role in military operations. Moreover, it is essential to have commercial satellite communications for modern warfare as its conducted today. This is because of two unrelated trends: the development of command-and-control mechanisms that operate in smaller units, resulting in a significant increase in the number of communication links needed for operations, and the insufficient procurement of military satellite communications to meet the growing demand. As a result, 84% of satellite communications supporting operations in Operation Iraqi Freedom rely on commercial Satcom (Rausch, 2006). However, it is important to note that this dependence on commercial satellites, such as those leased from Intelsat and Eutelsat, also brings about a vulnerability. These satellites are not specifically designed to withstand malicious interference or jamming. Consequently, there is a potential risk that crucial military communications could be disrupted or weakened at a critical moment due to unauthorised transmission to the satellite by an adversary (Rausch, 2006). Despite it, as shown by the data provided by the UCS the use of military satellites during the last decade has been of 113 satellites, which compared to the usage done during the period of 1995-2014 of 82 satellites, provides an increase of 31 satellites launched for military purposes (UCS, 2023). However, it is still important to denote the fact that the launch of those satellites remain in hands of the private sector, and therefore, reliant on the commercial satellites with a focus on its military application.

2.2. The Miniaturization of Satellites in the Technological Edge

The resulting lower entry barriers have encouraged the emergence of new space actors and made it easier for local access to space, which

along with the rapid technological advancements, has resulted in the growing trend of generating smaller satellites or as denoted miniaturization of the satellites; greatly impacting the fields of space exploration and communication. Miniaturization is therefore significantly altering the economic dimension of the global market space activities. This is achieved by increasing the number of satellites to be launched annually, promoting the emergence of new activities, and necessitating the renewal of several other more traditional activities (Rapp & Topka, 2021). This shift towards the use of nanosatellites or CubeSat which as established by the California Polytechnic State University in 1999 “is characterized as a 10-centimeter edge cube, or 1U, with a maximum weight of 1.33 kg and maximum stacking of six-teen units, or 16U” (Rigo, et al., 2022, p. 168), has emerged as a transformative force in the aerospace industry. The miniaturization of satellites is producing a silent revolution in the global space industry. This transformation is not necessarily disruptive, but rather it brings the space industry into a mass production and widespread or a “trivialization” of the use of space techniques for various activities on Earth. Moreover, due to the emergence of mega-constellations formed of small satellites, the space infrastructure is undergoing diversification beyond expectation. This expansion is leading to a general spread presence, therefore losing its specificity, while transitioning towards a dematerialization, privatization, and internationalization. Consequently, gradually surpassing the control of the states (Rapp & Topka, 2021).

Miniaturized satellites provide enhanced flexibility in mission design and development, offering numerous advantages. Due to their small size, the satellites can be effectively deployed in constellations, thereby facilitating extensive data collection, and improving the global coverage available.

Therefore, these technological advancements have proven to be advantageous for Earth Observation and remote sensing applications, enabling frequent and accurate monitoring of the environment's changes, disaster response, and resource management (Kramer & Cracknell, 2008). For that matter, nowadays, due to the advancement in technology and the shrinking size of the electronic components, it is possible for less powerful states or even private individuals to own their own CubeSat, if the cost of payload remains below a few million dollars. This significant decrease in manufacturing and launching costs for satellites could potentially alter the dynamics between the public and private sectors. Thus, instead of coordination and cooperation, there may be a shift towards coexistence and even conflict. This is due to the fact that the increasing number of new artificial objects in the Lower Earth Orbit (LEO) may generate space debris without any proper control or accountability (Frankowski, 2017).

Currently, a significant number of nanosatellites, approximately a total of 1500, have been successfully launched. This achievement can be credited to the effective mass production of components and the utilization of easily accessible commercial supplies. This approach allows for a rapid development process, although it may result in a shorter lifespan. Initially designed for educational purposes, the nanosatellite format has become increasingly popular in various commercial and high-value applications due to advancements in hardware miniaturization and extensive research and development of over two decades (Rigo, et al., 2022). However, the increased miniaturization of satellites poses a series of challenges. On the one hand, the restricted payload capacity of small satellites imposes several limitations on the integration and advances in the scientific

instruments and communications systems. Therefore, on the other hand, to achieve the optimal performance and reliability within these limitations, it is of need to implement innovative engineering solutions, such as the creation of compact and power-efficient components and systems (Kramer & Cracknell, 2008). Thus, the importance of technological advancements, including software-defined solutions and high-throughput satellite (HTS) systems. On the one hand, software-defined satellites function as a space-based computing cloud platform, under which the provision of configuration changes through software updates sent from Earth could be performed. On the contrary, HTS satellite technology “is based on high level frequency re-use across multiple narrowly focused spot beams” (Orlova, et al., 2020, p. 4), resulting in a significant increase in capacity compared to the traditional satellite systems. Therefore, the implementation of HTS systems has led to a noticeable boost in satellite capacity and bandwidth for end users, all at a reduced cost. Additionally, other trends such as the manufacturing of 3D printing or In-Orbit services could be present but at a lower frequency (Orlova, et al., 2020).

2.3. Analysis of the Usage of Satellites in the Last Decade. A US Case Study with a focus on SpaceX

In the case of the United States, several national laws and regulations have been developed to govern the space activities executed by US citizens or enterprises, as states oversee maintaining any activities performed by private companies etc within their jurisdiction. Hence, an important piece of legislation in direct relation to the development and regulation of commercial space activities, is the US Commercial Space Launch Act (CSLA) of 1984. This act sets up a framework for regulations

and licensing of space launchers under the supervision of the licensing authority, the Federal Aviation Administration (FAA). As established in the CSLA Section 6(a)(1): “No person shall launch a launch vehicle or operate a launch site within the United States, unless authorized by a license issued or transferred under this Act” (Congress, 1984).

The fluctuating and uncertain space ecosystem in the matter of the US, the possibility of maintaining commercial vehicles in space became determined and reliant on the economy. Therefore, as access to space became essential, the reduction of costs to reach this commodity became fundamental. Been, the National Aeronautics and Space Administration (NASA) the most predominant US governmental agency in control of space activities and given the economic crisis of 2008; subsequent economic cuts directly affected NASA’s budget during the Obama Administration of 2010. Thus, in accordance with the situation, the Commercial Orbital Transportation Services (COTS) Programme of 2010 originated. COTS was created to allow commercial space industries to deliver the cargo and crew services in need of the International Space Station (ISS) (NASA, 2014). Certainly, shown today by Orbital ATK, Boeing or SpaceX with the reliable development of freight transfers to the ISS under a cost-effective alternative for NASA. Not to mention, that SpaceX Crew Dragon and Boing CST-100 Starliner have directed their efforts towards an access to space lower than the current Soyuz program, the longest program used for space explorations (Vernile, 2018). Thus, in this context, it could be noted the US is a trailblazer in providing access to private actors in the space business. “The Commercial Transportation Act (1984), the subsequent Commercial Amendment Act of 2004, the U.S. National Policy on Commercial Space (2008) and the last Commercial

Space Launch Competitiveness Act (2015), together with the Obama Administration's Space Policy" (Vernile, 2018, p. 15); became instrumental for the construction of the commercial space sector within today's space competitive international environment. Constructing, therefore, the foundation of the new domain promoting the stand of the US industry on global markets in space.

On that account, for the purpose of the case study. The analysis of the US use of outer space and its consequent, in accordance with the introduction of the private sector in this domain will have the US Commercial Space Launch Competitiveness Act of 2015 as base. The act, as established, was created "to facilitate a pro-growth environment for the developing commercial space industry by encouraging private sector investment and creating more stable and predictable regulatory conditions, and for other purposes" (Congress, 2015). The moderate deregulation enacted by the 2015 Act, led to an observable growth from the private sector in space. Throughout the last 15 years, the reach of commercial activities in outer space has more than tripled; increasing from 110 billion dollars in 2005 (Anon., 2006) to USD 357 billion dollars in 2020 (Anon., 2021). The most important aspect featured by the private sector is the proportion to optimize the manufacturing costs. The period between 2010-2015 illustrated a peak in the investment in private companies in space; as shown by the Tauri Group, a defence and space manufacturer, in its Start-Up Space Report of 2016. During the period of 2010-2015, the investment of the private space sector reached around USD 5 billion dollars. However, as focused by this study the year 2015, became a record for the private space enterprises with a total in private investment and debt financing of USD 2.7 billion dollars. Interestingly enough, Venture Capitals

(VCs) became the main investors in space companies, with an investment in 22 firms only in 2015 (Tauri, 2016). Furthermore, the United States in 2016 became the country with the most executed space launches, 22, conducted by the private sector.

The changing conditions in outer space generated a direct impact on the strategic context followed by the US in space. “Space is both a source of and conduit for national power, prosperity, and prestige*”* (DOD, 2020, p. 3). The US national security prosperity is reliant on the endless access to space operations which along with the great power ecosystem competition generated in outer space due to the expansion of commercial activities has transformed the character of the space domain. Becoming, therefore, a threatening sphere to protect US interests through space power. Both the number of commercial companies and the flow of investment increases in space coincidentally from the successful launch of SpaceX, an American Corporation owned by Elon Musk, onwards. This successful story of this private company sent a positive message towards private investors in the US. Additionally, therefore, it could be noted the fact that the first private entrants in space have led to a democratization of space and its potential exploitation for commercial activities. The successful story of SpaceX commences in December 2015 with the first successful landing of Falcon 9, an orbital class rocket capable of refight (SpaceX, 2015).

The company was the first private enterprise to accomplish a launch and return of a spacecraft from Earth orbit and to launch a crew into the International Space Station (Eldridge, 2023). However, the technical achievements performed by SpaceX had significant effects on the business and the policy landscape. By offering affordable prices, SpaceX

disrupted the commercial launch industry and impacted to a great extent companies such as Sea Launch and International Launch Services. Additionally, SpaceX's entry into the national security launch marketplace has intruded into the legal action affecting the Air Force as the Air Force was the main leading party in control of this sector. Therefore, increasing the competition, as seen by Airanespace and United Launch Alliance's development of new launch vehicles to effectively compete with Falcon 9 (Anon., 2020). Consequently, the technical achievement and the financial benefits of the reusable spacecraft have led others such as Blue Origin to follow this path. Furthermore, as established by Chad Anderson, CEO of Space Angels, a venture capital firm investing in the company; "SpaceX increased access to orbit by lowering the cost and bringing transparency to the market for the first time by publishing pricing" (Anon., 2020).

SpaceX has made notable advancements in cost reduction, bringing down the cost of launch from USD 18,500 dollars per kilogram between 1970 and 2000 to USD 2,720 dollars per kilogram with Falcon 9.30, a reusable rocket from Falcon 9 (Cobb, 2021). This significant decrease in cost has resulted in a more inclusive access to space, not only for private enterprises but also various other not so well-established state actors that would not have had the chance otherwise. Hence, several Middle Eastern and African states which were previously not engaged in space activities such as the United Arab Emirates or Egypt, have been able to deploy successfully satellites. For that matter, the combination of all these factors has increased the economic value of space from 350 billion dollars in 2020 to an expected 1 trillion dollars by 2040 (Stanley, 2020). The investment in Space Tech Companies reached USD 132.2 billion dollars

in 2020, from which SpaceX has the leading position with USD 6.6 billion dollars and followed by USD 4.7 billion dollars of investment in the British company of OneWeb**.**

Over the last decade, many new private players have entered the space arena, and a great number of companies are joining with new ideas. Among their uses, it includes, 3D printing technologies in zero gravity, the development of greenhouses on Mars, mineralogical research on the Moon, or the colonization of Mars (Anon., 2022). Accordingly, there were around 6,477 space companies in the US in the year period of 2020, representing 56.4% of the world's SpaceTech companies (Anon., 2021). Those are, commercial entities that specialize in the development, manufacture and operation of the systems and technologies used for all space-related activities such as satellite communications or space exploration. Based on US data and accounting with their 123 operators; the private sector has had an immense growth from 2015 with 42 space launches, 2016 led to 40, 2017 encountered 139, 2018 sent 125, 2019 provided only a small increase with 126 launches. However, 2020 become the turning point with 825 launches, followed by 2021 counting with 1099 and finally, 2022 raised 1827 satellites into space (Anon., 2023).

In the past decade, there has been a significant increase in the number of participants in the space industry, with both new space and non-space companies entering various industry-development chains. The majority of these companies, 41% of all core companies, are engaged in Space Manufacturing; followed by Space Communications (16%) and Space Observation (12.3%) activities respectively (Anon., 2021). This space technology sector or SpaceTech, accounting for more than 6,600

companies in the sector as of today, shows a remarkable exponential expansion since the beginning of its use in the 1990s. Particularly, accounting from 2009 until the third quarter of 2019, a significant surge in the establishment of new companies became noticeable. Though the pandemic outbreak and its consequential temporary setback may have affected the growing tendency set in this sector, the North American region remains the leading part in this domain, followed by Europe and Central Asia. Therefore, for the purpose of this dissertation, a more detailed study on the use of private companies and its changing effect on the space security network will be provided. Furthermore, for a complete understanding of the matter, when referred to commercial companies; it is meant, any entity that provides launch services or satellite builders for governments at a competitive price.

US Case Study

The space security network as provided has shifted to a great extent from a total state domain from a few states such as the United States, Russia, and China; to a control provided by the private sector. Despite it, outer space is composed up to the latest date available, 1st of January 2023, by the jurisdiction portrayed by 85 countries relying on their control of the space activities on the 5,860 satellites sent by more than 10,000 enterprises globally (UCS, 2023).

The Union of Concerned Scientists (UCS) determined in January 2023 that they were 5860 satellites orbiting the Earth. Of them, 4213 belong to the US, 534 to the UK, 474 to China, 92 to Russia, and 547 to other countries. In accordance with an extensive report published by Citigroup in May 2022, the satellite market comprises the majority, accounting for over

70% of the space economy. Satellites can be divided into four main blocks depending on the services they provide in accordance with their activity of focus, these are the following: military, civil, commercial, or governmental. During the period of this study, 2015-2023, a total of 5,860 satellites have been active and sent into space; from which 258 were for military purposes, 128 for civil, 341 for governmental, 4938 for commercial, and 195 for a mix of other purposes. Therefore, showing an increase of 4,604 satellites in reference to the period of time of 1995-2014 under which 181 were for military purposes, 25 for civil, 197 for governmental, 334 for commercial, and 108 for other uses (UCS, 2023).

For that matter, on the one hand, satellites of remote sensing of the Earth (SR) offer valuable contributions to environmental monitoring and protection, humanitarian response, resource management and sustainable development. Moreover, in accordance with Straits Research, the global earth observation market had a valuation of USD 3.58 billion dollars in 2021 and is projected to reach USD 7.88 billion dollars by 2030, with an expected steady growth rate of 6.87% between 2022-2030. On the other hand, based on a report published by SkyQuest Technology Group in 2022, the global satellite communications (SATCOM) market is valued at USD 38.98 billion dollars. However, the market projections are expected to be USD 83.25 billion dollars by 2028, with an average annual growth rate of 11.45% (Anon., 2022). Market growth is expected as many players are entering the industry as connection services such as the internet, Global Positioning Systems (GPS) or mobile devices are in high demand. Currently, the market is primarily dominated by private companies such as SpaceX, OneWeb, Starlink, SES, Telesat, Viasat or Intelsat (Anon., 2022).

As provided by the data, the leading market in space is commercial activities with an increase of 4,604 satellites in the last decade, accounting for 4,938 satellites in space. Under which Western countries have achieved the greatest success (UCS, 2023). However, China has had the highest growth rate in the last years, with an increase of 170 satellites over the last two decades. Furthermore, as estimated by Euroconsult an average of 990 satellites will be launched yearly, generating by 2028 around 15,000 devices in orbit (Anon., 2022). Furthermore, as shown by the data and in accordance with the Space Tech Analytics report of 2021, the United States remains the leading actor in the space sector. There are 5,582 space companies in the US, almost 10 times more than the second country in power in the communication sector, the United Kingdom which accounts for 615 space companies (Koetsier, 2021). The economic power and political structure of the US permit the country to keep growing its assets in space. The United States accounts for 4,213 active satellites; from which governmental activities account for 37, military 96, commercial 3,944, and civil 25 (UCS, 2023). Therefore, becoming the number of commercial resources set in space triples the number of satellites used in military activities which is the second most use given to space by the US. Commercial ventures have become noticeable and of importance by 2021. It is important to highlight the fact that all commercial activities performed by the US are reliant on private companies as shown by Figure 1.2.

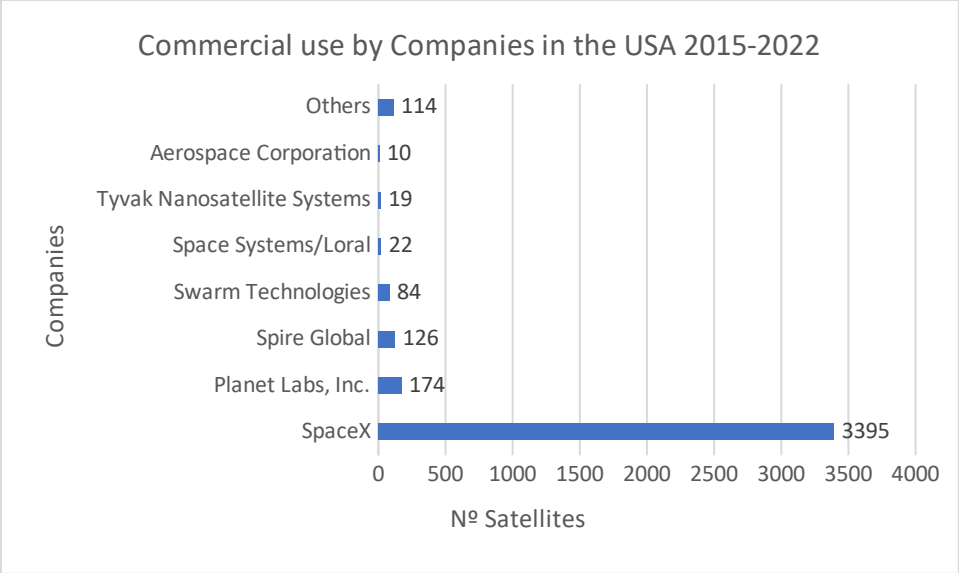

Figure 1.2

Source: Own creation with UCS data.

As provided in the graph, the commercial marketplace is completely monopolised by the private sector, in particular, 43 enterprises control the commercial US space sector in outer space. It is of relevance to denote the fact that the company SpaceX has become a leading enterprise during the last years, surpassing the rest of the companies' combined by 2,846 manufactured active satellites launched into space during the last decade. The enterprises that control the outer space market cover several different aspects of the market; even though all of them supply business for the commercial and communications sector in space. Therefore, on the one hand, the leading enterprise, SpaceX, provides aerospace manufacturing and space transportation. While the companies that follow such as Planet Labs, Inc. a private earth imaging company, Spire Global a private satellite power data enterprise, Swarm Technologies a low-cost global connectivity company, Space Systems/Loral or known as Maxar Technologies a

commercial satellite systems and aircraft provider, Tyvak Nanosatellite Systems specialised in design, integration and the launching of nanosatellites or Aerospace Corporation a non-profit organisation that provides technical and scientific data; have become the main actors in outer space during the last decade. Therefore, overruling the power of states within the space commercial sector, is the sector that has had the most attractiveness and resources during the last two decades. For that purpose, a more detailed graph of the growth of the leading companies in the commercial area in space would be provided.

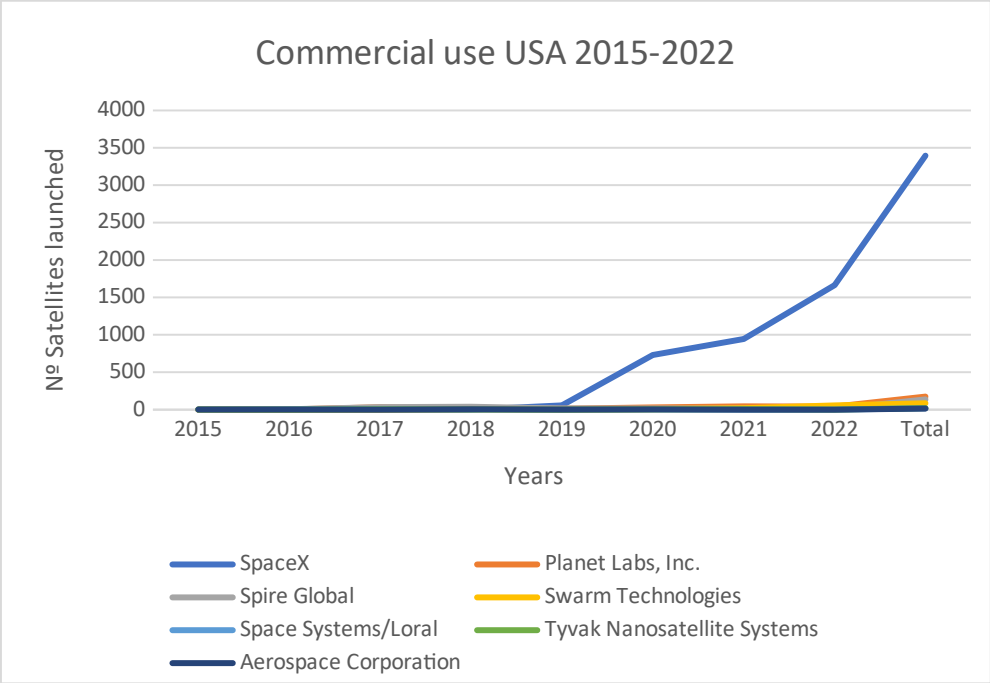

Figure 1.3

Source: Own creation with UCS data.

It could be noted in Figure 1.3 the exponential growth of SpaceX during the period of 2019-2022, a growth unmatched by any other private company in space. Thereafter, during the following next paragraphs a

more in-depth analysis of Elon Musk's space company, SpaceX would be provided as the effect on the change of the spatial security network with the reliance of states, in this case, the United States, on private companies. SpaceX, formed in 2002 became a key element for the increased commercialisation and to the entrance of private companies to the space marketplace as mentioned previously, also impacting the shift of power within the space security network. SpaceX provided reusability, commercial space transportation, innovation and disruption, a satellite constellation project with Starlink for the provision of broadband internet coverage, and a long-term goal of the colonisation of Mars.

Over the past decade, there has been a remarkable growth in space activities, due to the contribution of private entrepreneurs such as Jeff Bezos with Blue Origin or Richard Branson with Virgin Galactic. These companies have collaborated with esteemed organizations such as the US Aeronautics and Space Administration (NASA) and other governmental agencies (Yap & Kim, 2023). These startups have sprung out of raising millions of dollars for data collection, communications, asteroid mining, and primarily for the development of new rockets. However, some of the recent arrivals might have vanished as quickly as they came; others, maintain themselves by increasing their customer bases (Anon., 2020).

Space enterprises are pushing the boundaries of rocket technologies and satellites at an accelerating paste in the space innovation ecosystem. As put by Marco Caceres, a senior space analyst at Teal Group a US aerospace consultancy; "We're in a transition era where the military and NASA feel comfortable buying services instead of developing their own"

(J.Levine, 2019). The transition of NASA from the reliance on their own commercial manned spacecraft to the private sector occurred with the cancellation of the NASA Space Shuttle program in 2011 due to safety and budget constraints and a shifting focus on future exploration goals. Following this event, NASA's partners outsourced through Russia's usage of engines or as a partner for the launching of individuals into the ISS. However, after 2015 private rocket companies such as SpaceX or Blue Origin became of interest in the effort to shift US reliance on competitors towards more national auto-determined self-reliance in space activities (Risen, 2015). As an example of it, NASA's budget in the 1960s for the Apollo program reached USD 28 billion dollars, which in today's economy could be translated into 280 billion dollars (Society, s.f.). However, the cost reduction of startups has successfully proven the fact that for example, SpaceX's launching systems of rockets cost around 97% less than the Russian Soyuz spacecraft in the 1960s. Proving the ability of private contractors to be at the same level of competition as aero spatial contractors such as Boeing or Lockheed Martin (Anon., 2022).

In order to provide a more in-depth analysis of the impact of private companies in space such as SpaceX and its impact on the security network and use of space. A brief dissemination of the reliance of the US State in the private sector, SpaceX, more specifically with the instruction and substitution of NASA activities will be provided in this section. The United States National Aeronautics and Space Administration was developed in 1958 for the gain of knowledge on space exploration. Over the years as other actors in the space security network, these agencies portrayed work as being affected by the new innovations reaching outer space. NASA has not only reached to other allies, but it has also extended

contracts to companies across the US to “provide spaceflight hardware, software, and mission integration and operations services on a commercial basis for the agency’s International Space Station Program in support of the commercialisation of low-earth orbit” (NASA, 2021). Therefore, as put by NASA Administrator Jim Bridenstine “The idea is to explore, retire risk, commercialise, and then move on down the road” (Levine, 2019). The generation of bilateral contracts between NASA and private companies such as SpaceX or Boeing began after the economic crisis of 2008 and the consequential budget reduction imposed by the US government. Furthermore, the end of the space shuttle program in 2011 reaffirmed the idea of a strong reliance on the private sector; since contracting private companies also let NASA cut costs. And therefore, leading to NASA awarding 6.9 billion dollars in contracts to Boeing and SpaceX for the creation of launch vehicles to carry NASA personnel to the ISS. For that matter, the era of New Space is signified by the shift of private companies deciding the direction of space exploration (Levine, 2019). As noted, as an industry driven by military and governmental programs, the introduction of new players has brought new interests and opportunities in the ecosystem.

National governments remain of significant influence on commercial space activities, frequently by the provision of funding. As an illustration, the US agency under the 2008 Commercial Resupply Services, awarded NASA with USD 5.9 billion dollars in the initial round of commercial resupply contracts. Additionally, allocating 14 billion dollars in the subsequent round. Furthermore, through the 2011 Commercial Crew Program, NASA invested a substantial amount of billions of dollars in several companies, aiming to foster the development of a secure and dependable US

commercial crew space transportation capability (Ben-Itzhak, 2022). More recently, in 2021 NASA granted a contract worth USD 415.6 million dollars for the development of the commercial space station, directed to Blue Origin and Nanoracks. Therefore, aiding science experiments and other payloads to the ISS by private companies; including Northop Grumman, a well-established defence contractor (Davenport, 2022). Despite it, NASA's primary partner remains to be Elon's Mush SpaceX, due to the proven help provided by this space private company to the public agency. For numerous years, SpaceX has been the cargo and supplies provider to the ISS on behalf of the agency. Therefore, allowing a more collaborative effort from both parties, resulting in the opportunity to transport astronauts to the ISS with the use of SpaceX's technology (Davenport, 2022). However, along with the involvement of new services in space, NASA along with it has integrated a 3-million-dollar Communications Services Program into its budget. Therefore, this new program substitutes the multibillion-dollar "government-owned Space Network with commercial communications services and capabilities" (Sheetz, 2019).

In conclusion, it is possible for the privatization of space security to develop in unexpected manners. However, in today's space environment, private actors are more likely to provide the role of security regulators than security providers. Therefore, in situations where investments in space technologies have become of less profitability in accordance with other areas of the economy, the private sector may prioritize soft law and conflict prevention in space. Thus, other private actors such as the Secure World Foundation (SWF) focus on space sustainability and would become of significant importance in shaping the international guidelines for space

activities; in addition to the major space companies such as SpaceX, Blue Origin or Virgin Galactic (Frankowski, 2017).

Though private enterprises play an increasingly significant role in space, it is crucial to acknowledge that space activities should still be viewed and regulated from a state-based perspective. The Outer Space Treaty holds states accountable and responsible, as mentioned before, for all space-related activities carried out by their citizens. Consequently, governments continue to have a fundamental role in supervising private activities in outer space to guarantee compliance with pertinent international agreements and domestic laws (Cobb, 2021).

CHAPTER 3: SPACE AS A COMPETITION AREA

3.1. Private Companies and The Recollection of Information: The Big Data Fiasco

The information revolution has had a significant impact on our society, leading to advancements and valuable knowledge in different fields. Private companies play a crucial role in gathering, studying, and applying vast volumes of data, the Big Data fiasco. Nevertheless, there are concerns regarding the level of intrusion in data collection by these companies and the potential consequences for privacy, security, and public trust. Public and private interests are intertwined, and due to lobbying, public agencies may provide the impression that by a purchase of a service from a private operator, the public interests become better managed without undue financial risks. Therefore, the argument becomes a contributing fact to the understanding of the process of the privatization

of space security. Moreover, the participation of commercial entities in the provision of space activities generates a connection between the lobbies, services, and public administration. However, the increased demand has been outsourced to the private sector such as telecommunications or satellite imagery (Kolovos, 2017).

In the past, a wide range of media and communication methods were employed in military intelligence. However, following World War II, a shift towards stricter control, mechanization, and centralization of intelligence information within the Office of strategic services in the US. With the advent of the Cold War, the use of data from aerial and satellite reconnaissance became more prevalent. As the automation of map and image data collection become more widespread, there was a greater emphasis on the promptness and integration of the data, as well as their interpretation for decision makers (C.Clarke, 2020). There is a significant amount of potentially misleading information that can pose a threat in modern warfare scenarios. In the past, such information was not regarded as a significant threat due to its limited scope but it has now become one of the most formidable challenges to confront. Considering this, space-based information and communication services offer a valuable source of reliable and trustworthy information compared to other alternatives (Adriaensen, et al., n.d.). Therefore, satellites have become a vital player in modern society by enabling the collection of valuable data and information from remote and inaccessible regions. Moreover, the increasing complexity of satellite technologies has expanded their applications across a wide range of fields, including climate monitoring, disaster management, agriculture, and urban planning (Kamarulzaman, et al., 2023).

As denoted, satellites are “any man-made object placed in a near-periodic orbit in which it moves mainly under the gravitational influence of one celestial body, such as the earth, sun, another planet, or planet’s moon” (GEMET, n.d.). In the past, satellite images were costly and primarily used for military purposes, such as threat monitoring and assessment. An example of this is the reconnaissance satellite known as CORONA, which was launched in 1960 and ceased operation in 1972 due to the unauthorized release of confidential images on the Internet. These images contained sensitive information related to the military security and defence of the US. CORONA was primarily developed for surveillance over areas including the Soviet Union, China, and other parts of the world. The first civilian earth satellite, Landsat, launched in 1972. Landsat 1 to 5 were successfully launched without competition until 1986 when the first commercial satellite, SPOT, was introduced (P, et al., 2016). The availability of commercial satellites has gradually made satellite images more affordable and expanded their range of applications. Satellites such as Ikonos and QuickBird offer global, accurate, and high-resolution images to individuals, organizations, and governments (P, et al., 2016). Satellite imaging systems can be categorized into radar and optical systems. Radar systems provide their own energy to illuminate an area of interest and measure the reflected signals, while optical systems capture the reflected electromagnetic waves of sunlight and/or infrared radiation emitted by objects on the ground. Optical satellites are more commonly utilized compared to radar satellites. Researchers are able to collect data unaffected by local air traffic constraints through the use of satellites (P, et al., 2016). This allows them to analyse land covers at different times, which is ideal for long-term studies. Satellite-based research methods are

advantageous as they save time, reduce costs, and enhance the ability to classify vegetation through spectral and texture analyses. In contrast, ground measurement methods are challenging, expensive, time-consuming, and labour-intensiveT (P, et al., 2016).

All space-related objects, such as rockets and satellites, produce immense amounts of data. For instance, in 2020, there were 2,666 operational satellites in orbit, each collecting thousands of terabytes of data daily, which adds up to petabytes annually. To put it into perspective, one petabyte is equivalent to 1,000 terabytes or the storage capacity for approximately 250 full-length (Larovici, 2022). Therefore, as seen, the quantity of data is quite substantial. Furthermore, future space missions, such as Surface Water Ocean Topography (SWOT) or NASA-ISRO Synthetic Aperture Radar (NISAR), are expected to generate even more data. Combined, these missions will produce around 100 terabytes of data per day. SWOT will contribute about 20 terabytes, while NISAR will generate approximately 80 terabytes daily. Currently, NASA's Earth science data archive is around 40 petabytes, but by 2025, following the launch of SWOT and NISAR in December 2022, it is estimated to hold over 245 petabytes of data (NASA, 2021). At present, the main core algorithm, scikitlearn, available in the Python software database, offers data processing methods such as classification, regression, and clustering algorithms. The TensorFlow program in Python software, with its dataflow graphs, automatic derivation, and customisation capabilities, calculates the data. Although the use of databases has been extensive in various fields, the landscape architecture design field is still in the explanatory phase. By screening a vast amount of data from databases, the current landscape design includes data from various sources, such as geographic

information system data, including remote sensing image data (RS), digital elevation data (DEM), and meteorological data. The derived data is utilised accordingly (Guo, et al., 2021).

The growth of Big Data can be attributed to the increasing number of data sources and the wide variety of data available in today's world. Big Data is commonly defined as a massive amount of data from various sources, which is unstructured and difficult to manage using traditional technologies. According to most definitions, Big Data is a large pool of data that requires innovative technologies for capture, communication, aggregation, storage, and analysis. The characteristics of Big Data are often described by the four Vs: volume, velocity, variety, and value. Volume and velocity refer to the significant growth and high speed of data, while variety highlights the diverse formats and structures of the data. This poses challenges as traditional relational databases struggle to process unstructured data, leading to the development of new database technologies like NoSQL databases. Additionally, value emphasizes that while there is a vast amount of data, only a small portion of it is truly valuable for making informed business decisions. In the field of military surveillance, the data can be machine-generated, such as imagery, seismic, and data sensor, as well as from open-source intelligence. The application of Big Data tools offers significant advantages in national defence, particularly in terms of security and real-time data processing (Bognár, 2020). However, Big Data faces a transparency paradox, as the operations of big data itself are largely concealed due to legal and commercial secrecy. Additionally, big data creates an identity paradox, as individuals desire control over the formation of their identity. Infrastructure security involves ensuring secure computing in distributed programming

frameworks and implementing security practices in nonrelational data stores. Data privacy focuses on techniques such as privacy-preserving analytics, cryptographically enforced data-centric security, and granular access control. Data management involves secure data storage, transaction logs, auditing, and data provenance. Lastly, data integrity and reactive security involve end-point validation, filtering, and real-time monitoring (Bognár, 2020).

The increase in investments has resulted in increased competition and innovation and has allowed for the development of new business models such as mega-constellations. These systems utilise hundreds or thousands of satellites in LEO to provide services like low-latency broadband. Deloitte predicts that by the end of 2023, there will likely be over 5,000 broadband satellites in LEO, bringing high-speed internet to a million subscribers worldwide. Additionally, by 2030, an estimated 40,000-50,000 satellites could serve over 10 million end-users (Coykendall, et al., 2023). One of the key concerns arising from private companies' involvement in the recollection of space data is the issue of data ownership and control. As these companies invest significant resources in satellite deployment and missions, questions arise regarding who owns the data collection by their satellites. Moreover, as private companies' motives are driven by commercial interests and profitability, this focus may lead to a prioritization of the data collection for commercial applications overshadowing scientific objectives. Therefore, data access becoming a critical issue due to the vast control of private companies over space data.

3.2. A New Possible Domain of State Relations

The security of space is a collaborative effort aimed at achieving mutual benefits. However, despite the importance of cooperation in space security, this can become challenging. In the current landscape, competition is gradually being replaced by collaborative efforts centred around military alliances and emerging strategic interests. Given this scenario, there is uncertainty regarding the continuity of cooperation as a fundamental value and principle in space activities. This endeavour is essentially a collaborative effort aimed at achieving mutual advantages. However, cooperation in this regard is not always simple, as outer space, much like geopolitical relationships on Earth, is influenced by both cooperative tendencies and factors such as competition, self-interest, power imbalances, and apprehension. However, as a mode of control of the security of space, the cooperation relations contribute to provide transparency, trust, and alliance capable of transcending the political provocations (Adriaensen, et al., s.f.).

Institutionally, the ruling focal point for cooperation is laid out in the UN COPUOS, which fundamental mandate focuses on enabling the sharing of information about activities in space, and encouraging and assisting nations in collaborating in a peaceful manner together for the use and prevention of conflicts in outer space (UN, 1959). Despite this, it is of importance to highlight the fact that cooperation is more likely established around technical areas. The agreement of 1962 made it easier for countries to exchange weather data and launch meteorological satellites. It also allowed for efforts to map Earth's geomagnetic field and experiment with satellite communications (Sagdeev & Eisenhower, 2008). These practical approaches to cooperation in space are still important today and have become essential services for the entire world. This includes the

share of meteorological and climate data, making civilian positioning, navigation, and timing services accessible and compatible, and making EO data more widely available to the public (Adriaensen, et al., s.f.). Thus, the coordination and sharing of information, data, and services have been formalised through the use of organisations such as the International Committee on Global Navigation Satellite Services (ICG) of 2005, under the UN to provide compatibility and transparency among the systems, composed around by 62 member agencies coordinating data from 170 satellites to harmonise civil EO programs.

Exploration in outer space plays an important role in balancing national interests and collective aspirations. Despite the competitive nature that characterises space activities during the Cold War. The pursuit of space exploration gradually fostered cooperation, starting with the 1975 Apollo-Soyuz Test Project. This project, which marked the first international human spaceflight, symbolised a growing dissension between the United States and the Soviet Union. However, it was also driven by practical and self-interested motives. Importantly, the mission also showcased the possibility of cooperation in technological areas, such as the exchange of scientific data related to ongoing space probes and robotic missions (Adriaensen, et al., n.d.). This laid the groundwork for the cooperative spirit that has been a defining aspect of space exploration ever since. Therefore, in space, the agreement of 1992 between Russia and the US to enable astronaut exchanges and dock NASA's Space Shuttle with Russia's Mir space station. Leading, to the generation of the ISS, as an enduring symbol of cooperation in space over the last two decades. Thus, showcasing a permanent presence of cooperative states such as the US,

Russia, the EU Space Agency, Japan Aerospace Exploration Agency (JAXA), or the Canadian Space Agency (Adriaensen, et al., n.d.).

Today leading states such as the US and Russia remain leaped to each other through the ISS; NASA been dependent on Russia through the use of Soyuz, while Russia becomes dependent on US satellite communications. Despite the efforts of both parties to reduce dependency, this longstanding cooperation has managed to overcome geopolitical tensions on Earth, including the political consequences of recent interventions in Ukraine. Collaborative endeavours on the ISS have mostly remained unaffected by escalating hostilities and sanctions in other areas (Adriaensen, et al., n.d.). Moreover, similar to space exploration, some initiatives have an international scope. For instance, the KiboCUBE joint project between UNOOSA and JAXA utilises Japan's Kibo module on the ISS to launch CubeSats on behalf of educational and research institutions from developing nations. However, most collaborations are of a bilateral nature. NASA currently holds over 700 agreements with international organisations, China with 120 (Xinhua, 2018), and the Indian Space Research Organisation (ISRO) with 50 countries (Adriaensen, et al., s.f.). However, as more states introduce themselves into space, the significance of bilateral relations in expanding national capabilities. As an example of it, the UAE's national space agency has signed around 16 cooperative agreements with international space agencies for the advanced capabilities provided by the cooperation of space exploration and human spaceflight. Furthermore, it is of importance to highlight regional cooperation in space as a critical tool for its increased access to the domain. However, it is mostly developed by European countries and the use of the European Space Agency (ESA) but followed by Africa and

the UAE. Yet showing the enduring tensions maintained between regional cooperation and strategic cooperation (Adriaensen, et al., n.d.).

Cooperation on space security to mitigate natural threats is another core contribution to the domain. As an example, in 2013 the UN COPUOS created international networks for the coordination, early warning, and future defence measures such as the International Asteroid Warning Network (IAWN), and the Space Mission Planning Advisory Group (SMPAG). Furthermore, this encompasses matters that pertain to dual-use capabilities, such as active debris removal and advanced rendezvous and proximity operations, as well as issues related to arms control, such as limitations on international interference or harm to satellites. Additionally, there is a lack of effort to establish a broader and more inclusive approach to SSA. This matter sheds light on the delicate balance between the need for cooperation in safeguarding space as a global resource and the national security concerns that fuel strategic competition (Adriaensen, et al., n.d.). While debris mitigation has become an important aspect of international cooperation for the security of outer space, ensuring safety from debris relies heavily on SSA, which is currently characterised by limited cooperation. It is important to note that despite its usefulness, there is currently no global system in place for monitoring objects and activities in outer space or managing space traffic and safety. However, it is worth mentioning that there is still some level of cooperation on SSA, although it is primarily focused on military efforts and is predominantly supported by the US (Adriaensen, et al., n.d.). Deeper cooperation on the sharing of more sensitive, classified data for the support of advanced safety and security in space that is currently limited to bilateral agreements between United States Strategic Command

(USSTRATCOM) and key security partners; including 19 states as of 2019 in the agreements (USSTRATCOM, 2019). Furthermore, other actors, such as European states are also developing their own independent SSA competences. China and Russia for example despite possessing extensive national capabilities, do not share the data recollected. Additionally, several private enterprises offer commercial SSA services, although the ongoing challenge of balancing the common interest of space security along with national security issues relates to the increasing use of outer space (Adriaensen, et al., n.d.).

The vulnerabilities shown in outer space, like SSA, are resulting in the emergence of new forms of selective cooperation based on the intensification of military associations and strategic alliances. Most of the cooperation involves the sharing of space-based capabilities and data for terrestrial military purposes. For example, the Netherlands, Canada, and the UK participate in the US Advanced Extremely High Frequency (AEHF) satellite program, while other countries: Denmark, Luxembourg, Canada, New Zealand, Australia, and the Netherlands share the use of US Wideband Global Satcom communication services (Adriaensen, et al., n.d.). However, this cooperation is now expanding into a formal alliance structure focused on defence interests in outer space, in collaboration with the Five Eye intelligence alliance to share signal intelligence. The outer space security partnerships are growing, there are already strengthened space defence-related cooperation partnerships among several nations such as US-Japan, US-India, Japan-India, India-France, India-Vietnam, Germany-Japan, or China-Pakistan (Adriaensen, et al., n.d.).

As already seen before, the introduction of the private sector in space has had a direct impact on the completion of the space activities, previously executed by states. Considering the growing number of satellites that companies are requesting broadcasting rights from the US Federal Communications Commission, there is a possibility that certain orbits might reach their maximum capacity. This means that these orbits will have reached the maximum limit of satellites that can be operated, as determined by the physical and radiofrequency interference factors. As a result, there might arise disagreements regarding which country has the legitimate claim to utilise specific orbits or potential resentment when a particular orbit becomes predominantly occupied by one country's commercial sector (Samson, 2022). Moreover, the competition over the electromagnetic spectrum becomes a possible path for the future of international security issues on the mega-constellations. To a great degree, most of the launching companies are based in the West, which may influence the global perception of the impact and intentions in outer space. However, it should be noted that there have been plans for at least one Chinese company to launch around 13,000 satellites, as well as South Korea developing its own mega-constellation (Samson, 2022). Therefore, the commercial sector possibly becoming a concerning contributing factor to the destabilization of the capabilities used solely by governments. However, there is no clear view on the solely negative effect of commercial capabilities in space, as they could become an enhancing factor for international security and stability.

For instance, the field of SSA, which involves monitoring and understanding the space environment and human activities in space, was initially limited to a select few governments. However, it is now becoming

more accessible through the growing commercial sector. This development has the potential to contribute to stability in various ways. One significant advantage of relying on commercial providers, who primarily sell images of space, is that they are often more willing to share information compared to certain government sources, which may be constrained by the sensitivity of their data. Consequently, a thriving private sector in space could offer multiple sources of SSA, thereby corroborating official statements about space activities and promoting responsible behaviour in outer space (Samson, 2022).

The current trend of commercial entities taking over the space industry is causing Russia to fall behind. This has significant security implications that are concerning. It is not surprising that Russia lacks a significant commercial space sector, as it has historically been opposed to the involvement of the private sector in space. Additionally, Russia's civil space program is currently facing challenges in finding stability and has experienced some notable quality control issues publicly (Axe, 2021). Despite it, new ties in outer space could be seen as Russia and China signed in 2021 the International Lunar Research Station for the cooperation in lunar exploration (Jones, 2021).

CHAPTER 4: THE PRIVATE SECTOR IN THE INTELLIGENCE WORLD

The obsession of humanity with the cosmos has resulted in a multitude of revolutionary discoveries and scientific progress. By expanding our understanding beyond the limits of Earth, space exploration presents extraordinary opportunities for unravelling the mysteries of the universe, exploring our beginnings, and finding solutions to global issues. This

section of the dissertation aims to emphasize the importance of space for security and intelligence recollection, also discussing the potential advantages and challenges posed not only by these endeavours but also by the introduction of private companies into this domain.

4.1. The effects of Private Companies in Space to GEOINT

The long-lasting fascination of humanity around outer space for the quest of knowledge beyond Earth has been the driving force behind the ambitious scientific pursuits. Hence, the collection of intelligence through space exploration has played a crucial role in the understanding of the celestial phenomena, planetary defence, the exploration of possible extra-terrestrial life, and the development of ground-breaking technologies that have wide-ranging applications. Thus, nowadays, Artificial Intelligence (AI) comprised as “all the techniques that enable computers to mimic intelligence, for example, computers that analyse data or the systems embedded in an autonomous vehicle” (EESA, 2022) is making significant advancements in space exploration, contributing to autonomous spaceflight, planetary exploration, and cosmic mapping. Today, AI plays a crucial role in performing tasks that would otherwise be challenging for humans to accomplish in space, such as analysing cosmic events, managing systems, mapping, and more. It is a resource employed in various aspects of space exploration, including autonomous rovers, assistants and robots, intelligent navigation systems, satellite data processing, mission design and operations, mission strategy, locating space debris, data collection, and exoplanet discovery. Therefore, various agencies and companies, including NASA, the European Space Agency

(ESA), SpaceX, and Google, are utilising AI to discover celestial objects and enhance the success of the operations (DeltecBank, 2023).

At present, there is a growing focus among governments on improving their ability to collect and analyse intelligence information from space. Space-based resources, such as satellites and other reconnaissance platforms, offer unprecedented benefits in terms of national security, scientific exploration, and geopolitical influence. The pursuit of intelligence data from outer space allows governments to monitor global events, enhance military capabilities, address security risks, and gain valuable scientific knowledge. The exploration and utilisation of space have become increasingly important for governments around the world. From the starting point, the race for dominance as already mentioned, commenced during the Cold War to obtain a strategic edge by deploying reconnaissance satellites, to the inception of space-based intelligence collection greatly impacting global geopolitics. Space-based assets have undergone significant advancements in satellite technology, imaging resolution, and data processing, thereby facilitating more refined and immediate intelligence gathering. Therefore, due to an increasing dependence on network-centric operations, governments have placed a greater emphasis on enhancing their capacity to gather and analyse intelligence data.

The term space observation in literature comprehends two dissimilar categories. In the first instance, surveillance, the capability to provide general information about changes in a state. Because of surveillance being dependent mainly on the spatial resolution from the systems. In the second instance, reconnaissance, as method of detection of

transformation in the areas of interest (Kolovos, 2017). In recent years, Geospatial Intelligence or GEOINT has gained significant attention within the commercial and governmental sectors, in the same way as in the academia circles. However, the term as it is conceived to date has transformed from its previous connotations when created (Clark, 2020). The original definition contained in the US Code Title 10, 467 (5) of the term relates to the foundation of the United States National Geospatial-Intelligence Agency (NGA); under which it is stated Geospatial Intelligence as “the exploitation and analysis of imagery and geospatial information to describe, assess, and visually depict physical features and geographically referenced activities on the Earth” (NGA, s.f.). Geospatial Intelligence consists of “imagery, imagery intelligence, and geospatial information” (C.Clarke, 2020, p. 127). However, the current usage of the term does not mandatory include solely imagery products, whilst they are frequently used. Geospatial Intelligence has expanded its scope to enclose a broader meaning beyond information solely collected and utilized by the secret service. “GEOINT is emerging as the most valuable tool for envisioning and predicting activity around the world, serving everyone” (C.Clarke, 2020, p. 129). The tools and techniques employed by Geospatial Intelligence include “remote sensing, image analysis and interpretation, geographic information systems and science, positioning and tasking, and the human and computational systems that assemble, conflate, and process the data and information from both open and secure systems deployed worldwide” (C.Clarke, 2020, p. 127).

Ensuring national security and defence is of outmost significance for the smooth operation and sustainable development for the long-term growth of every nation. Thus, Geoinformation technologies happen to have

extensive application for the realm of national security defence; specifically, the utilization of Global Positioning Systems (GPS) and Satellite Remote Sensing Systems (RSS) (Kostev & Anguelov, 2022). Furthermore, the major key elements that compose GEOINT include "imagery analysis, geospatial analysis, and geospatial information and services" (C.Clarke, 2020, p. 127). Thus, the sources from which imagery can be obtained are various. On the one hand, coming from "satellite, aircraft and unmanned aerial vehicle images" (C.Clarke, 2020, p. 127). On the other hand, geospatial analysis leverages the use of "locations, distributions, and patterns of gestures on maps on images and from existing geodatabase to examine and explore spatial relations among the features" (C.Clarke, 2020, p. 127). Moreover, Geospatial Intelligence involves the integration of precise location data with the corresponding attributes for both natural and human features employing the capabilities of Geographic Information Systems (GIS) (C.Clarke, 2020). GIS provides a comprehensive perspective through visualization and the extraction of relevant information from the database to identify threats in a timely manner. The dissemination and access to intelligence through GIS methods lets the visualization and identification of threats from different natures such as technological, human, or natural visible (Kostev & Anguelov, 2022). Additionally, it enables the visualization of spatial location of military and technical infrastructure sites, transport network, geographical attributes, population distribution, settlements, and the territorial distribution of military forces. Such insight contributes to the management and defence of military logistics, operations, and exercises (Kostev & Anguelov, 2022). The creation of landscape map depicting provides planners and decision makers with the instruments to make worthy use of the Geospatial Intelligence for civil and military employability

(Clark, 2020); with the use of technological systems such as GIS, DEM, GPS or SSA. Geographic Information Systems grants access to real-time up to date information to assist the improvement of the management of the decision process. However, it is of importance to underline the fact that GIS depends on the availability of Digital elevation model (DEM). The DEM is comprised of a matrix of numbers under which each entry corresponds to a particular location on the surface, and the numerical value associated to the entry that denotes the elevation point of the location designated to the referenced point (Clark, 2020). Moreover, DEM is used to amend aerial and satellite imagery for mapping or three-dimensional models for military purposes. On the other hand, within civilian purposes DEM is used for 'food modelling, mineral exploration, modelling water flows, doing groundwater studies, and ensuring safety' (Clark, 2020). Another technological system of great significance is the utilization of GPS for the obtention of precise geolocation.

The commercialisation of outer space has brought a significant increase in private companies entering the field of space exploration and satellite technology. This trend has the potential to greatly impact GEOINT, providing access to new data sources and advanced technologies. As private companies launch their satellites and gather large amounts of geospatial data, concerns regarding data ownership and privacy rights become more prominent. In the past, GEOINT has mainly been managed by government agencies, but the involvement of private entities raises questions about data accessibility and usage. The absence of clear regulations may lead to the misuse of geospatial information for commercial purposes, potentially jeopardising both individuals' privacy and national security interests. Therefore, the increased involvement of

the private sector in space has led to heightened competition in the GEOINT sector. Traditional government agencies may encounter difficulties in keeping up with the rapid technological progress driven by private sector investments. The dispersion of GEOINT resources among various private and public entities could lead to duplications and inefficiencies, reducing the overall effectiveness of intelligence collection and analysis efforts. While private companies bring new data sources and services, their commercial interests may prioritize certain areas over others. As a result, there may be gaps in information and limited coverage in less profitable regions for private ventures. In situations where access to critical intelligence is limited, governments may face challenges in making well-informed decisions during crises or conflicts.

The commercial industry has made significant progress in GEOINT remote sensing and processing. Consequently, space-based sensors currently offer critical data on GEOINT in various fields such as weather monitoring, communication, and Earth observation. The security of nation states and regional geopolitical alliances, as well as modern military engagement and important commercial and public services, heavily depend on satellite-derived data and communication networks (Pearson, et al., 2018). Therefore, ensuring the protection of space assets in now of utmost importance. GEOINT scientists must describe, assess, and visually represent these assets to enhance the Common Operating Picture (COP) (Coorey, 2018). It is worth noting that space-based assets now play a crucial role in determining the whereabouts of potential adversaries. Therefore, the commercial industry has greatly transformed GEOINT in space. Although there are several positive aspects to it, some negative consequences come along with it too. Commercial data providers have

significantly expanded the coverage of Earth by employing various technologies such as synthetic aperture radar (SAR), radio frequency (RF), multispectral, hyperspectral, and more. This allows for wealth of information to accompany the multitude of images captured. For instance, when observing a ship, one can cross-reference the RF signal to determine its location. If the ship is not emitting the expected signal, it may suggest suspicious activity (Datta, 2022). Thus, the speed at which such data is gathered is a crucial aspect of the big data challenge. A single remote sensing mission can accumulate a significant volume of data, which rapidly escalates to terabytes and petabytes when stored for possible future use (Coorey, 2018). Therefore, providing enormous amounts of data at real time paste to be able to analyse by intelligence analysts when directing sensitive missions or for mere decision-making purposes. Hence, arising the question of the reliability of the data provided and recollected by the resources supplied by the private sector.

On the other hand, GEOINT is expected to increasingly hold value in addressing the misuse of the World Wide Web for malicious purposes such as terrorist recruitment, communication, combating homegrown terrorism, and safeguarding against cyberwarfare by international adversaries. Recent incidents, like Russia's attacks on the US power grid on election, Iran's data gathering from renowned universities, and North Korea's cyberattacks on the 2018 Winter Olympic games, highlight the urgency of this matter (C.Clarke, 2020). However, the telecommunication systems are the most vulnerable due to the possibility of jamming or spoofing. Therefore, the introduction of the private sector in outer space has led to the creation of a mega-constellation that produces an extensive amount of data per minute, which becomes available to the highest bidder

becoming an immediate threat to national security and humankind. Not only the availability of the data becomes an issue but the analysis and coordination of it becomes a challenge. Moreover, as the number of satellites also increase the threat on its systems becomes more palpable. For that matter, international cooperation and diplomacy are necessary to address the involvement of private companies in space. It is essential for governments, private entities, and international organisations to collaborate in their efforts to tackle challenges pertaining to data sharing, satellite collisions, and territorial sovereignty.

IV. Conclusion

The aim of this dissertation was to answer the following question: how the entrance of the private sector in outer space has impacted the security network in space. Therefore, in the 21st century, the dynamics of the space ecosystem is not only reliant on the control of two main powers-the US and Russia- in the domain. However, in the present day, due to the undergoing rapid changes, the space domain has become more complex with a significant number of state actors and commercial entities controlling this sphere. This has resulted in great proliferation of space technologies and the increased commercialisation of space activities. Consequently, becoming space a contested, competition area posing a challenge for the space ecosystem.

The involvement of the private sector in space has brought a significant change from a traditional geopolitical field to a solely economically focused dynamic in outer space. In the past, space exploration was mainly driven by governments for national security purposes. However, the emergence of the private ventures has revolutionised this landscape,

becoming a solely driven profitable business. Therefore, becoming space a platform dominated for services such as satellite-based communication, space tourism, resource extraction, and telecommunications. However, presenting challenges in terms of space governance, sustainability, and ensuring fair access to space resources.

On the one hand, the accessibility of space for the private sector has been greatly improved by the miniaturisation of satellites. Small satellites, known as CubeSats and nanosatellites, are more affordable and easier to launch, enabling private companies and startups to engage in space mission with fewer financial obstacles. Therefore, the increased accessibility has resulted in a rise of commercial space endeavours, including EO, communications, and scientific research. However, the rapid proliferations of these small satellites has presented some challenges such as the accumulation of space debris, overcrowding the orbits, and potential interference with existing satellite networks. Therefore, generating the need for the implementation of effective space traffic management and satellite disposal practices. As the space ecosystem has become monopolised by private companies. Dominant states such as the US have shifted their focus from only owned manufactured space assets to the reliance of their space security network on private companies, as seen by the case of SpaceX. Therefore, leading in the hands of a few non state international owned enterprises the national concerns and security of the nations.

On the other hand, the introduction of the private sector in the space security network has brought numerous positive contributions, such as technological advancements, increased investment, and more diverse

services. However, it also raises concerns related to dual-use technologies, data security, regulatory challenges, and potential market dominance. Striking a balance between leveraging the private sector's capabilities while addressing these challenges is crucial to ensuring that commercial involvement enhances space security and serves the interests of all stakeholders. Effective cooperation between governments and private companies can harness the potential benefits of the private sector's engagement while mitigating potential risks.

From a geostrategic standpoint, the dominant entrance of the private sector in space has not only affected national security but also the use of this domain for security purposes. More in depth, the use of space information recollection, denoted as GEOINT. As enterprises launch satellites uncontrolledly, the amount of information recollected becomes impossible to channel at an effective paste. Not only the decision-making process becomes directly affected but the reliability of the source and its access becomes a substantial factor to have into consideration for the use of information for time sensitive features. Moreover, despite the cheap and convenient access that private satellites create. This lack of security measures towards jamming or spoofing threats, very common and accessible for terrorist groups for example. Furthermore, the unsecured access to the information source, given to the highest bitter generated greatly concern for future use of outer space for intelligence recollection. Therefore, Big-Data, Security and Cooperation becoming the three factors of importance in the future of outer space. Thus, for future references the concern of outer space on the security network and the impact of the private monopoly in this sphere should be highly taking into consideration for the recollection of sensitive information, real-time operations, and

decision-making. Lastly, despite the increased power and control of the new venture. States would always remain the ones in power of this domain. However, new networks might be created to maintain space as a viable, resourceful, and peaceful domain for the enjoyment of all.

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